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Communities Count: exploring the role of participatory monitoring in conservation and development initiatives

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Abstract

Working at the nexus of conservation and development is challenging. Participatory environmental monitoring (PEM) is, on paper, a win-win for conservation and development, but there has been limited evaluation of its effectiveness in improving the lives of local people while also supporting improved management of species of conservation concern. In this thesis, I use a multidisciplinary approach to gain a better understanding of the role and implications of PEM for conservation and development, using a project in Madagascar as a case study.

I conducted a systematic literature review and online survey to describe approaches to PEM. I found that PEM schemes are variable, widespread and growing in number, but local participation is still limited and opportunities exist to improve use of modern technologies. Using occupancy modelling, I found that the case study lacks power to detect trends at the landscape level, but could provide useful presence-absence information on species and threats at the village level. However, the biggest issue highlighted by this research relates to inadequate data management that prevents most data being available for analyses and 'learning-by-doing' feedback loops. Using semi-structured interviews, I gathered local peoples' perspectives of the project operating in their village and found that the project was widely known within the villages, but that not everyone benefits. Based on these findings and with my own first-hand experience of the case study project, I designed a tool for practitioners to use during the design and implementation of a PEM scheme.

This thesis highlights the need to carefully consider all aspects of a PEM project, from the ecological knowledge gleaned from the data to the social impact across all sectors of the community. In doing so, this research demonstrates that PEM is challenging, complex and by no means a silver bullet for meeting dual conservation and development goals.

Declarations

This thesis results entirely from my own work. The work of all others is appropriately acknowledged and referenced in the text.

Samantha Earle, December 2016

Copyright Declaration

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I have many people to thank for their help and support over the past four years. I'd like to kick off with a big thank you to EJ Milner-Gulland for being such an inspiring, encouraging and patient supervisor. A big thanks also deserved by Richard Young for taking me on in the first place, and also for your help and sound advice along the way. None of this would have been possible without Maria O'Donoghue and the Val O'Donoghue Scholarship in the Natural Sciences set up in her late husband's name. I am very grateful to your financial support, that has enabled me to follow a dream and develop both in my personal and professional life.

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SAE,

12th December 2016

Abbreviations and Acronyms

AIC	Akaike information criterion
CBC	community-based conservation
CBD	Convention on Biological Diversity
CBNRM	community-based natural resource management
CEEF	*Cantonnements de l'Environnement, de l'Écologie et des Forêts* – Local Department of the Environment, Ecology and Forests
CIREEF	*Circonscription Régionale de l'Environnement, de l'Écologie et des Forêts* – Regional Constituency of the Environment, Ecology and Forestry
CMP	conservation measures partnership
COBA	*Communauté de Base* – local community association in Madagascar
CR	Critically Endangered (IUCN Red List category)
det	probability of detection
df	degrees of freedom
DGF	*Direction Générale des Forêts* – Direction General of Forests
DREEF	*Direction Régionale de l'Environnement, de l'Écologie et de Forêts* – Regional Directorate of Environment and Forests
Durrell	Durrell Wildlife Conservation Trust
EN	Endangered (IUCN Red List category)
est	estimate
FAO	Food and Agriculture Organization of the United Nations
GCF	*Gestion Contractualisée des Forêts* – Contracted Forest Management
GELOSE	*Gestion Locale Sécuriseeé* – Secured Local Management of Natural Resources
GFW	Global Forest Watch
GLM	generalised linear model
GLMM	generalised linear mixed model
ICDP	integrated conservation and development programme
IPBES	Intergovernmental Policy on Biodiversity and Ecosystem Services
IUCN	International Union for the Conservation of Nature
LC	Least Concern (IUCN Red List category)
MDGs	Millennium Development Goals
MNP	Madagascar National Parks
n	number
NA	not applicable
NGO	non-governmental organisation
NPA	New Protected Area
NS	Not significant

NT	Near Threatened (IUCN Red List category)
occu	probability of occupancy
OS	open standards for the practice of conservation
p	p-value
PA	Protected Area
PEM	participatory environmental monitoring
PES	payments for ecosystem services
PNG	Papua New Guinea
prob	probability
R	proportional difference in occupancy
RA	research assistant
REDD+	reducing emissions from deforestation and forest degradation
SE	standard error
SMART	in relation to objectives = specific, measureable, ambitious, realistic, time-bound
SRAF	*Service Régional Administratif et Financier* – Regional Administration and Finance Service
SRC	*Service Régional de Contrôle* – Regional Control (Enforcement) Service
SRE	*Service Régional de l'Environnement* – Regional Environmental Service
SREco	*Service Régional de l'Ecologie* – Regional Ecological Service
SRF	*Service Régional des Forêts* – Regional Forestry Service
TEEF	*Triages de l'Environnement, de l'Écologie et des Forêts* – Triage of the Environment, Ecology and Forests (Local jurisdiction)
UNEP-WCMC	United Nations Environment Programme – World Conservation Monitoring Centre
VOI	*Vondron'Olona Ifotony* – local community association in Madagascar
VU	Vulnerable (IUCN Red List category)

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Chapter 1 Introduction to the Thesis

1.1 Background

Monitoring is defined at the process of gathering information about variables that characterise a system state for the purpose of assessing system state and tracking changes over time (Yoccoz et al. 2001). In the context of nature conservation, the ecological variables of interest may be biodiversity, species richness, species occupancy, abundance or density, habitat quantity, habitat quality, level of anthropogenic pressures. Monitoring has a range of functions, such as estimating system state and detecting change (Kremen et al. 1994; Margoluis et al. 2009a); informing corrective action or decision-making (Dallmeier et al. 2002); raising awareness among the public and policymakers (Rees & Pond 1995); enforcing rules or laws (Andrianandrasana et al. 2005; Sommerville et al. 2010), assessing progress towards targets (Tittensor et al. 2014) and predicting future states (Nemani et al. 2009).

Despite the widespread recognition of the importance of monitoring, few conservation initiatives incorporate effective monitoring and are able to demonstrate that interventions are having an impact (Brooks et al. 2006; Ferraro & Pattanayak 2006; Pullin & Knight 2001; Yoccoz et al. 2001). Field et al. (2007) describe conservation monitoring as an '*illusion of productivity created by the accumulation of essentially useless data*'. However, there has recently been a shift, such that monitoring is now increasingly being considered an integral part of conservation initiatives globally, regionally and locally. At the global scale, signatories to the Convention of Biological Diversity are striving to meet the current 20 Aichi Biodiversity Targets (Secretariat of the Convention on Biological Diversity 2014) by 2020 (di Marco et al. 2016; Tittensor et al. 2014). Monitoring biodiversity at the national level is required to track progress towards global goals as well as governments' own targets. At the local scale, there is an increasing demand for conservation programmes to prove the effectiveness and success of interventions based on evidence from monitoring (Ferraro & Pattanayak 2006; Redford et al. 2011).

There are substantial challenges to measuring global biodiversity and aligning monitoring objectives from the local to global scale (Stephenson et al. 2015; Washington et al. 2015). For this reason, Stephenson et al. (2015) advocate the need for collaboration between government, civil society organisations and academia to measure progress towards the Aichi targets as well as towards fulfilling national and local conservation programmes and capacity building needs. Danielsen et al. (2014) argue that REDD+ provides an opportunity for involving stakeholders in collecting relevant data for national targets as part of international environmental agreements.

Concurrently, there has been increased emphasis on the importance of considering the wellbeing of communities living in or near to areas of conservation interest. Most governments have agreed to the Convention on Biological Diversity where articles 8.j, 10.c and 10.d mention indigenous and local communities' lifestyles (CBD 1992). More recently, the Intergovernmental Platform on Biodiversity and

Ecosystem Services integrates indigenous and local knowledge into the science-policy interface. Coupled with this increased general interest in monitoring, environmental monitoring schemes that involve local people have been proposed as a way of achieving dual conservation and development targets, where local people receive direct benefits from participating in monitoring activities. There are a variety of terminologies referring to monitoring involving local people, such as community-based monitoring, participatory monitoring, locally-based monitoring and locally-led monitoring. Throughout this thesis I use the term 'participatory environmental monitoring' (hereafter PEM) to encompass this range of approaches. This range of terms reflects the fact that local monitoring has been used in various forms for many years (e.g. Marks 1996 describe wildlife records for local hunter observations in 1989) and local peoples' involvement in monitoring is highly variable (Danielsen et al. 2009).

The common factor in the range of terms is a reliance on local people at one or more stages of the project cycle process, from design, data collection and management to data analyses and decision-making. As a minimum, local people are trained and equipped to conduct regular surveys in the area of interest, although professional researchers are responsible for designing the scheme, interpreting and using the data. This is the lowest level of participation by local people, categorised as 'externally driven by local data collectors' by Danielsen et al. (2009). At the other end of the participation scale, 'autonomous local monitoring' describes schemes where local people design, collect, interpret and use the data, with little or no help from external agents.

Involving local people in monitoring is attractive to project managers and funders for practical and logistical reasons. One practical argument for the involvement of local people is the cheaper cost of local monitoring compared to professional scientists (Hockley et al. 2005). Other arguments include the range of potential social, development and wellbeing benefits of engaging local people in the management of their own resources (e.g. Fraser et al. 2006; Funder et al. 2013). Involving local people could fulfil various roles in enhancing the wellbeing of local people, such as providing access to a job, feeling more empowered and secure. Although there has been progress of evaluating the social impact of conservation interventions on wellbeing (Woodhouse et al. 2015), the perceptions of local people and the impacts of PEM schemes on local people has had limited study. Two studies have explored empowerment of local people involved in monitoring. In a participatory natural resource monitoring scheme in Tanzania, Funder et al. (2013) found that the villagers altered the scheme in subtle ways that led to extra benefits (such as controlling access to resources) that were not planned by external implementers. Constantino et al. (2012) investigated the relationship between community-based resource management and empowerment across four systems in Brazil and Namibia. They concluded that the monitoring system promoted individual psychological empowerment, although other more complex forms of empowerment (such as community, social, political and economic empowerment) were rare and context specific. In relation to social connectedness, effective communication and co-operation are essential for the long-term sustainability of monitoring projects involving local people (Palmer Fry 2014; Selvey 2013).

In theory, PEM can provide information about the state of the environment with the goal of informing decisions on the management of the area, but the degree to which this goal is met is variable (Sheil 2001), and not all PEM schemes successfully translate monitoring data into management decisions (Boissière et al. 2014; Garcia & Lescuyer 2008). Villaseñor et al. (2016) conducted a literature review to explore the factors that affect the link between monitoring and decision-making. In doing so they categorised each project as either being: (1) collaborative learning which is motivated by a desire to enhance the capacity of local people to take better decisions, with emphasis on the monitoring as a learning process, or (2) evidence-based which is driven by conservation or government agencies needs to conduct biodiversity assessments. Information derived from the collaborative learning was used more often than evidence-based approaches. In addition, those projects where there was a local decision-making process enabled information to strengthen initiatives and management. This emphasises the need to carefully consider how local people will participate and the social context in which a scheme is operating.

In addition to the link between monitoring data and direct local management in the first instance, the data also need to answer questions about the state of the ecosystem or the impact of interventions so as to provide evidence to decision-makers at higher levels (Field et al. 2007). Several studies have explored data quality and quantity produced from PEM compared with professionally conducted studies, showing that data collected by PEM schemes are similar at detecting the status and trends of species and natural resources to professional studies (e.g. Danielsen et al. 2014). This becomes even more pertinent given the substantial resources required to conduct monitoring and limited financial resources under which most conservation or ecological projects operate.

There is little understanding of the relationship between conservation (related to environmental data) and development (related to the wellbeing of local people) dimensions of monitoring involving local people. Is there a trade-off between these two elements, or is there a way of improving both? What are local people's motivations, expectations and general perceptions of the monitoring? What are the range of benefits and impacts of monitoring on local people? What are the favourable and unfavourable conditions for PEM? How does a practitioner design and implement a PEM scheme? This thesis aims to give answers to some of these questions.

1.2 Aims and Objectives

The overall aim of this thesis is to gain a better understanding of the role and implications of participatory environmental monitoring for conservation and development. I frame this investigation using the case study of participatory environmental monitoring in Menabe, Madagascar and in doing so to aim to provide practical and sound advice to project managers.

The main objectives are to:

- explore the use, pros and cons of environmental monitoring projects involving local people and how this approach to monitoring fits into the conservation and development discourse;
- review the current use of participatory environmental monitoring within conservation globally and suggest ways to improve its uptake and effectiveness;
- assess the ability of the ecological data collected by participatory environmental monitoring to detect change in the case study site;
- understand local people's perceptions of the benefits, challenges and impact of the case study participatory environmental monitoring project;
- based on the understanding obtained from the global review and the case study, develop a decision framework to guide the implementation of a PEM monitoring scheme for use by practitioners.

1.3 Thesis Structure

The thesis can be split into four components combining background information, ecological research, social science research and the synthesis and application of the research (Figure 1.1).

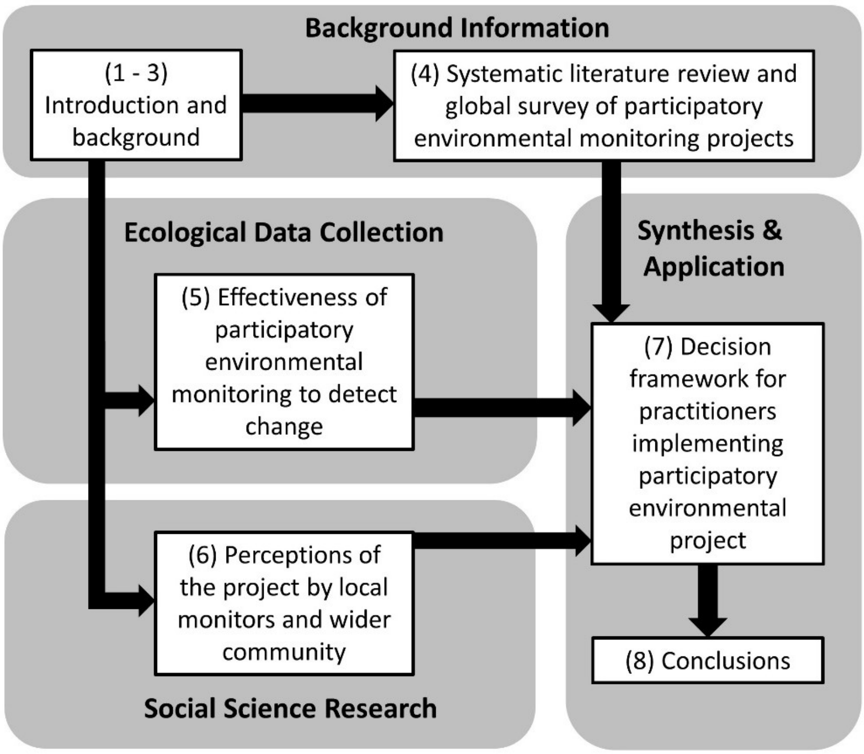

Figure 1.1. Framework of the chapters (numbered) and the main themes of the research.

1.3.1 Chapter 2: Background

This chapter reviews the conservation and development discourse, the rationale, pitfalls and promises of monitoring involving local people.

1.3.2 Chapter 3: Case study

In this chapter I introduce the main case study of a PEM project in Madagascar which is used throughout the thesis.

1.3.3 Chapter 4: Review

Chapter 4 is a systematic literature review and global survey of PEM projects to understand the degree to which PEM schemes have changed over time in terms of the levels of participation, goals, the type of data collected and the methods used to collect the data. I discuss the gaps or lags in the development of PEM and the potential for PEM to take advantage of emerging technologies.

1.3.4 Chapter 5: Ecological robustness

Using data collected by the case study project, I investigate the power of the data collected to detect environmental change under a range of approaches and budgetary constraints. One approach is an occupancy model of a range of indicators with the intention of making inferences about trends at the landscape level. I compared the cost of this approach to a simpler approach of recording presence-absence information at the village level, which does not attempt to make inferences over a larger area. I intend to publish this paper (journal yet to be decided) with the following possible co-authors: H. Andrianandrasana, G. Guillera-Arroita, J. Lahoz-Monfort, E.J. Milner-Gulland, R. Young.

1.3.5 Chapter 6: Local perceptions

This chapter examines local perceptions of the case study in terms of knowledge of the project, the benefits and loses from a range of people across the study villages, including those that collect the data and those that are not directly involved. I intend to submit this paper to 'Madagascar Conservation and Development' with the following co-authors: H. Andrianandrasana, R. Heriniaina, E.J. Milner-Gulland, R. Young.

1.3.6 Chapter 7: Decision framework

This chapter draws on first-hand experience and all previous chapters to create a decision framework, composed of a decision tree and an accompanying table to assist practitioners implementing a PEM scheme or to encourage a systematic retrospective review of an existing scheme. The utility of the framework is demonstrated using a real life case study of a potential PEM scheme in Papua New Guinea and a review of the existing case study in Madagascar.

1.3.7 Chapter 8: Discussion

This chapter highlights and discusses the main conclusions reached in the thesis, key implications for the future of the case study in Madagascar and PEM schemes in general, plus discuss directions for future research.

1.4 My approach

I come from the natural science discipline born from a passion for wildlife and intrigued by the complexity of conservation problems. I soon understood that in order to reach conservation goals, conservation organisations and initiatives have to work together with local people (Bennett et al. 2016). For this reason, I have wished to expand my research into the human dimensions of conservation. However, my background brings me far short of the sort of skills and understanding required to carry out a thorough anthropological study. In addition, the financial, logistical and time constraints of conducting this research as a PhD thesis, I have made no attempt at conducting an ethnological study. For example, in chapter 7 where I explore the perceptions of local people toward the PEM scheme, I refrain from inferring knowledge and understanding of norms, beliefs and attitudes towards general conservation and life. To do so would have required participant observation and synthesising information from different sources over an extended period of time in order to build up a narrative account of local perceptions (Newing et al. 2011).

Instead I took a positivistic approach (Moon & Blackman 2014) and ensured that I had very focussed research questions and focussed quantitative questionnaires to collect the information. From the start of my fieldwork I was very aware of the bias my presence in the village might have on my research. During the pilot surveys for data collection for chapter 6 the villagers, especially children, were very curious about me; unsurprising given that I fit the standard profile of a foreign researcher in a developing country: young, white, able-bodied, unable to speak the local language. Added to this, the communication barrier meant that my presence had an effect on what other people said and did, ultimately impacting the data I collected and interpretation and conclusions I might make. I also accept that there is a fine line between remaining objective whilst providing insights into a particular conservation activity that I believe is important. Aware of all these potential biases and prejudices, I decided to hire two local people to collect the data in my absence, after 6 weeks of intensive training. I believe my pragmatic, natural science based approach to all aspects of my research (including the review, fieldwork and decision framework) is an appropriate way of answering my research questions. I recognise that a reductionist approach will only give part of the story, I believe it is valid part in order to provide a useful, valid and insightful framework to build upon for future exploration of the complexities.

Chapter 2 Background to PEM

2.1 Rationale for monitoring

Monitoring is the systematic process of collecting data for the purpose of measuring where a project, policy or programme is at any given time and tracking changes in state over time (Gerber et al. 2005; Yoccoz et al. 2001). Monitoring is not a stand-alone activity; it is connected to an active process of decision making to achieve objectives and is therefore a crucial component of any project management or intervention (see Figure 2.1). Like other components of the project management cycle, monitoring can be conducted by local people, a manager or outsiders. Monitoring, like projects generally, can take place at all scales, from measuring implementation and progress towards international environmental targets such as the 20 Aichi Targets (Butchart et al. 2015), regional level monitoring such as part of the 'monitoring, reporting and verification' component of REDD+ schemes (Palmer Fry 2011; UN-REDD Programme 2009) to small-scale conservation projects such as catches of target fish species in a small fishery (Lunn & Dearden 2006). Across this range of scales monitoring has a range of possible goals:

- detecting change in the system state for the purpose of developing scientific knowledge (Kremen et al. 1998; Margoluis et al. 2009a);
- informing corrective action or decision making as part of an adaptive management framework or to decide between competing policy options (Dallmeier et al. 2002);
- engaging the public and policy makers, leveraging effort and raising the profile of conservation issues (Rees & Pond 1995);
- enforcing rules or laws (Sommerville et al. 2010; Andrianandrasana et al. 2005);
- predicting future states and fluctuations in a system (Nemani et al. 2009);
- auditing and certifying implementation of project activities (Kapos et al. 2009).

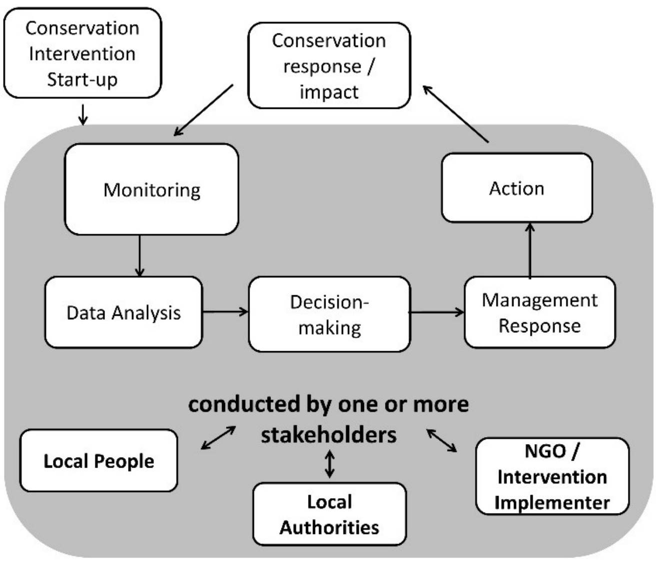

Figure 2.1. A summary of a project cycle and the types of stakeholders that might be involved in a conservation project

Despite the widespread acknowledgement of the importance of project monitoring, it is often overlooked or poorly executed (Yoccoz et al. 2001; Brooks et al. 2006; Ferraro & Pattanayak 2006; Field et al. 2007). Many local-scale conservation projects are based solely on personal experience rather than on scientific evidence (Pullin & Knight 2001). Where data are gathered, often they are not connected to management decisions or informing the project cycle (Field et al. 2007; Sheil 2001).

When monitoring does take place, it is frequently hampered by various logistical, political or financial constraints. A monitoring program cannot succeed without:

- A clear definition of what questions the monitoring should address (the goals of monitoring) and how progress should be measured (Tear et al. 2005);
- A clear link to decision-making through a theory of change (Gerber et al. 2005);
- A sampling design producing data with adequate statistical power to detect trends so that the goals of monitoring can be achieved (Field et al. 2004);
- Sufficient long-term funding for collecting and analysing data over the long-term (Field et al. 2007; Garcia & Lescuyer 2008; Keith et al. 2011; McLain & Lee 1996; Walters 2007).

2.2 Effective and efficient monitoring

The term 'effective' means: *"successful in producing a desired or intended result"* (OED 2016). In the context of monitoring, this means more than just gathering data, but also ensuring that it is used to meet the goal of monitoring (Biber 2013), such as detecting environmental trends or informing decision-making. There are a range of way to assess whether a monitoring method is fit for purpose such as ease of use, compatibility with existing activities, methodological rigour, financially stable, institutionally stable (Seak et al. 2012). Ultimately, a manager needs to ensure that monitoring is sustainable; in the context of monitoring, this means "possible to continue the activities indefinitely at a level that ensures the objectives of monitoring are fulfilled" (Danielsen et al. 2005). If effective monitoring cannot be achieved, it may not be worth monitoring at all (McDonald-Madden et al. 2010).

'Efficient' means *"achieving maximum productivity with minimum wasted effort or expense"* (OED 2016). In the context of conservation monitoring this means getting the most information out of a system from a given budget, which requires that a combination of funds, time, energy and human capacity resources are spent carefully (Gray & Kalpers 2005). This is particularly important because funds for environmental management and conservation activities are limited and far exceeded by conservation needs (James et al. 1999; Balmford et al. 2003). Gray and Kalpers (2005) describe an efficient ranger-based monitoring programme in the Virunga-Bwindi region of East-Central Africa, where the data are collected in a systematic way for a low cost, and the information can be easily fed into analysis systems and processed in a timely manner to directly feed into management.

Efficient use of monitoring effort is vital (Nichols & Williams 2006), therefore managers have a responsibility to collect meaningful data that are useful for decision-making without wasting resources by over-sampling or collecting unnecessary information. In addition, Jones et al. (2010) warn that even when project managers do spend time and effort monitoring, cost-effectiveness is unlikely to be linearly related to the amount spent.

Systematic conservation planning aims to achieve a conservation target at least cost and thereby maximise the conservation return-on-investment (Murdoch et al. 2007). For example, Ando et al. (1998) was one of the first studies to usefully include costs in a target-driven analysis, by including the heterogeneity in land prices alongside the incidence of endangered species in the site selection process for biological reserves. By taking a cost-benefit approach to the conservation planning process, biological targets could be achieved at 25-50% of the cost of the plans that were based on biodiversity alone. Other more recent examples include calculating the costs of various conservation planning strategies (Naidoo et al. 2006; Pence et al. 2003).

A cost-benefit analysis is a systematic way of comparing a range of options for a project, decision or policy (Hanley & Spash 2003). It is a comparison of total expected cost of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much. Businesses have long used accounting to measure the costs and return of investments of their operations, but conservation projects have been slow to adopt this auditing tool (Christensen 2003). As conservationists, rarely do we assess the value of gaining more information (Possingham et al. 2012). Collecting more information has associated costs, such as management costs, acquisition costs, opportunity costs and transaction costs (Naidoo et al. 2006). However, biodiversity and development benefits can be very difficult to calculate because of the range of currencies (Caughlan & Oakley 2001; Possingham et al. 2012). For example, in the context of conservation involving ecological and social benefits, these benefits can be quantifiable but difficult to compare (such as species richness, population growth, financial return) or difficult to quantify (such as forest quality, human wellbeing, change in social status).

In the context of environmental monitoring a conservation manager must be prepared to trade off investment in monitoring with investment in implementation and management, perhaps to the extent that it is not worth monitoring at all (McDonald-Madden et al. 2010). In theory, there is an optimal amount to spend on monitoring and management given a fixed budget (see Figure 6.1 of Possingham et al. 2012 for a diagram). A manager or implementer must be aware that a monitoring strategy optimised for one benefit may not be optimised for another benefit. Possingham et al. (2012) therefore suggest that we need to either focus on reaching one primary objective or accept a compromise by adopting a broad-multi-criteria approach.

2.3 Citizen science

Citizen science "*involves citizens as researchers*" (Kruger & Shannon 2000) rather than traditional science where professional scientists have collected and analysed environmental data. Citizen science may also be termed 'community science' (Carr 2004) or 'voluntary biological monitoring' (Conrad & Hilchey 2011).

During the 1990s and 2000s there has been a huge rise in citizen science programmes and groups collecting environmental data, particularly in the USA and Canada (Conrad & Hilchey 2011). For some animal groups, in particular birds, there has been a strong amateur naturalist culture recording bird observations. eBird is one example of a citizen science programme where data collected by amateur naturalists is entered online and provides data on bird distribution, seasonal occurrence and relative abundance (Sullivan et al. 2009).

Citizen science data are collected by members of the public, motivated by an interest in nature or common concern of their surrounding environment (Conrad & Hilchey 2011). In this thesis I distinguish citizen science from participatory monitoring schemes in developing countries. Citizen science schemes are more typical of developed countries, where people use their spare time and consider monitoring as a recreational activity. However, in participatory monitoring schemes, local people are usually approached by an external agency (such as an NGO or local authority) and consulted about the possibility, their interest and willingness to take part in an environmental monitoring scheme. They may choose to become involved in the scheme, but probably need to be incentivised or convinced that there will be a benefit from participating.

2.4 Monitoring involving local people in developing countries

Traditionally, within a conservation programme in a developing country, monitoring has been a top-down process with the function of reporting to funders. This type of monitoring is expensive (Hockley et al. 2005) because it is usually been conducted by professional highly trained experts who are hired for the job (Fraser et al. 2006). However, nowadays there is increased recognition of the importance of involving local people in the sustainable development and control of natural resources (Agrawal & Gibson 1999; Holck 2008). This is also reflected in the call for the involvement of local people in international forest policies such as the Conventional on Biological Diversity (CBD 1992) and the REDD+ programme (UN-REDD Programme 2009) and global agendas of donor agencies (Ribot 2004).

One reason for involving local people in conservation interventions is that they have a vested interest in the natural resource that is subject to management and have the most to lose and gain from environmental stewardship (Constantino et al. 2012). For practical reasons, local people are often involved in the ecological monitoring component of a conservation project, where they are residents and close to the natural resource of interest, familiar with their surroundings and can be trained to collect data at a lower cost than professional scientists (Holck 2008). Furthermore, the support and involvement of local people in conservation initiatives and forest management is important to ensure sustainability, enhance capacity and secure community rights to maintain or improve their forests in the long term (Stevens et al. 2014), as well as being essential for ethical accountability (Makagon et al. 2014).

In the scientific literature a range of terminology is used to describe monitoring involving local people. As these schemes came from the 'community-based conservation' approach they were initially referred to as 'community-based monitoring' schemes (Danielsen et al. 2005; Topp-Jørgensen et al. 2005). However, the terminology has expanded to 'locally-based monitoring' and 'participatory monitoring'. With all of these labels, the commonality is that monitoring is carried out by local people, usually with little formal education, residing close to the area of interest (Danielsen et al. 2005). In the interests of consistency, I use the term 'participatory environmental monitoring' or PEM throughout the thesis. The phrase 'environmental' has been incorporated to allow for the inclusion of schemes collecting environmental data, such as water quality or climate (e.g. Shaffer 2014).

Participation by local people in monitoring in conservation projects is increasing (Kouril et al. 2015). However, the degree of local involvement in monitoring is highly variable; Danielsen et al. (2009) succinctly describe five typologies of participation which range from no local involvement with monitoring designed, summarised in Table 2.1. Palmer-Fry (Palmer Fry 2014) added intermediate categories between 3 and 4 to fully describe the gradual shift in participation at various stages of a project. These extra categories are valid, however, for the purpose of simplicity I will continue with the five principal categories, as depicted in Table 2.1.

Table 2.1. Summary of the typology of participatory monitoring categories, taken from Pretty (1995) and Danielsen et al. (2009).

	Category	Description	Level of participation by local people
1	**<u>No Participation</u>** externally driven, professionally executed	No part of the scheme involves local people.	none
2	**<u>Passive Participation</u>** Externally driven with local data collectors	Local people are only involved in gathering data. The design, analysis and interpretation of the monitoring data are undertaken by external agencies/professional scientists.	
3	**<u>Functional participation</u>** Collaborative monitoring with external data interpretation	Local people collect the data, perhaps for material incentives, although they are not involved in data analysis. They may be consulted and asked questions by external agencies and therefore could be involved in management-oriented decision-making, but if this happens is usually very limited.	
4	**<u>Interactive participation</u>** Collaborative monitoring with local data interpretation	Local people collect the data and are involved in data analysis and decision-making, although external, professional support is required to facilitate the process and provide training.	
5	**<u>Self-mobilisation</u>** Autonomous local monitoring	The whole monitoring process is carried out autonomously by local people. Although external agencies may be advocates of the scheme.	all local people

2.5 The conservation and development discourse

Monitoring involving local people is relevant to the conservation and development discourse because of the focus on dual conservation and development goals. Biodiversity conservation is central to environmental policy and has shifted from 'nature for itself' to 'people and nature' (Mace 2014), thus conservation and development are intricately linked. The challenge of balancing conservation and development goals is not new; there has been much debate about the role of conservation agencies in poverty alleviation (Roe 2008; Salafsky 2011). The term 'Integrated Conservation and Development Projects' (ICDPs) became mainstream in the 1990s, but nowadays most conservation is probably some form of ICDP where there is a conservation goal with development or vice-versa. There is much debate about the effectiveness of ICDPs and community-based conservation in general (Brooks et al. 2013; Wells & McShane 2004). This is mainly because it is difficult to align ecological and social objectives (McShane et al. 2011; Salafsky 2011) and there can be a misfit in the interests of different institutions and stakeholders (Brown 2003).

One of the most successful approaches to conservation and development is the Community Based Natural Resource Management (CBNRM) Programme in Namibia. In this example, property rights to natural resources have been transferred from the state to communities, there have been significant rises in wildlife populations and cash and non-cash income to conservancies and from CBNRM activities as well as some community and household level benefits (Barnes et al. 2002; Boudreaux & Nelson 2011; Riehl et al. 2015).

Despite the challenges, community-based conservation remains a popular and widespread approach to tackling conservation problems (Brooks et al. 2013) and is in keeping with international treaties and programmes, such as the Convention on Biological Diversity and REDD+ (Danielsen et al. 2011) as well as human rights (Makagon et al. 2014). Furthermore, academics and implementers are finding ways to improve community-based conservation initiatives. For example, Garnett et al. (2007) suggest a framework for improving the effectiveness of conservation and development interventions, based on considering five types of capital: natural, human, social, built and financial. Similarly, Tallis et al. (2008) describe a framework to support conservation and economic development taking an ecosystem services approach.

2.6 A conceptual framework for the dual goals of participatory environmental monitoring

Monitoring involving local people can be composed of both conservation and development goals (Figure 2.2) with a range of potential benefits to both dimensions.

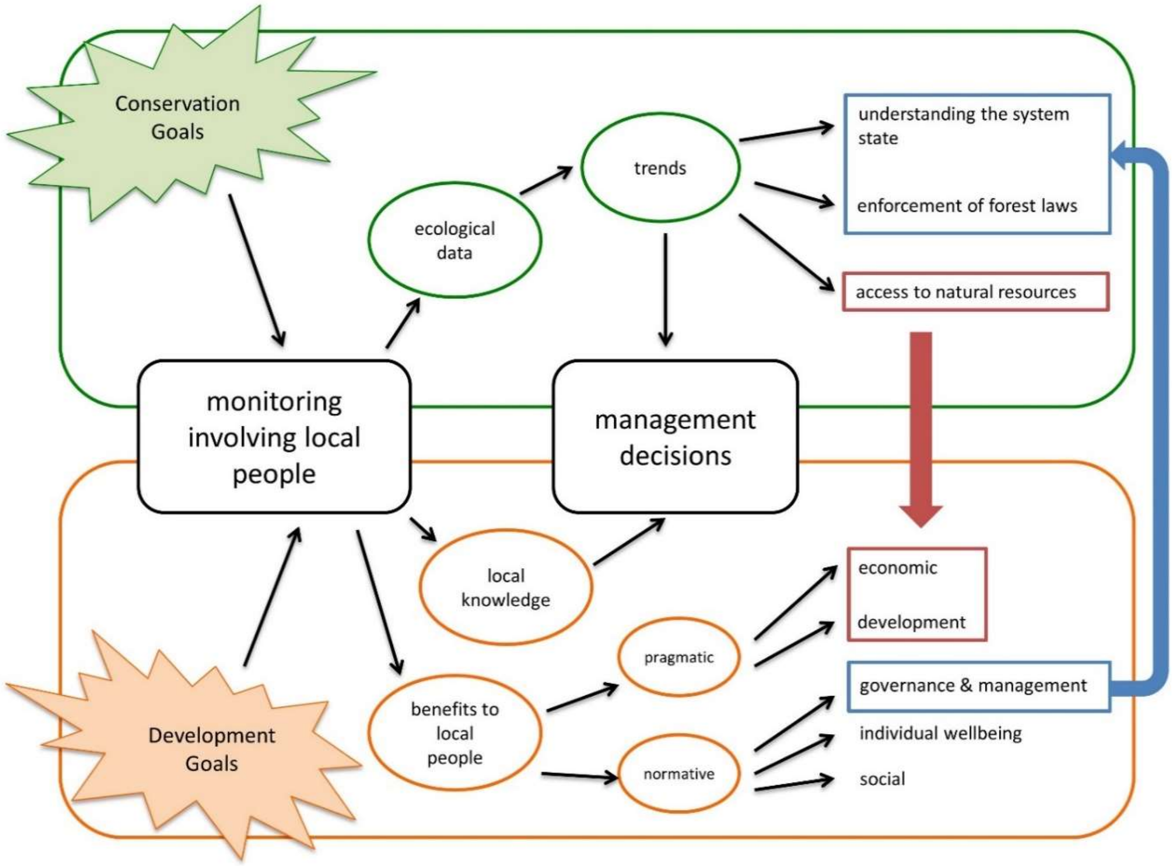

Figure 2.2. A conceptual framework of the links between conservation and development goals of monitoring involving local people, with feedbacks flowing from conservation to development (red arrow) and development to conservation (blue arrow).

To conservationists, one benefits of involving local people is the cheaper cost of local monitoring compared to professional scientists (Hockley et al. 2005). Local people have fewer travel costs, rudimentary equipment, lower salary requirements and do not have to be employed on a full-time basis. Even if there are high start-up costs as a result of training up local people, in the long term the overall cost of locally-based monitoring is substantially cheaper than expert-led monitoring conducted by external researchers (Danielsen et al. 2011).

From the development and social perspective there are also a range of benefits (summarised in Table 2.2); such as engaging with local people to enhance their sense of ownership of their resources, which in turn can be fed back into management decisions. Pragmatic benefits include an improved economic situation by securing a salary, or by receiving increased development support through the provision of materials or equipment, for example for schools or health centres, in turn for participation or data collection, as a way in encourage involvement. Potential normative benefits include the increased engagement with governance and management of areas of conservation and local interest (such as nearby forest), also the potential for improvement in a range of wellbeing components (such as security) or social improvements (such as being more respected by other people).

There are also positive feedback mechanisms between the conservation and development aspects of this approach, such as the impact of access to natural resources on economic standing and development of a community (Figure 2.2, red arrows) or the potential for governance and management to contribute to forest law enforcement (Figure 2.2, blue arrows). It is these positive feedback loops and linkages between conservation and development that may make PEM well suited, at least in theory, to positively contributing to addressing complex conservation dilemmas.

Table 2.2. Summary of the potential benefits to local people by involving them in environmental monitoring.

Benefit	Description	Type of Benefit	Example
Increased awareness within community	Encourages them to take part in conservation efforts and generates a sense of pride about their environment and reinforcing the conservation effort.	social	Local monitoring and conservation of freshwater turtles in Ecuador (Townsend et al. 2005).
Trust and social bond between villagers	Opens up a forum where management and control of natural resources can be openly discussed, this ensures that all stakeholders know about infractions and the villagers can monitor each other's' actions and build trust.	social, wellbeing	Local hunters in the Bolivian Chaco (Noss et al. 2005); local monitoring of wetlands in Madagascar (Andrianandrasana et al. 2005).
Prompt response to threats	Local people are on the ground and rapidly identify threats, with an efficient reporting system, management decisions can be quickly made and a prompt response can result - also linked to empowerment, see below.	management	A review on the scale and speed of implementation in relation to involvement of local people (Danielsen et al. 2010).
Individual and community empowerment*	Local people drive and feed directly into the process, interact with local government authorities and are involved in decision-making that will affect their own lives	social, wellbeing and management	Empowerment of local people in Brazil and Namibia (Constantino et al. 2012).
Use of local knowledge to enhance the quality of the decisions made	Improves understanding the local context and situation and can be applied with scientific techniques to better conservation efforts and ensure management decisions are locally meaningful.	management	Local pastoralists involvement in reducing desertification in Botswana (Fraser et al. 2006); although see Nielsen and Lund (2012) for an example of the influence of the political culture and institutional setup on a project in Tanzania.
Increased wellbeing of individuals	Local people are often provided with a salary and/or materials and equipment. Ideally the economic benefits are self-sustaining for the long term. At a minimum the benefits of being involved in the project must exceed the costs.	economic, development and wellbeing	Financially self-sustaining monitoring by local people in Tanzania (Topp-Jørgensen et al. 2005).

*Empowerment is a widely used but poorly defined word, here empowerment is defined as *"a participatory, developmental process through which marginalised or oppressed individuals and groups gain greater control over their lives and environment, acquire valued resources and basic rights, and achieve important life goals and reduced social marginalisation"* (Constantino et al. 2012).

2.7 The challenges of participatory environmental monitoring in the real world

Levels of participation in conservation projects have remained lower than might be expected (Campbell & Vainio-Mattila 2003). Despite the potential benefits of local people being involved in monitoring, or indeed conservation initiatives generally, in practice there are few examples of successful, sustainable and meaningful monitoring programmes of this nature. The biggest hurdles relate to:

- balancing the skills and knowledge of local people with sufficient and meaningful data for external agencies;
- ensuring the true benefits to participation outweigh the costs;
- lack of appropriate social and political culture to enable the use of data collected by local people in decision-making and management;
- lack of self-sustaining financial mechanisms to ensure the monitoring can continue beyond the original funding stream.

2.7.1 Balancing local skills with scientifically robust data

Rural people in developing countries often have a low literacy level and poor skill base for environmental monitoring activities. Therefore the data collection method might only require minimal writing (rather than writing detailed accounts of observations or instances) and equipment that can be easily and reliably operated with some basic skills and training (Holck 2008). By simplifying data collection, rather than training a limited group of people, monitoring activities can be opened up to increase participation across a community (Funder et al. 2013). However, this is likely to compromise the standard of the scientific method used and the quality of data compared with monitoring conducted by professional scientists (Danielsen et al. 2007; Finn Danielsen, Jensen, et al. 2014). This can result in creation of non-standardised, site-specific datasets that make spatial comparisons and aggregation to higher scales a challenge.

To balance local skills with scientifically robust data, Reed (2008) suggest that a project should have a highly-skilled facilitator to manage different skills and perspectives and hybridise the knowledge from local people and project researchers and implementers. However, this can be difficult to achieve in practice. For example, Fraser et al. (2006) describe the process of selecting indicators for management of coastal temperate rainforest in British Columbia, Canada. They found that the involvement of local people to select indicators generated a long list of indicators and was time and resource intensive. During this time, the value of the participatory indicator selection process diminished due to a perceived lack of progress in implementation and therefore, was not translated into good policy. Had the engagement with local people been better managed and controlled in a timely and efficient manner at the outset, they might have generated a concise, meaningful and representative list of indicators which also addressed those aspects of the environment which mattered most to local people. Therefore, a balance must be found between ensuring data are scientifically robust and local people feel fully engaged and benefit by participating in monitoring activities.

2.7.2 Ensuring the benefits outweigh any costs

There should be some benefit to local people to participating in a PEM scheme, whether it be financial, provision of materials or equipment or less tangible benefits relating to human wellbeing (Danielsen et al. 2007). There is some sort of a cost to being involved in the monitoring, such as an opportunity cost of not tending to crops, working in a shop or engaging in some other livelihood activity, but any costs must not outweigh the benefits (e.g. Hockley et al. 2005). See Table 2.2 for a detailed description of the potential benefits to local people.

2.7.3 The social and political culture

The social and political culture can make or break PEM efforts intending to link information from monitoring to decision-making. Villaseñor et al. (2016) conducted a review of PEM schemes and explored their contribution to decision-making, concluding that PEM efforts are not always successful at informing decision-making. If land management is driven by political, social or economic concerns such that decisions cannot be made at the local level or there are internal power struggles over natural resources (Boissière et al. 2014; Nielsen & Lund 2012), then attempts to fully engage local people in monitoring and management will be ineffective. Under these circumstances local people will, at best, only gather data and will have no further involvement in connecting monitoring to control and management of their resources (Danielsen et al. 2009; Garcia & Lescuyer 2008).

2.7.4 Establishing a self-sustaining mechanism

In many cases a donor agency provides substantial financial and practical resources during the start-up phase of monitoring involving local people. For monitoring to continue over the long-term there must be a self-sustaining mechanism that ensures there are adequate funds and resources for monitoring to continue to enable the initial donor to withdraw from the project (Topp-Jørgensen et al. 2005). Although in the minority, several PEM schemes have been sustained with little external support for more than a decade. One example of this is the Event Book System in Namibia which was started in 2000 in a few community wildlife areas but has expanded to neighbouring communities and has been adopted in national parks and is still in operation today (Stuart-Hill et al. 2005). Not only does the PEM scheme continue without large amounts of external support, but it also demonstrates that local people have control of the PEM scheme and are fully engaged with management and control of their natural resources (Agrawal & Gibson 1999). However, this is relatively rare and most projects require continued external support or they will cease to exist if the initial donor withdraws (Garcia & Lescuyer 2008).

Chapter 3 Background to the Case Study

The case study that I use in this thesis is a Participatory Environmental Monitoring (PEM) scheme in Madagascar, implemented and managed by Durrell Wildlife Conservation Trust (Durrell). I use this case study in Chapters 5 and 6 to explore the role of participatory environmental monitoring in conservation and development initiatives.

3.1 The national context: Madagascar

Madagascar has long been recognised as a global biodiversity hotspot and a priority for conservation (Myers et al. 2000). Madagascar was part of the Gondwana supercontinent, but separated from all landmasses approximately 88 million years ago (Storey et al. 1995). During this long period of isolation, the biota of Madagascar underwent substantial insular speciation (Vences et al. 2009) resulting in exceptionally high levels of endemism for many biological groups, particularly in forests (Goodman & Benstead 2005; Wilmé et al. 2006). The rates of endemism for 10,000 – 12,000 plant species are 83%, macroinvertebrates is approximately 85% of more than 5,800 species, whilst the endemism of land vertebrate fauna is 84% of 879 species (Goodman & Benstead 2005).

Madagascar is the world's fourth largest island, with an estimated population of 24 million people (World Bank 2016). In 2009 a political crisis sent the country into turmoil. The 'transitional government' was not recognised as legitimate by the international community and, as a result, international aid donations were withdrawn, except emergency humanitarian support. With the prospect of a fair elections, aid money started to flow back into Madagascar in 2012 (Waeber et al. 2016). Following presidential and legislative elections in December 2013, constitutional governance was restored and a new government was appointed in January 2014. During 2002-2006 Madagascar was on track to achieve its Millennium Development Goals (MDGs), however, the period of political turmoil set back progress and Madagascar failed to achieve any of the goals by 2015 (Waeber et al. 2016). In 2014 it was ranked 154 out of 188 on the Human Development Index (UNDP 2016) and ranked 34 out of 226 for highest birth rate (The World Factbook 2016). It is one of the world's poorest countries with "the highest proportion of working population living below the international poverty level of $1.25 per day of any country in the world" (Waeber et al. 2016). On 27 October 2016, the FAO released a statement that 850,000 people are acutely food insecure (not able to meet their food needs) in southern Madagascar, due to prolonged drought resulting in a "80% reduction in maize production compared with the already reduced levels of 2015" (FAO 2016).

The on-going social and political turmoil in Madagascar have had a devastating impact on the environment (Zinner et al. 2013). Madagascar's flora and fauna are endangered due to habitat loss, fragmentation and over-exploitation, as in other tropical habitats across the world (Morris 2010). It is estimated that since human colonisation, approximately 2000 years ago, only 10% (of Madagascar's land area of 594,150 km^2) of natural habitats remain (Goodman & Benstead 2005). Despite substantial investment in conservation and environmental policies (outlined in the next section), deforestation and forest degradation rates continue to increase (Waeber et al. 2016). Harper et al. (2007) analyse aerial photographs and Landsat images which show that forest cover has decreased by almost 40% from the 1950s to ~ 2000. To add to this, estimates by the Global Forest Watch (GFW) show that tree cover loss has more than tripled from 2004 levels of 81,845 Ha to 318,464 Ha in 2014 (GFW 2016).

Primary causes of forest loss in Madagascar include tavy/hatsake (slash-and-burn agriculture), logging for precious woods or construction material, collection of fuelwood, charcoal production and mining. These activities have been a problem for decades in Madagascar, perpetuated by extreme poverty and corruption and shaped by social, political and economic factors (Allnutt et al. 2013; Scales 2011; Scales 2012). A current example of this, is a sapphire rush that began in a Protected Area in the Corridor Ankeniheny Zahamena, Bemainty, in eastern Madagascar, after the gems were discovered there in late September. On 21 November 2016 it was reported (Jones 2016) that there are approximately 45,000 illegal miners and that the numbers could be growing by 1,500 – 2,000 people a day. Not only is this devastating to the forests and wildlife, but it is likely to also become a humanitarian issue as insecurity increases, schools close, sanitation diminishes and water becomes polluted – such is the desperation for new income sources.

3.2 Madagascar's environmental policy

Since 1927 Madagascar has steadily increased its Protected Area (PA) coverage (Virah-Sawmy et al. 2014). Initially, Madagascar's Protected Areas (PAs) were created for biodiversity conservation, scientific research and recreation, falling into the IUCN's PA management categories 1a, II and IV (Randrianandianina et al. 2003). Rising human populations in PAs, coupled with a lack of management for customary local use of natural resources, resulted in *de facto* open access to natural resources in Protected Areas leading to degradation (Antona et al. 2004; Weber 1995). To address this situation, in 1996 Madagascar began to decentralise management of natural resources from the Ministry of Environment and Forests (*Ministère d'Environnement et Forêts*) to community organisations, *Communauté de Base* (COBA), under a process referred to as GELOSE (*Gestion Locale Sécuriseeé* - Secured Local Management of Natural Resources). This community-based natural resource management (CBNRM) legislation was streamlined in 2001, specifically for forest management, known as GCF (*Gestion Contractualisée des Forêts* – Contracted Forest Management). The vision of this CBNRM policy is that the management of forests and natural resources are decentralised from governments to give autonomy to communities in their use of natural resources, thus ensuring local people's needs were met and to overcome the difficulties of regulating forest management and enforcing forest laws by the government (Cullman 2015). Whilst the GELSOE/GCF contracts do not transfer property right, they do give communities rights to access natural resources plus the responsibility and cost for monitoring and enforcement of management rules, which may exceed local capacities (Antona et al. 2004). There is little evidence that these contracts have been successful in conserving forests or promoting community development largely due to a lack of institutional support and misalignment of objectives between the state and communities (Pollini 2011).

During the fifth World Parks Congress of the IUCN in Durban, South Africa in 2003, the former President of Madagascar, Marc Ravalomanana, made a promise to triple Madagascar's Protected Area (PA) coverage to meet the IUCN recommendations of protecting 10% of its territory. This amounts to increasing coverage from 17,000 km² to over 60,000 km² and the creation of 93 new Protected Areas. This became known as the 'Durban Vision' which expanded the PA network with the creation of community-managed PAs, as IUCN Category V or VI landscape areas, which support and integrate human activities and recognise the importance of human interactions with the environment (Gardner 2011). In many villages a community-forest management association had already been established, known as *Vondron'Olona Ifotony* (VOI) or *Communaute de Base* (COBA). Similarly, with the GELOSE/GCF contracts, on their own, these associations are ill-equipped to monitor and manage the resources on which they rely, therefore communities require substantial assistance, especially because the government has not provided a blueprint for how these new Protected Areas (NPAs) can be implemented and managed. As implementation of the Durban vision proceeded, there was still some debate about how those communities that have signed GELOSE/GCF contracts will interact or integrate with the NPAs.

Madagascar has relied heavily on non-governmental organisations (NGOs) to carry out activities that would normally be government responsibilities, including conservation NGOs (Cullman 2015). Therefore, NGOs have a large influence over governance and government ministries, who rely on their support to implement CBNRM policies. Given this close relationship between government and NGOs, CBNRM policies and NPA creation have been implemented in conjunction with conservation NGOs. Each NPA has a designated NGO to take responsibility for establishing the NPA and engaging the communities.

Designating these NPAs is a two-step process of temporary protection status followed by definitive protected status if legislative requirements are met. In May 2015, the Government of Madagascar passed a decree to make the NPAs legal. As this process happens for each individual NPA and given the nature of governmental communications, it is difficult to identify the exact number of NPAs and the overall progress. However, according to UNEP-WCMC (2016) in November 2016 there were 146 PAs in total (including NPAs and pre-existing PAs), covering 30,000 km² (5% of total land area). However, because the government has provided no blueprint for implementation and management of these NPAs and it is the responsibility of each designated NGO, there have been some challenges during the creation of these NPAs (Cullman 2015). These relate to the impacts of a new governance structure on the social dynamics of the communities, misalignment of objectives between local people and outside interests and lack of true participation of local communities in governance (Virah-Sawmy et al. 2014). Although the intention is that these areas be managed for both conservation and development goals, there is uncertainty, especially in forested areas, whether both goals can be achieved simultaneously (Gardner 2014); mainly because local people living in poverty in rural communities close to forests rely or fall-back on degrading activities, such as bushmeat hunting and charcoal production to meet their needs.

3.2.1 Environmental governance

In terms of administration, Madagascar is divided in 22 regions which are further subdivided into 119 districts, 1579 communes and 17 845 Fokotany (a village or urban neighbourhood). Governance and law enforcement of Protected Areas is organised through a series of departments through all administrative divisions of Madagascar (Figure 3. 1). The Ministry for Environment, Ecology and Forests (MEEF) is responsible for managing the Protected Area networks along with Madagascar National Parks (MNP) and NGOs. MNP is an agency responsible for the management of protected areas whilst the MEEF and DGF are primarily responsible for the management of non-protected forest. At the sub-national level, Regional Directorate of Environment, Ecology and Forests (DREEF) are responsible for decentralised governance within each of the 22 regions of Madagascar. Each DREEF is responsible for administering, enforcing and managing environmental and natural resources within their respective region, which is then filtered down to district and local levels. At the local level responsibility for environmental governance lies with the Local Department of Environment, Ecology and Forests (or *Cantonnements de l'Environnement, de l'Écologie et des Forêts* - CEEF). For clarity, herein I refer to CEEF as 'local government authorities' to distinguish from local authorities such as Commune Mayors, Fokotany Presidents and village councils.

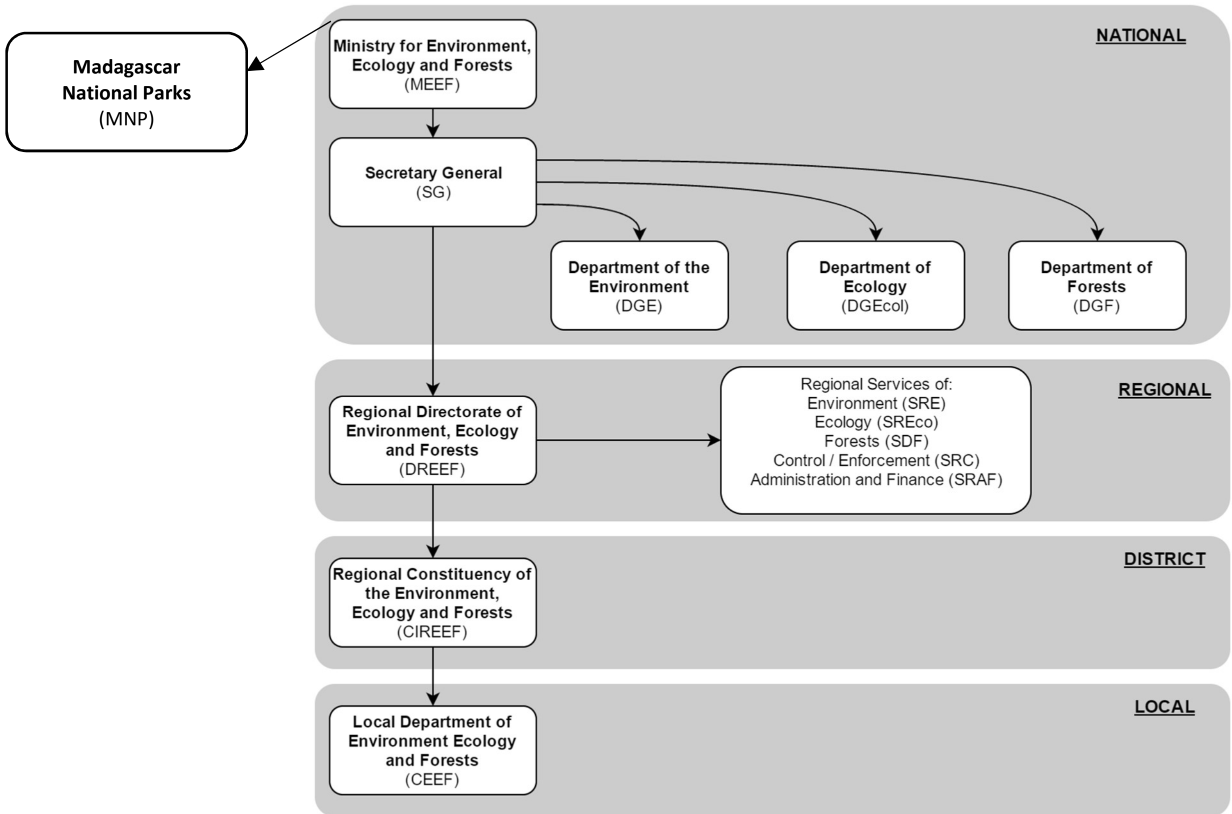

Figure 3.1. Organogram of Madagascar's environment, ecology and forests governance that cascade from the national to local level. For clarity, not all department at the national level are shown.

In addition to a hierarchal framework for governing the environment, from the national to local level, Madagascar also has extensive environmental policies and legislation (Hill et al. 2014). However, Madagascar's recent political crisis, deepening poverty, limited infrastructure in combination with an underfunded MEEF, low technical capacity and high levels of corruption at all levels means that the effectiveness of governance and forest law enforcement on-the-ground is substantially hindered (pers. comm. H. Andrianandrasana).

3.2.2 Customary law

In addition to government laws, Madagascar also has traditional law based on local customs, called '*dina*', that are recognised by the government. The *dina* is a traditional system of oral (sometimes also written) laws between groups of people at the local level, taking a "bottom-up" approach. There are as many kinds of *dina* that as there are communities. For example, one *dina* might concern grazing commons, another might relate to fishing zones. In the 1990s the Government enacted legislation to integrate the *dina* with government laws and have been proposed as a mechanism to facilitate community-based management of natural resources (Scales 2014). Rakotoson and Tanner (2006) explore three ways that the *dina* could be integrated in marine resource management. They conclude that despite the potential to reconcile modern and traditional governance, there remain some challenges to implementation and that the *dina* needs to be strengthened to protect local people's rights. The influence of the *dina* varies throughout Madagascar; in Menabe in western Madagascar (the location of the case study of this thesis – see section 3.3 below) the *dina* is weak and has a low level of influence in environmental governance (pers. comm., H. Andrianandrasana). In this particular instance this is attributed to the high commercial value of timber in the region which has encouraged corruption at levels beyond the capacity of traditional authorities or law. As a result, over the past 2-3 years *dinas* relating to management of natural resources have largely become powerless in Menabe.

3.3 The regional context: Menabe

The main case study of this thesis is focussed on a PEM scheme in Menabe in central western Madagascar. The habitat of Menabe is dry deciduous forest, freshwater wetlands and mangroves and home to at least four regionally-endemic vertebrate species: giant jumping rat (*Hypogeomys antimena*), flat-tailed tortoise (*Pyxis planicauda*), narrow-striped mongoose (*Mungotictis decemlineata*) and the smallest primate in the world, Madame Berthe's mouse lemur (*Microcebus berthe*), in addition to many other nationally-endemic plant and animal species, many of which are threatened.

Like much of Madagascar, Menabe has suffered from forest conversion into agricultural land for subsistence and plantations (Zinner et al. 2013). In 1928 a large sisal plantation was established in Menabe that attracted a workforce from the Antandroy ethnic group of the south of Madagascar, Betsileo and Merina from the highlands and Antesaka (or Korao) from the east (Sandy 2006; Scales 2011). When sisal was abandoned in the 1970s the migrant population was left to make a new living alongside the resident

Sakalava villages. The migrant population had envisioned they will return home to the south-east, but in reality, they are probably there to stay. Culturally, Sakalava are cattle herders and rice farmers, whereas maize is the traditional staple for the Antandroy (Sandy 2006) and therefore the two groups exert different impacts on the landscape. The main anthropogenic pressures on the forests of Menabe are slash-and-burn (known locally as 'hatsake') for clearing agricultural land, small scale logging for subsistence use (such as building houses and firewood), illegal commercial logging operations and charcoal production as a small scale cash-generating activity (Ganzhorn et al. 2001).

3.4 The NGO context: Durrell Wildlife Conservation Trust

The Durrell Wildlife Conservation Trust (herein 'Durrell') has a long term history in Madagascar. Table 3.1 provides a summary of some of the main conservation, rural development, research and monitoring activities in Menabe and some of the key moments in Madagascar's environmental history over the past 30 years relevant to this case study. At present, Durrell focuses on conservation of threatened species in eight sites in Madagascar with a dedicated fulltime staff of 45 people. Durrell have long-adopted a community-based approach to their conservation activities in Madagascar and has developed a good relationship in the communities in which they work. Although is Table 3.1 is by no means an exhaustive list of Durrells activities or research, it does demonstrate the long-term role that Durrell have been playing in the conservation community in Madagascar. As a result, Durrell is well respected and trusted within Madagascar and within the broader conservation community as a whole.

Table 3.1. Timeline and a summary of the key points in Madagascar Environmental history (purple), Durrell's work outside of Menabe (yellow), Durrell's work in Menabe (pink) and the PEM scheme (green).

Year	Activity
1986	Durrell's work began in Madagascar with the ploughshare tortoise in Baly Bay and research on endemic fauna in Alaotra wetlands.
1990	Ex-situ breeding of Alaotran gentle lemur.
1994	Monitoring of the gentle lemur population in the wild begins.
1996	Madagascar begins to decentralise management of natural resources from the Ministry of Environment and Forests to community organisations, known as Gestion Locale Securisee (GELOSE).
1997	Education and public awareness campaigns in Alaotra.
2000	Durrell begins working in Menabe focussing on community-based conservation, conservation education and population monitoring of flagship species, working in collaboration with local NGO 'Fanamby'.
2001	A presidential election was held in which both major candidates (Ratsiraka and Ravalomanana) declared victory and a political crisis followed.
	Community-based natural resource management legislation streamlined, known as the Gestion Locale Contractualisee des Forets (GCF).
	Annual census of Alaotran gentle lemur begins.
	Participatory environmental monitoring begins in Alaotra, and extended by adding more villages in 2002.
2002	Participatory monitoring turned into a competition in Alaotra.
2003	Alaotra wetland declared a Ramsar site.
	President declares to triple Madagascar's Protected Area coverage at the Worlds Parks Congress, this becomes known as the 'Durban Vision'.
	Durrell starts working in Manombo.
2004	Durrell begins to implement PES scheme in Menabe, starting with 3 villages in the north.
	Durrell begins working in Nosivolo.
2005	Scientific publication in Biodiversity and Conservation by Andrianandrasana et al. (2005): Participatory ecological monitoring of the Alaotra wetlands in Madagascar.
	Durrell extends PES scheme in Menabe to two more villages in the south.
2006	Menabe receives temporary protected status, Fanamby is the official designated NGO responsible for implementation and management, with substantial and ongoing support from Durrell.
2007	Alaotran wetlands receive temporary protected status, Durrell is the leading NGO and responsible for implementation and management of the new Protected Area.
	Durrell adds 5 more villages to the PES scheme in Menabe.
	Durrell collaborates with Nordic Agency for Development and Ecology (NORDECO) to implement 'Monitoring Matters' project in Menabe in 10 villages.
2008	Scientific research on the monitoring and modelling the population of Alaotran gentle lemur by Guruzeta Guillera Arroita (MSc Conservation Science, Imperial College London): implications for the monitoring of the gentle lemurs, such as (Andrianandrasana et al. 2005).
	Scientific research on habitat selection of the Alaotra gentle lemur by Jose Lahoz-Monfort (MSc Conservation Science, Imperial College London): the use of remote sensing data for habitat modelling.
2009	Political crisis.
	Analysis of data collected by local people and professional scientists as part of the MOMA project and Postgraduate Diploma in International Wildlife Conservation Practice at the University of Oxford (Andrianandrasana et al. 2009).
2010	Scientific research completed on PES scheme (during 2004-2008) in Menabe by Matthew Somerville during PhD research (2010a - Imperial College London), which was subsequently published as 4 peer-reviewed papers in international journals: 2009, 2010b, 2010c and 2011.
2011	Durrell receives a MacArthur Foundation grant to develop PEM scheme, which enables it to be implemented across five regions in Madagascar, and extended to include 8 additional villages in Menabe.
2012	International aid starts to flow back to Madagascar.
	Scientific research on fisheries and fishers' behaviour in the wetlands of Lac Alaotra by Andrea Wallace (PhD Imperial College London).
2014	New government appointed.
	Scientific paper published by the MOMA project, where Menabe features as a part of the study site (Danielsen et al. 2014): A Multicountry Assessment of Tropical Resource Monitoring by Local Communities.
	MacArthur Foundation grant finishes.
2015	Author conducts fieldwork in 7 villages in Menabe.
2016	Menabe and Alaotra officially declared as a new Protected Areas.
	Herizo Andrianandrasana submits DPhil thesis to University of Oxford discussing the landscape scale impacts of Durrell's community-based conservation work across Madagascar.

Durrell began working in Madagascar in 1983 through a formal accord with the government, but their first programmes were on the Critically Endangered ploughshare tortoise (*Astrochelys yniphora*) in Baly Bay (western Madagascar) and in the Lac Alaotra wetlands and marsh in the central highlands, the only home of the Critically Endangered Alaotran gentle lemur (*Hapalemur alaotrensis*). Activities in Alaotra continued throughout the 1990s, including monitoring, education and public awareness campaigns. In 2001, a PEM project begins in five villages in Alaotra, where local people were trained to collect data about species and threats. The goal of this scheme was to "*detect natural and/or human induced changes in the state of biodiversity and natural resources as an aid to evaluating and improving management*" (Andrianandrasana et al. 2005). In 2002, eleven additional villages were added to the scheme and linked with quizzes and annual inter-village competition. The quizzes were intended to evaluate local knowledge and raise environmental awareness. All villages were assigned one of three groups based on their location and quality of marsh habitat. Within each group, villages were given a score based on the level of positive environmental results based on five indicators (Alaotran gentle lemur, water birds, fish catches, marshes, hunting). Data for the scoring were collected by a team (of up to 17 people) of members from the community and technicians. Prizes were awarded to and chosen by the villages for first, second and third place in each group. The prizes came in the form of development aid, such as materials and equipment for schools or well, the nature of which was determined by the local village associations. In an attempt to avoid elite capture, the development was awarded to the whole community rather than to specific households (Andrianandrasana et al. 2005). The prizes and quizzes ceased around 2013, but the monitoring evolved into a PEM scheme that was implemented in five regions across Madagascar (see section 3.5 below).

In 2000, Durrell began working in Menabe in collaboration with Fanamby (a local environmental NGO). Efforts focussed on community-based conservation, monitoring and environmental education and awareness. In 2004 Durrell implemented a Payments for Ecosystem Services (PES) scheme in three villages (Tsitakabasia, Kiboy and Tsianaloka) in the north. Additional villages were added in 2005 (Marofandilia and Ankorabato) and 2007 (Lambokeley, Kirindy, Ampataka, Anktrevo and Mandroasty). The goal of this scheme was to create incentives for active local community forest management, whereby communities received payments from Durrell depending on the state of a set of biodiversity, threat and governance indicators which were designed by Durrell in collaboration with the local community and authorities (Sommerville 2010). Each village was scored during an annual assessment by Durrell staff, government representatives and community members, which determined the amount to be given to each community. The payments received by the village had to be used to support community development such as purchasing diesel generators, cooking equipment and building materials. This scheme ceased in 2013 due to logistical and funding constraints.

Since the early 2000s Durrell have been working with Fanamby to develop and implement the Menabe NPA, an area of 1,250 km^2. Although Fanamby is the lead NGO and legally responsible for implementing the NPA, Durrell have provided substantial support. This NPA received legal temporary Protected Area status in 2006 and was formalised in May 2016.

3.5 Durrell's history of PEM in Madagascar

In 2007-2009 Durrell was invited by the Nordic Agency for Development and Ecology (NORDECO) to participate in a global evaluation of PEM schemes across six countries called 'Monitoring Matters' (MOMA). Building on the monitoring that was associated with the PES scheme in Menabe, Durrell decided to trial the new PEM scheme in 10 villages in Menabe (Anketrevo, Ankoarbato, Ampataka, Kiboy, Kirindy, Lambokeley, Mandroatsy, Marofandilia, Tsianaloka and Tsitabasia). Prior to the start of the project, Durrell provided training to the local patrol team. These local teams were responsible for collecting data by walking transects two or three times a month. They recorded observations on data sheets, which were collected by Durrell. Initially, the local people were not involved in the design of the scheme or the data analysis (but this changes as the scheme expanded – see below), therefore this scheme can be described as 'passive participation (see Table 2.1 and Danielsen et al. 2009). Every three months, trained staff also conducted patrols in the same areas. The data collected by local people and professional scientists (Durrell staff) was analysed and compared (Andrianandrasana et al. 2009). They showed that although the local patrol teams underestimated absolute population densities compared to the scientists, they still detect the same trends. Considering that professional surveys are prohibitively expensive, Andrianandrasana et al. (2009) conclude that these patrols are a potentially useful tool for monitoring, especially if the data collection can be calibrated and/or there is additional training and investment in the patrols to improve data collection, motivation and collaboration with local government authorities.

In 2010 Durrell successfully applied to MacArthur for a grant to build on the success of the PEM scheme in Menabe and extend it to an additional 8 villages. Durell also implemented the PEM scheme in the freshwater wetland and marshes of Lac Alaotra in the highlands, Melaky (part of the Greater Menabe area to the north of the current Menabe sites), Nosivolo (river and watershed in the east) and Manombo (coastal rainforest in the east containing a Special Reserve) (Figure 3.2).

These sites were chosen for the PEM scheme because they have all become NPAs and Durrell have been collaborating with other NGOs and/or government agencies and working with local people. Menabe and Alaotra were chosen for the PEM scheme because of Durrell's long-term relationship with villages and previous community-based conservation activities in these sites. Melaky is north of Menabe, and considered part of the Greater Menabe area and Durrell has been working with the Peregrine Fund during the creation and implementation of the NPA Tsimembo. In Nosivolo, Durrell was working with the University of Anatananarivo and NGO Conservation International to develop fish monitoring protocols. In Manombo, Durrell was working with Madagascar National Parks and the regional forestry department for monitoring and enforcement in the Special Reserve.

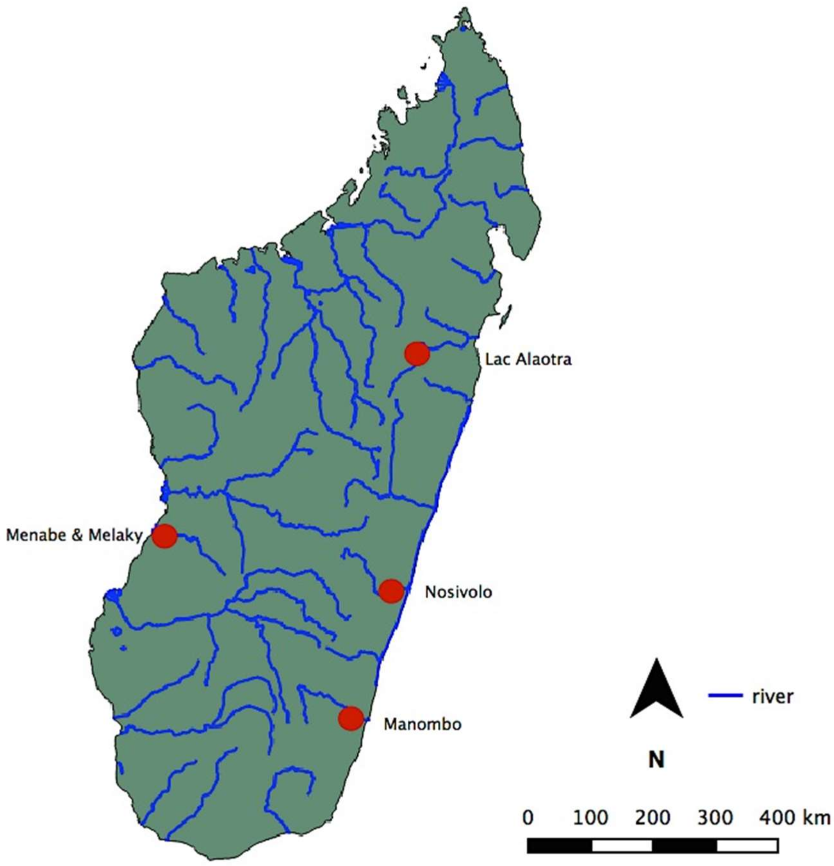

Figure 3.2. Durrell's participatory monitoring sites in Madagascar.

Based on Durrell's groundwork over 2007-2009, it became clear that the monitoring procedure could be used as a way to record and report forest law infractions (such as fires, evidence of illegal hunting) to the authorities and develop law enforcement and control of natural resources. The current PEM scheme evolved from the MOMA project, with the ultimate goal of conserving biodiversity and improving the development and wellbeing of local people, by (Durrell 2010):

- ensuring that natural resources are available and accessible to local people,
- reducing threats to the forest and wildlife,
- generating positive attitudes towards the environment and conservation initiatives.

Based on the authors understanding of the project from discussions with Durrell staff, projects reports, visits to some project village and the local people's perspective developed during this study, I developed a theory of change to describe the PEM scheme (Figure 3.3). It was discussed with Durrell staff to ensure that it is a true representation of the scheme (pers. comm. H. Andrianandrasana). This theory of change incorporates ecological, social and development goals of the project and how these are linked from the implementation of the project and other community-based activities (the input) through a series of outputs and outcomes[1].

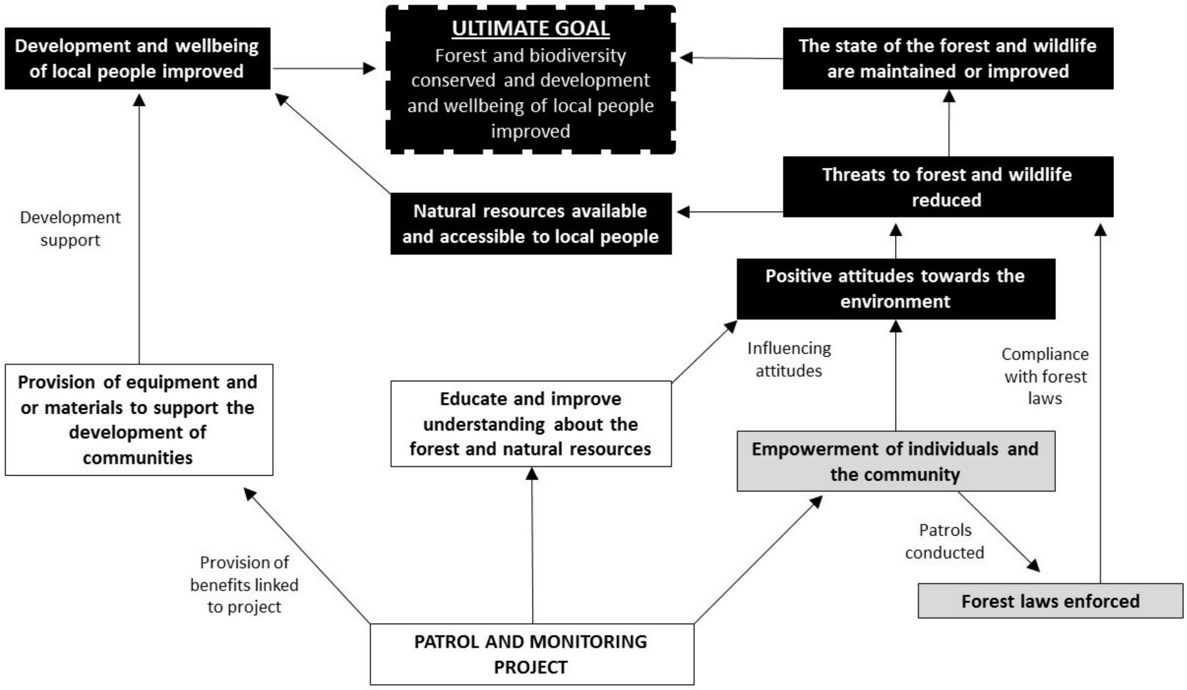

Figure 3.3. Theory of change to describe how the monitoring project might lead to the ultimate conservation and developments goals. White boxes = inputs, grey boxes = outputs, black boxes = outcomes, black box dashed edge = ultimate goal.

Durrell village associations (VOI, section 3.2) that had been created as part of the creation of NPAs, each with a monitoring team of 4-6 people from each village. Since starting this project Durrell have trained nearly 400 local monitors in 76 villages across the five sites. Based on the typology by Danielsen et al. (2009, also see Table 2.1) this PEM scheme can be described as 'functional participation', where the local people are involved in selecting the indicators and collecting the data, but the data are analysed and interpreted by Durrell. As local people became increasingly involved in the design of the scheme, it evolved from 'passive participation' to 'functional participation' (Table 2.1 and Danielsen et al. 2009).

Although the setup in each site was intended to be broadly the same, there are some large differences between the sites. For example, different types and numbers of indicators were designed depending on

[1] In this model the provision of cooking and agricultural materials is linked to the monitoring project because the local people do not distinguish these two initiatives implemented by Durrell – see Chapter 6.

the habitat (Figure 3.4). There are also likely to be differences in the implementation of the scheme in each site, depending on logistics, such as the frequency of Durrell visits to the project areas.

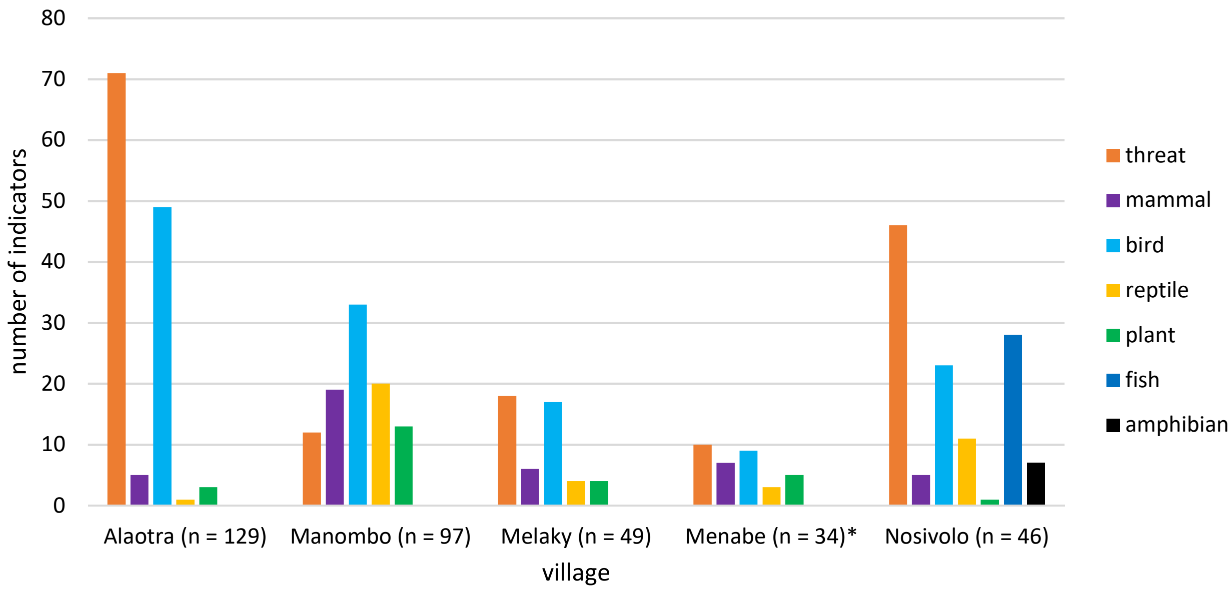

Figure 3.4. Summary of the number and type of indicators in each site of Durrell's PEM scheme, the total number of indicators in each village is indicated in parentheses. *The number in Menabe is lower than all others because the Menabe data have been carefully cleaned (to iron out spelling mistakes and naming discrepancies) for analyses in Chapter 4. However, data for Alaotra, Manombo, Melaky and Nosivolo are based on the raw information collected, and therefore the number of indicators is probably an overestimate.

3.6 Participatory Environmental Monitoring in Menabe

Durrell implemented the PEM scheme in 15 villages in Menabe (approximately 50% of villages in and around the Menabe NPA). In the core Menabe area there are two mangrove sites and 13 forest sites (Figure 3.5). In each village, there is an association related to community forest management, set up as part of the NPA process. Supported by Durrell staff, each village association created a village patrol team comprising of six monitors (Figure 3.6). In each village, becoming a member of the patrol team was a two-step process. Firstly, people had to declare their interest to the main village committee, who then selected six people who had the most experience with previous monitoring or the most interest in the forest and monitoring activities. They received a small payment (US$3 per monitor per month[2]) for their work, mostly to offset the opportunity costs of not doing agricultural or revenue-raising activities, rather than a salary per se. At the same time, Durrell operates other community-based conservation activities where the whole village receives benefits on a regular basis; such as building materials, equipment for use by the

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[2] For means of comparison, in Madagascar, the minimum monthly wage for agricultural and non-agricultural workers in May 2015 is approximately US$40-41. Country Reports on Human Rights Practices for 2015: Madagascar. Bureau of Democracy, Human Rights and Labor, U.S. Department of State. http://www.state.gov/j/drl/rls/hrrpt/humanrightsreport. Accessed 25 November 2016.

whole village, or training to improve agricultural techniques. Although Durrell's community development interventions were running before the PEM scheme and are technically separate to the PEM scheme, most people in the communities do not differentiate them from the PEM scheme.

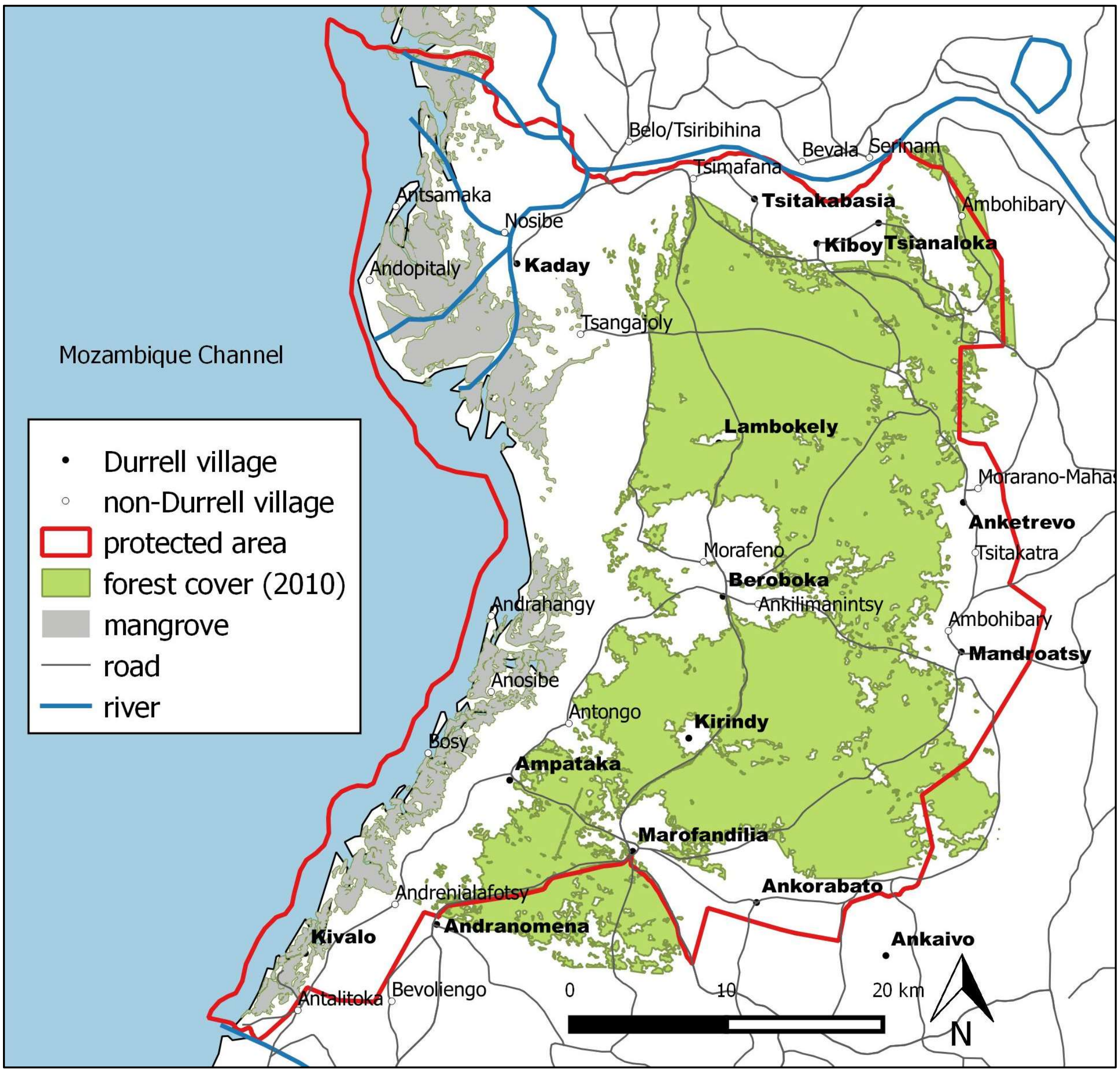


Figure 3.5. Map of the Menabe Protected Area and study sites.

Figure 3.6. Five monitors from Beroboka village. (Credit: S. Earle)

Typically, a team of monitors walk through the forest two to three times a month in a team of 2-4 people. These 'transects' or patrols may vary, but typically take half a day to complete. The monitors are equipped with a uniform, notepads and in some cases a bicycle to make it quicker and easier to reach the start of a patrol route. In consultation with the local communities at the start of the scheme in 2010-2011, a range of species and threat (e.g. evidence of fire, snares, poaching) indicators were chosen. Durrell provided extensive training to the monitors on how to conduct the patrols and record their observations.

The monitors record their observations in a notebook, and these are copied onto paper forms upon return to the village. Durrell's frequency of visits to the village vary by location (as some are easier to access than others) and the season (many roads are impassable during the wet season of November – April). However, ideally Durrell will visit each village once a month, but not less frequently than once every three months. During each visit, Durrell staff talk to the village chief and the monitors and then collects the completed data entry sheets and are responsible for entering the data into Excel and analysing the results.

In addition to the data entry sheets, the monitors also completed a monthly report summarising their observations of forest law infractions (such as fires, animal traps etc.). These were passed onto local government authorities responsible for enforcing forest laws. This process was intended not only to provide a record of the infractions, but also enable the authorities to follow-up this information and enforce the forest laws.

3.7 Scoping trip and PEM workshop

In May 2014 I visited Madagascar on a scoping trip to meet the Durrell Madagascar team and to attend a workshop Durrell was holding on the PEM scheme in Anatananarivo. The one-day workshop was organised by Durrell and attended by other conservation NGOs, local government authorities, and representatives for the Ministry for Environment and Forests. In addition, Durrell also brought 106 monitors from five sites in Madagascar. During this time, I took the opportunity to conduct a rapid survey of these monitors. Seven English-speaking Malagasy research assistants, not associated with Durrell, were trained to conduct a questionnaire of 20 open and closed questions about the PEM scheme. Of the 106 attendees, 70 were interviewed and their responses recorded. These data were translated into English by the research assistants. During the three week trip I also had the opportunity to spend time in Menabe and visited three villages during a two-day trip with the two members of the Durrell team. Although the data collected during the workshop has not been directly used in this thesis, the information and the trip to the villages was invaluable in informing the research questions and fieldwork for Chapter 6 and my overall understanding of the PEM scheme.

3.8 The reality of the PEM scheme in Menabe

During January – April 2015 I visited four villages in Menabe that are involved in the PEM scheme, as part of data collection for Chapter 6. This, along with my short trip in May 2014, provided me with an opportunity to better understand the PEM scheme and how the monitors collected the data. In each of the four villages, I sat down with three research assistants who spoke the local language (see section 6.2.1 for more detail on the recruitment and training process), to ask about how they conduct the patrols (Figure 3.7) and collect the data. In order to meet the monitoring goal of detecting change over time in a scientifically and robust way, there needs to be a consistent sampling strategy, upon which a set of assumptions can be made for statistical analysis.

During this time, I realised that there were inconsistencies in how the monitoring was conducted between the villages; relating mostly to when and where the patrols were conducted in each village and how much time and effort was allocated and recorded. Differences between the four villages and the implications for data analyses are summarised in Table 3.2. Although this only includes four of the 18 villages involved in the Durrell PEM scheme in Menabe, it is likely that these inconsistencies extend throughout all villages. Throughout this thesis, I explore and discuss the implications of these weaknesses and suggest how the PEM scheme in Menabe could be improved.

Figure 3.7. One of my research assistants (left) discuss the PEM patrols with three monitors in Andranomena village and draw out the route in the sand. (Credit: S. Earle).

Initially, each month, the summary report of forest law infractions was compiled into a separate report that was given to the local government authorities responsible for enforcing forest laws. However, this proved to be difficult to sustain and motivation waned as the monitors saw no response from the authorities. Therefore, these formal written reports became irregular and in many cases ceased to be produced at all.

At the start of the research, it was anticipated that data for five or six years would be available for analyses. However, I soon established that there was a data bottleneck at the point of entering and processing the data that had been collected. Although Durrell regularly collected the paper data sheets filled in by the monitors, there was not sufficient capacity and resources to enter this data into Excel for data analyses over the long-term. This was the result of inadequate planning and budget for the data management and analyses of the information collected by the monitors. This meant, that despite year-round and ongoing data collection in Menabe and other sites, only data for years 2011 – 2013 were available for analyses in this research. The consequences of inadequate planning and underestimating the cost of data management is an important issue that is discussed in more detail in Chapters 7 and 8.

Table 3.2. Summary of the data collection in four villages involved in the PEM scheme in Menabe.

Element	Ankorabato village	Andranomena village[b]	Kirindy village	Marofandilia village	Implications for Data Analyses
SPATIAL DATA: Forest type[a]	4 distinct zones, some are multi-use some strictly protected. Most recorded on the data sheets.	All protected (Special Reserve), regions of the reserve, e.g. near a lake, along/near disused road, near a gate in the boundary. Locations recorded on the data sheet (n = 21).	Patrol an area of approximately 600 ha. No zones or patches.	The monitors conduct patrols in 2 protected parts of the forest. These areas are 'identical', but one is closer to the village than the other. These different patches are not recorded on the data.	The data are collected in areas with different access rights: some are strictly protected and some are multi-use. This will have implications for the level and types of threats observed and species composition.
TIME DATA: Time of day	Some zones closer to the village than others, always leave the village at 0600, but the start time of the patrol varies from 0700 to 1000. Sometimes the patrol is completed at 1200, other times the patrol takes all day. No times are recorded and no-one has a watch.	Time of data the data collected are variable and not recorded. No-one has a watch.	Time of day not recorded, but the monitors usually leave the village around 0800 and arrive to start the patrol between 0830-0900, depending on whether they have used a bike to get to the start of the patrol.	Time of day not accurately recorded, but the monitors leave the village around 0600 and arrive to start the patrol at 0630-0700 depending on whether they have used a bike. They conduct the survey until approximately 1300.	Although there are no start or finish time for the patrols, all the data are collected in the morning. The time of patrols may affect the species observed (as species' activity changes throughout the day), but unlikely to affect the threats observed.
EFFORT DATA: Patrol route, duration and length	A random route through each zone is walked by a 3-person team once a month. Each route is about the same length – from one side of the zone to the other. Depending on the time of year and the density of the forest, the duration of the patrol varies.	Work with MNP agents, who decide where they go and what they do. 4 monitors spend 14 days a month camping and walking around the reserve. The route is decided by MNP agents. Patrol duration is not recorded.	There is one route that goes east to west. Every 500m there is a mark, the nearest mark is recorded on the data sheet (although this information has not recorded on the excel data for the years 2011 – 2013).	The monitors use a different route for their patrols every time. No markings or locations recorded. Patrols are conducted approximately 0630-0700 to 1300.	Across all villages the patrol route, length and duration is variable and not recorded. This will make comparisons between villages challenging.
Indicators	Monitors record all indicators (species and threats) seen, including the number of individuals, when known. If a species is heard it is recorded as one individual.				There is good consistency in which species and threats are recorded, although the counts may be unreliable for species where only a call is heard.

[a]Multi-use area: access to collect timber and other non-timber forest products is permitted. Strictly Protected Area: Can be a Special Reserve or National Park. Local people are not permitted access to these areas.

[b]Andranomena village is different to all other villages because it is part of a Special Reserve and is managed by Madagascar National Park (MNP), who have agents based in the village that are responsible for enforcing forest laws and decide where the monitors conduct their patrols.

3.9 Choosing Menabe as a case study

Menabe was chosen as an ideal case study for this thesis because it has the most experience with PEM, having trialled this type of monitoring for the MOMA project and been a case study for previous and current academic research.

Menabe was the case study for Sommerville's PhD thesis (Sommerville 2010). This research investigated the social and ecological dimensions of implementing PES using Durrell's project in Menabe. Although this was focussed on the PES scheme, it provided a useful background to this thesis. Sommerville (2010) found that the creation of local institutions, through the PES scheme, encouraged more self-reporting of environmentally damaging behaviours than perceived pressure from Durrell, other NGOs or governments. Regarding the ecological dimensions of the PES scheme, the indicators were selected because they were of conservation interest or easy to identify, although most lacked sufficient power to detect change in abundance over appropriate time scales. Sommerville made a series of recommendations for the PES scheme including changes to the payment and incentive structures, feeding back and engaging with local people, plus assisting local governance institutions to take responsibility for management. As a result of this research and these recommendations, there is a good understanding of the social dynamics and the ecological dimensions of the PES scheme in Menabe.

This research was conducted at the same time as Herizo Andrianandrasana was doing a DPhil based in the Zoology Department of the University of Oxford, which was submitted about the same time as this thesis. His research evaluates the impacts of Durrell's community-based conservation across Madagascar, by contrasting changes in a series of ecological and wellbeing indicators in Durrell-intervention villages compared with control villages (matched to intervention villages using a propensity scoring method). The topics of these theses are complementary, but operate at separate scales; this thesis takes a local-scale approach to a PEM scheme, whereas Andrianandrasana (2016) takes a landscape-scale approach to the impacts of community-based conservation generally.

In summary, this case study was chosen to explore PEM for a range of reasons. Firstly, an opportunity arose for me to collaborate with Durrell for the topic of my thesis. Given Durrell's efforts and research to evolve and evaluate monitoring (Guillera-Arroita 2008; Lahoz-Monfort 2008 in Alaotra), commitment and experience to community-based conservation in Madagascar and the decentralisation and creation of NPAs this research is relevant and timely. Of the five PEM sites in Madagascar, the PEM scheme in Menabe is the most advanced of all the Durrell sites because of the previous MOMA project. In addition, Menabe was also ideal for practical and logistical reasons, most of the site is accessible and secure. In summary, Durrell's groundwork has been extensive in this region, there has been a long and consistent relationship with the communities (since 2000), previous research on the PES scheme and current research on Durrell's impact of community-based conservation, it is an ideal case study to explore PEM.

Chapter 4 A review of progress of participatory environmental monitoring

4.1 Introduction

Over the past two decades a wide range of international policies have called for the engagement of communities in initiatives relating to the management of resources on which they rely. Most governments have agreed to the: (1) Convention of Biological Diversity where articles 8.j, 10.c and 10.d mention indigenous and local communities' lifestyles (CBD 1992), (2) Convention of Biological Diversity Aichi targets (#18) on traditional knowledge, (3) Intergovernmental Platform on Biodiversity and Ecosystem Services that integrates indigenous and local knowledge into the science-policy interface. The goal is to assist communities in pursuing sustainable livelihood opportunities and ensure that conservation interventions do no harm or undermine their human rights, traditional practice or tenure (Shoreman-Ouimet & Kopnina 2015; Makagon et al. 2014; Stevens et al. 2014). Community-based conservation has evolved from pure species or habitat focussed efforts to incorporate social science and the wellbeing, development and therefore increase engagement with local communities (Berkes 2007). At the local level, conservation success is often dependent on support and buy-in from communities to ensure local people cooperate with authorities and participate in management plans over the long term (Bennett 2016).

Participatory environmental monitoring (PEM) has been described in an array of terms, such as community-based monitoring, locally-led monitoring or combinations of the above. I describe PEM as an activity where communities are involved in the design, collection and interpretation of environmental data. The level of participation can vary from autonomous monitoring where local people design, collect data and analyse the data with little or no help from external agents (e.g. Mbata et al. 2002; Sheil & Beaudoin 2015), to monitoring driven by professional researchers or organisations with minimal assistance (usually data collection) from local communities (Danielsen et al. 2009). For the purpose of this study, I restrict schemes to developing countries, where local people often live near and rely on the natural resource (such as a forest). PEM contrasts with conventional monitoring where only professional scientists design, collect and analyse data without involving local people at any stage. I also distinguish PEM from citizen science which draws on interested volunteers or amateur naturalists to collect data as a hobby because they enjoy it or as a way of contributing to a particular cause or mission, and is typically found in developed countries (Devictor et al. 2010; Sullivan et al. 2009; Theobald et al. 2015). Involving local people in environmental monitoring has become an increasingly popular way of incorporating communities into decision-making and management of natural resources (Kouril et al. 2015).

Concurrently, the increased availability and reduced cost of electronic equipment and information technology has resulted in monitoring, generally, becoming increasingly high-tech (August et al. 2015; Teacher et al. 2013). However, recent research by Brammer et al. (2016) indicates that for some PEM schemes, digital data entry can be costly, distract from core objectives and therefore compromise sustainability. They conclude that the role of digital technology, or whether it is appropriate for a particular PEM scheme, should be determined by the local context rather than a desire to use technology.

With the increase in PEM, the advancement of ecological monitoring generally together with the pressing need to involve local people further in conservation efforts, it is important to understand the current practice in PEM. Kouril et al. (2015) reviewed PEM schemes, with a particular focus in the Sub-Arctic and Arctic regions. They document an increase in peer-reviewed and grey literature relating to PEM, the proportion of various indigenous groups involved in these initiatives and the degree to which traditional local ecological knowledge is used and participation levels according to the groups in Danielsen et al. (2009). Of 84 sources identified during a literature search, they found that participation was generally low. Most schemes were externally driven with local data collectors (49%) or involved local people in design and data collection with external data interpretation (33%), whilst 20% involved local people in the analysis or interpretation and no formally autonomous monitoring schemes were identified.

The degree to which schemes have progressed over time in terms of levels of participation, goals, type of data collected and methods used is largely unknown, however. Therefore, to further our understanding of PEM and inform future directions, I conducted a systematic literature review and an online survey targeting conservation practitioners, with the intention of identifying any gaps or lags in the development of PEM, guide future work and encourage collaborations between academics and practitioners to ensure that PEM schemes are taking advantage of new technologies and involving local people in the best way possible. The research questions and hypotheses are as follows:

1. *Are local people becoming more involved in the design and data interpretation of PEM schemes?* With the rise in the number of conservation schemes engaging with local people and communities, I anticipate that local people are also becoming more involved in the design and interpretation stages of PEM schemes, rather than just acting as data collectors.
2. *Are the goals of PEM schemes changing?* As conservation initiatives realise the need to incorporate local peoples' wellbeing, I expect that scheme goals may have expanded from pure ecological studies to include monitoring of the social development of communities.
3. *Are the type of data collected changing?* I predict that there has been an increase in the diversity of types of data collected as the number of schemes and scope of goals increase.
4. *Are the data collection methods changing?* With the increased use of technology applied to environmental monitoring, I anticipate that there is a rise in the skill level required to collect and analyse the data and in the use of modern digital technology for data collection.

4.2 Methods

4.2.1 Data collection

PEM schemes were included in the review if they met all the following criteria:

(1) produce information intended for use as part of natural resource management, a conservation intervention or a REDD+ scheme, and
(2) have data collected by local people, defined as people with no formal scientific training beyond secondary education that live in or adjacent to the area of interest, and
(3) were undertaken in a developing country (to differentiate from citizen science), as defined by the OECD as countries and territories eligible to receive official development assistance (see OECD 2016).

Data were collected in two ways; a systematic literature search on 25th September 2015 identified relevant studies from the Web of Science database (https://apps.webofknowledge.com), and an online survey targeting individuals and organisations that are involved in PEM. Guidelines by Pullin & Stewart (2006) and Roberts et al. (2006) were followed for the systematic literature search. Boolean operators were used to search titles, abstracts and keywords of the literature with the following terms: "community monitoring" OR "participatory monitoring" OR "locally-based monitoring" OR "locally-led monitoring" OR "community-based monitoring" OR "community-led monitoring" OR "local people monitoring" OR "volunteer monitoring" AND one of the following: "conservation" OR "ecology" OR "environment*" OR "biodiversity" OR " REDD*" OR "sustainable" OR "indigenous" OR "traditional knowledge". This search produced 11,864 records. The records were sorted by relevance using the Web of Science relevance sort where the higher the rank, the more search terms appeared in the record. The titles and abstracts of the first 1000 were read. If the record met the criteria (as above), the paper was downloaded for a review of the full article so that the relevant information could be extracted. If the criteria were not met, they were rejected and no longer part of the review. See Figure 4.1 for a summary of the review process and the number of papers accepted and rejected.

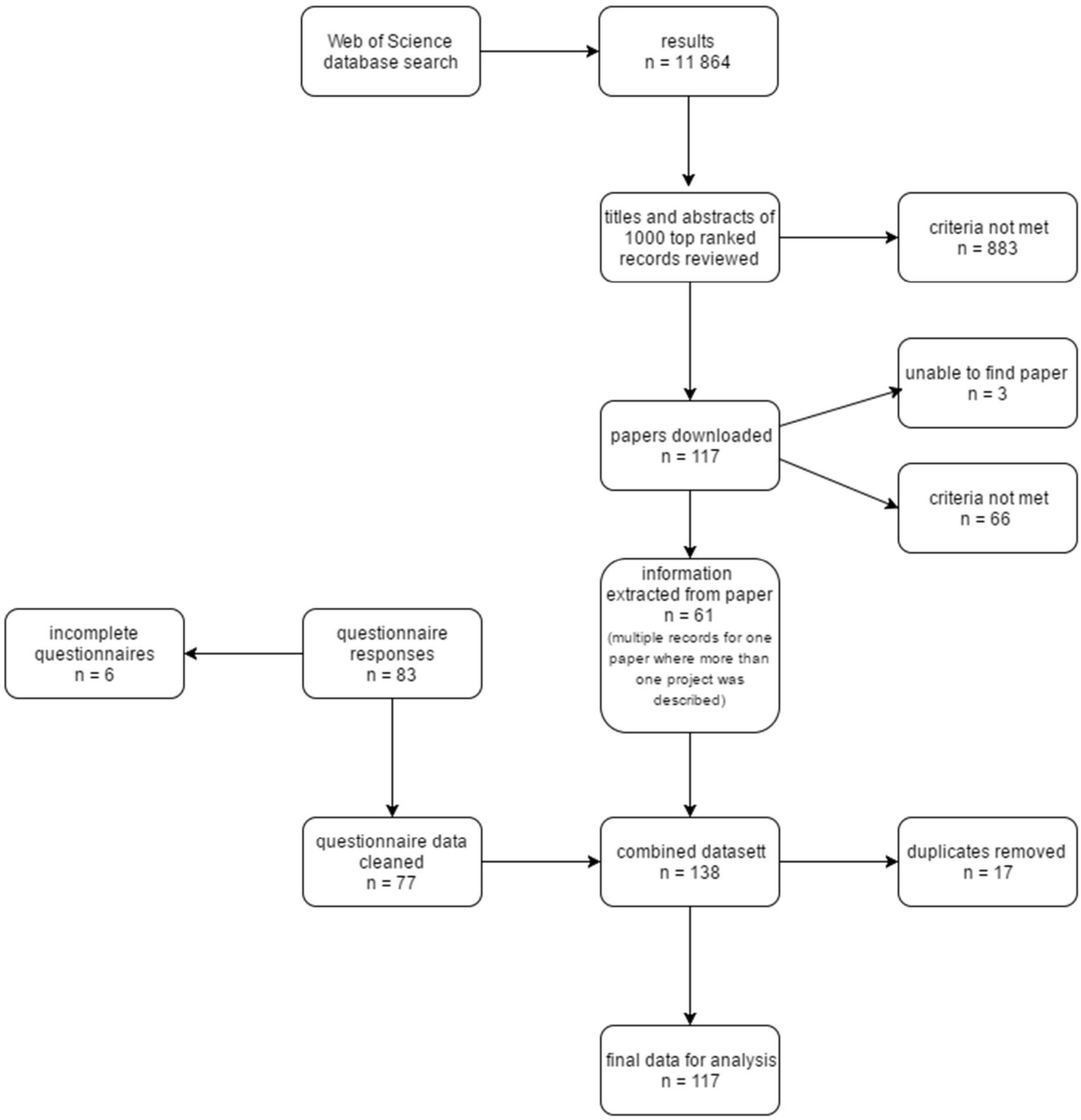


Figure 4.1 Summary of the source of data, the number of questionnaires received and papers reviewed and accepted. "Criteria not met" refers to those papers that did not meet the criteria set out at the beginning of section 4.2.1.

The online questionnaire (see Appendix A.1) was developed and administered via Qualtrics (www.qualtrics.com). The questionnaire was designed and administered in such a way that snowball sampling was possible and respondents were encouraged to forward on the website link to other contacts to widen the reach of the survey. I started this sampling with contacts who I knew were involved in participatory monitoring and made the most of networking opportunities during the International Conference for Conservation Biology in August 2015 to advertise the online survey as far and wide as possible. If respondents were involved in more than one PEM scheme that fulfilled the criteria, they were asked to complete a survey for each scheme.

4.2.2 Level of participation categories

To assess the level of participation by local people beyond simply collecting data, each scheme was classified into one of five groups, depending on the level of participation in the design and interpretation phases of the scheme, as summarised in Table 4.1, which was adapted from Danielsen et al. (2009) and Palmer Fry (2014).

Table 4.1. Summary of the participation categories (labelled 1 to 5) used in the data analyses that cover the spectrum of possible involvement of local people and external/professional agents or organisations, where a scheme scoring 5 has a high level of local involvement, and a scheme scoring 1 has a low level of local involvement. External people are those that do not live adjacent to the area of interest, or are professional researchers, scientists, full-time Protected Area rangers, NGO employees or members of a government agency or local authority.

		Scheme Design		
		Local people only	**Local and external**	**External people only**
Data interpretation	**Local people only**	5	4	3
	Local and external	4	3	2
	External people only	3	2	1

4.2.3 Analyses

Based on the name of the author or the questionnaire respondent, country of the scheme, the project name, habitat and goals it became clear that there were duplicates in the schemes reviewed from the literature and questionnaire responses. In total, 9 schemes had two records and 4 schemes had three records. These duplicate records needed to be condensed so that they were only represented once in the database. Internal validity checks were conducted on these duplicates to ensure that information recorded for each scheme was accurate. The duplicate records were compared for the similarity of the data, according to the following information:

1. year the scheme started,
2. year the scheme finished,
3. habitat,
4. goals,
5. methods used to collect data,
6. type of data collected,
7. levels of participation in the design phase,
8. level of participation in the data interpretation stages.

Each part scored 1 if they were identical or 0 if they were different, the maximum score for each scheme was 8. Of all these elements for the 17 schemes with duplicate records, there was 88% agreement between the duplicates. Where there were differences in answers, the response from the questionnaire was preferred over the literature because responses from people familiar with scheme are less likely to be subject to publication bias. *A priori* lists were used for scheme goals, method of data collection and the type of data collection (Table 4.2), based on the authors' experience of ecological data collection and informed by the techniques described in Sutherland (2006).

Each of the multiple choice answers for the goal of the project, the type of data collected and the methods used were categorised into groups for the purpose of data analysis. Data exploration and statistical analyses were conducted in R (R Core Team 2015). The year the scheme started was used to assess the trend in the number of PEM schemes. Using R, all response and explanatory variables were checked for normality and collinearity using descriptive statistics (means and frequencies), pairwise scatterplots, correlation variances and variance inflation factors (Zuur et al. 2010). The range of the number of local people involved in collecting data ranged from 1 to 1000, which was on a very different scale to all other continuous variables used in the analysis. Therefore the 'scales' package in R was used to rescale the number of monitors to 1 to 5 to aid analysis and interpretation (Gelman 2008).

Binomial Generalised Linear Models (GLMs) or ordinal logistic regression models were used to explore each response variable using five covariates: continent, habitat type (forest, aquatic or other terrestrial), number of monitors (as an indicator of the scale of the scheme), the year the scheme finished or it was ongoing (pre-2006, 2006 – 2014 or ongoing) and the number of years the scheme had operated. Initially project finish was grouped into five year periods, but there were not enough records for 1990-2005, so instead they were grouped into pre-2006 and 2006-2014 categories for statistical analyses. To quantify the relative importance of each variable in the models, the Akaike weights over the subset of models within 4 Akaike information criterion (AIC) of the top model that include that variable were summed (Burnham & Anderson 2002). Those variables that had relative variable importance of 0.5 or greater were included in the final model.

4.2.4 Potential biases and risks

This research is intended to describe the approaches used and trends in participatory ecological monitoring. Whilst I believe that our search was systematic and thorough, more cases of PEM exist than could be captured because I only covered the academic literature in English available online, and the survey was only accessible to those familiar with English and who appeared in the snowball sampling framework. It is also possible that there is a publication bias where authors fail to publish or report on schemes that are not successful, or there is a lag between scheme implementation and publication, or simply because scheme organisers do not consider publishing scientific papers or reports a priority. I do acknowledge that is likely that there are many more autonomous monitoring schemes than I review, because by nature, local people might not have access to support for documenting or publishing their practice, unless an external agent takes an interest in their activities (as in Sheil & Beaudoin 2015). There is potentially a sampling bias with regards to the online questionnaire, as initially people who are currently or very recently involved in PEM were contacted, rather than those from 20 years ago. However, I have attempted to reduce these biases by conducting a simultaneous literature review with an online survey to gather information about past and ongoing schemes.

The survey link was emailed to contacts in the conservation practitioner and academic communities and advertised through social media to contact the maximum number of practitioners possible. This risk of this approach is the nature of an online survey where you cannot be sure who is completing the survey. However, the entries were carefully reviewed to ensure that the responses seemed sensible. In total, six questionnaires were discounted because less than 50% of the questions were unanswered. Despite these potential biases, I believe the results provide an indication of overall trends, particularly given that the survey was widely distributed through active PEM networks and the conservation community.

4.3 Results

The review process and online survey resulted 117 schemes that were suitable for review (Figure 4.1; and listed in Appendix A.2). There is an overall positive trend in the number of projects starting in each year, on average 2.5 schemes started per year between 1990 and 2006, compared to 7.3 schemes per year between 2006 and 2015 (Figure 4.2, $R^2 = 0.47$, F-statistic = 22.46, df = 1,25, $p < 0.001$). PEM schemes operate in a wide range of habitats and worldwide, but with forests dominating; accounting for 57% of schemes (Figure 4.3, n = 67). There was a low percentage of schemes in Oceania (6%), compared to other continents: Africa (38%), Asia (29%) and South and Central America (23%). There are also a variety of goals, data collection methods ranging in skill levels and technology required, in addition to a variety of data types collected (see Table 4.2 for a summary). This demonstrates that involving local people in environmental monitoring is widespread, growing and heterogeneous.

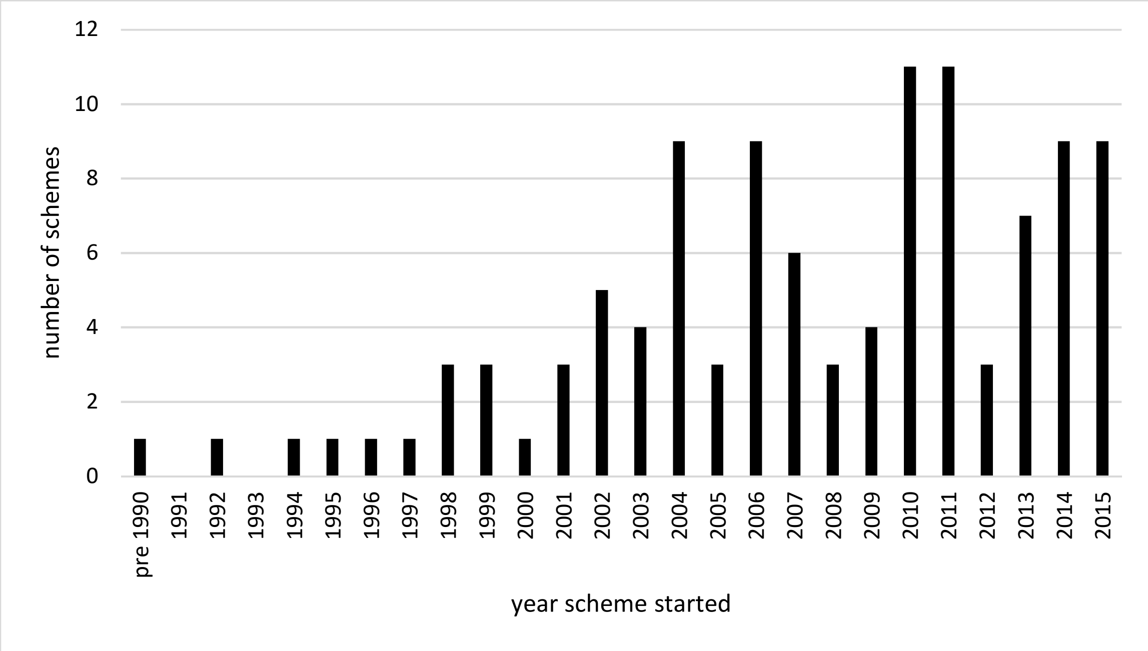


Figure 4.2. The number of schemes started in each year, based on the questionnaires and the literature, R^2 = 0.4733, F-statistic = 22.46, df = 1,25, $p < 0.001$).

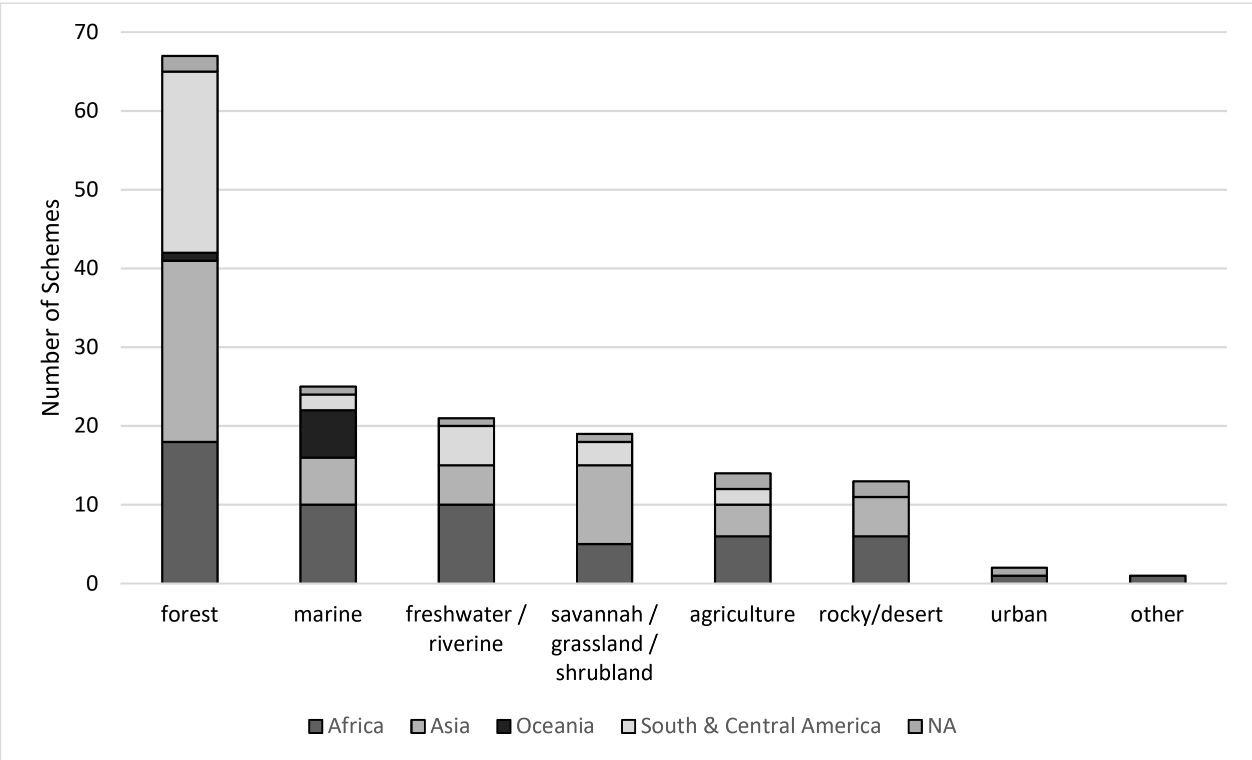


Figure 4.3. The number of schemes in each habitat type and continent, n = 162 and is greater than the total number of schemes reviewed (n = 117) because a scheme could occur in multiple habitat types.

Table 4.2. A descriptive summary and counts of the (a) goals, (b) data collected by the schemes and (c) method and level of skill required to collect the data. The total number of schemes reviewed is 117, but a scheme can contribute to multiple categories.

(a)

Goal Category	Goal	# Projects
ecological knowledge (n=106)	improve understanding of population ecology or the state of biodiversity, or for general interest	67
	contribute to a REDD+ pilot or scheme	21
	record changes in land use	18
feasibility (n=51)	feasibility study for the involvement of local people in monitoring activities	51
management natural resources (n=115)	decisions about the control and use of natural resources e.g. allocation of permits and access rights	53
	contribute to protected area management	45
	ensure compliance with rules	17
project management (n=54)	measure the impact of a conservation intervention	41
	provide evidence that activities have been implemented	13
social development (n=96)	improve the livelihoods of local people	46
	stimulate discussions within the community about natural resources and wildlife/habitats	42
	build community capacity, power and engagement with the management of natural resources	8
other (n=14)	other goal	8
	for legal requirements	6

(b)

Data category	Data type	# Projects
anthropogenic activities (n=71)	anthropogenic activities	40
	hunting data	31
birds (n=31)	birds	31
ecosystem elements (n=51)	landscape	17
	weather	12
	carbon stocks	11
	types of land use	11
human/socio-economics (n=40)	socio-economic data	25
	food security	8
	human-wildlife conflict	5
	human health	2
mammals (n=46)	mammals	46
plants/trees (n=43)	plants trees	25
	plants general	18
reptiles/fish/amphibians/ invertebrates (n=64)	fish	28
	reptiles	20
	invertebrates	10
	amphibians	6
other (n=1)	data other	1

(c)

Skill level required	Data Collection Method	# Projects
basic (n=109)	opportunistic observations	29
	random patrols	29
	informal conversations or meetings	22
	log books or diaries	21
	sign tracking	6
medium (n=158)	point counts	36
	pre-determined routes	35
	catch data	28
	structured interviews	25
	focus group	14
	random photos	11
	market surveys	9
complex (n=36)	GPS tracking	15
	fixed point photos	12
	camera trapping	9
other (n=5)	how collected other	5

4.3.1 Question 1: level of participation

Fewer local people are involved in the design than in the analysis stages of PEM schemes (43% and 75% of schemes respectively, n = 117; see Table 4.3). There was just one autonomous local monitoring scheme (Mbata et al. 2002), compared to 22 schemes that did not involve local people in either the design or data interpretation. There was also a large number of schemes where information on involvement at various stages of the scheme was lacking (n = 39). Of these, 22 were records from the literature where there was inadequate information to classify participation levels. In 17 questionnaire records the respondents were unsure or questionnaires were incomplete.

There was no significant change in participation in scheme design over time ($\chi^2 = 3.018$, df = 4, p = 0.554), or in data interpretation ($\chi^2 = 6.779$, df = 4, p = 0.148), or overall participation levels ($\chi^2 = 9.408$, df = 6, p = 0.152). This is further supported by an ordered logistic model of participation levels where none of the covariates (habitat, continent, number of monitors, year the scheme finished and the duration of the scheme) were significant predictors of participation level. However, the strong evidence that the number of PEM schemes is increasing indicates that participation in environmental monitoring generally is increasing.

Table 4.3. The number of schemes and the level of participation in the design and data interpretations stages of environmental monitoring scheme.

		scheme design				
		local people only	**both local and external people**	**external people only**	**NA**	**TOTAL**
data interpretation	**local people only**	1	2	0	0	**3**
	both local and external people	5	17	28	7	**57**
	external people only	1	2	22	3	**28**
	NA	2	5	17	5	**29**
	TOTAL	**9**	**26**	**67**	**15**	**117**

4.3.2 Question 2: goals

436 different types of goals were given for the 117 schemes (mean number of goals per scheme = 3.72). However, based on a list of 14 different goals that could be selected as part of the online questionnaire, 15 schemes chose 8 or more goals. These goals are varied (Table 4.2a), and were grouped into six categories for analysis; management of natural resources (26%), ecological knowledge (24%), social development (22%), scheme management (13%), to test the feasibility of the approach or as a pilot study (12%) and other (3%). Over time there has been an increase in goals concerned with the management of natural resources, social development and project management but no significant change in the number of schemes with goals related to ecological knowledge or feasibility studies (Table 4.4).

There were significantly fewer schemes with social development goals pre-2006 and between 2006 and 2014 compared to ongoing schemes (Table 4.4). Also, there was a higher level of local participation in schemes with social development goals. There were fewer PEM schemes with project management goals between 2006 and 2014 compared to current schemes. However, more schemes tested the feasibility of an approach between 2006 and 2014 than currently. Ecological knowledge schemes were significantly more likely to have low levels of local participation than expected.

Table 4.4. The estimate (est), standard errors (SE) and p-values (p) for the top models for binomial GLM for each goal type. '-' indicates that the variable was not included in the final model, but it was investigated as part of the analysis. P-value significance level codes: * = p ≤ 0.05, ** = p ≤ 0.01, *** = p ≤ 0.001.

	Binomial GLM								
Goal	**Participation level (baseline = 1)**			**Habitat**	**# Monitors**	**Continent**	**Year scheme finished category (baseline = ongoing)**		**Duration**
	2	**3**	**4**				**pre-2006**	**2006 – 2014**	
Management of natural resources	est = 1.41 SE = 0.60 **p = 0.018** *	est = 2.64 SE = 0.87 **p = 0.002** **	est = 0.85 SE = 0.88 p = 0.337	-	-	-	-	-	-
Ecological knowledge	est = -0.38 SE = 0.65 p = 0.560	est = 0.03 SE = 0.76 p = 0.970	est = -3.02 SE = 1.19 **p = 0.012** *	-	-	-	-	-	-
Social development	est = 0.48 SE = 0.69 p = 0.491	est = 2.70 SE = 1.14 **p = 0.018** *	est = 2.20 SE = 1.15 **p = 0.045** *	-	-	-	est = -3.71 SE = 1.06 **p < 0.001** ***	est = -2.29 SE = 0.67 **p = 0.001** ***	-
Project management	-	-	-	-	-	-	est = -1.18, SE = 0.75 p = 0.114	est = -1.64 SE = 0.59 **p = 0.006** **	-
Feasibility study or pilot project	-	-	-	-	-	-	est = -1.90, SE = 1.09 **p = 0.084**	est = 1.22, SE = 0.53 **p = 0.023** *	-
Other goals	not modelled								

4.3.3 Question 3: type of data collected

A large variety of data is collected (Table 4.2c), with data relating to anthropogenic activities (such as evidence of fires, snares, traps, logging) being the most common (61% of schemes). Bird and mammal data have significantly increased over time (Table 4.5). Due to the small sample size for schemes that collected socio-economic/human data before 2006 (4 schemes, representing 27% of pre-2006 schemes) it could not be included in the GLM analyses, but it is worth noting that 75% of current schemes are collecting social data of some sort. There is no further evidence of a trend in the type of data collected by PEM schemes.

Table 4.5. The estimate (est), standard errors (SE) and p-values (p) for the top models for binomial GLM for each data type. '-' indicates that the variable was not included in the final model, but it was investigated as part of the analysis. P-value significance level codes: * = p ≤ 0.05, ** = p ≤ 0.01, *** = p ≤ 0.001.

Data Type	Binomial GLM							
	Participation	Habitat (baseline = aquatic)		# Monitors	Continent	Year scheme finished (baseline = ongoing/current)		Duration
		forest	other terrestrial			Pre-2006	2006 - 2014	
Anthropogenic activities	-	-	-	-	-	-	-	-
Mammals	-	-	-	-	-	est = -0.33 SE = 0.69 p = 0.633	est = -2.55 SE = 0.70 **p < 0.001** ***	-
Ecosystem elements	-	-	-	-	-	-	-	-
Plants / trees	-	-	-	-	-	-	-	-
Birds	-	est = 1.78 SE = 0.86 **p = 0.039** *	est = 0.49 SE = 0.97 p = 0.616	-	-	est = 0.11 SE = 0.74 p = 0.876	est = -1.45 SE = 0.68 **p = 0.032** *	-
Fish	-	est = -1.98 SE = 0.69 **p = 0.004** **	est = -1.36 SE = 0.74 p = 0.068	-	-	-	-	-
Reptiles / Amphibians / invertebrates	-	-	-	-	-	est = 1.05 SE = 0.71 p = 0.140	est = -0.20 SE = 0.63 p = 0.751	-
Human / socio-economic /human-wildlife conflict	-	est = -1.25 SE = 0.78 p = 0.109	est = 0.68 SE = 0.77 p = 3.72	-	-	NA	est = -0.49 SE = 0.61 p = 0.423	-

4.3.4 Question 4: methods

Most schemes used more than one method to collect data; the number of methods used by one scheme ranged from 1 to 11, with an average of 2.7 methods per scheme. Most methods required a medium level of skill from the local data collectors (52%), while basic and complex skills were required for 26% and 12% of methods respectively (Table 4.2b). Over time, there is some evidence of an increase in the number of methods requiring complex skills (Table 4.6). The year the scheme finished was the best predictor of the level of skill required, with a significantly lower number of schemes using methods requiring complex skill between 2006 and 2014 compared to ongoing schemes (Table 4.6).

Table 4.6. The estimate (est), standard errors (SE) and p-values (p) for the top models for binomial GLM for each skill level. '-' indicates that the variable was not included in the final model, but it was investigated as part of the analysis. P-value significance level codes: * = p ≤ 0.05, ** = p ≤ 0.01, *** = p ≤ 0.001.

Method skill level	Binomial GLM						
	Participation	Habitat	Monitors	Continent	Year scheme finished (baseline = ongoing) pre-2006	Year scheme finished (baseline = ongoing) 2006 – 2014	Duration
Basic	-	-	-	-	est = -0.64 SE = 0.38 p = 0.092	est = -0.94 SE = 0.30 p = 0.067	-
Medium	-	-	-	-	est = -0.30 SE = 0.29 p = 0.300	est = -0.34 SE = 0.21 p = 0.114	-
Complex	-	-	-	-	est = -1.80 SE = 1.02 p = 0.078	est = -1.27 SE = 0.54 **p = 0.019** *	-

4.4 Discussion

4.4.1 Current state of PEM

The involvement of local people in environmental monitoring is widespread and on the rise (Figure 4.1 and Kouril et al. 2015). There are similar trends in citizen science projects, where there is increasing reliance on non-experts (such as volunteers, community groups, amateur naturalists) to collect and report data over large spatial and temporal scales (Tulloch et al. 2013; Conrad & Hilchey 2011). Kouril et al. (2015) included Europe, North America and Australasia as well as developing nations in their study, thus demonstrating the use of PEM on every inhabited continent. PEM is mostly used in forests (Figure 4.2) which could be because of the geographical bias of ecological studies in forests and woodlands (Martin et al. 2012), or due to the creation and development of REDD+ (Danielsen et al. 2013) or because of the high biodiversity value of forests (Olson et al. 2001).

This study shows that a large variety of data types are collected (Table 4.2b), including anthropogenic activities and a range of wildlife species, with an increasing number of schemes monitoring birds and mammals. Similarly, Chandler et al. (in press) explore biodiversity data from citizen science and PEM to track progress towards global biodiversity targets and found that birds and mammals were the most common species to be monitored as part of a PEM scheme. There are also a wide range of goals in PEM schemes (Table 4.2a), averaging 3.72 per scheme, but five schemes chose 8 or more goals from a possible list of 14. Those schemes with a large number and wide range of goal may need to refine their goals and consider making them 'SMART' (Specific, Measureable, Ambitious, Realistic, Time-bound) to fully understand why the activity is needed and what is hoped to be achieved. Small scale individual projects are often criticised for lack of SMART-ness in goal setting and trying to solve an ill-defined problem without acknowledging the risk of failure (Game et al. 2013).

By engaging with local people, environmental monitoring has much potential to feed into decision-making at a range of scales, from the local level to national and international policies, and to better understand changes in systems (Bonney et al. 2014; Devictor et al. 2010; Stephenson et al. 2016). However, this potential is not always realised in practise. Villaseñor et al. (2016) conducted a review of PEM schemes and explored their contribution to decision-making, concluding that PEM efforts are not always successful at informing decision-making. Use of the data generated from monitoring depended on the themes that were monitored (those that related to livelihoods or impacts on natural resources were more informative), the social context and devolution of power to communities and degree of matching between the temporal and spatial scales on which monitoring and management operate. These issues are not restricted to PEM schemes. For example, Newman et al. (2016) describe a growth in citizen science that is not yet impacting decision-making to its full potential and Stephenson et al. (2016) discuss the complexity of using biodiversity data for decision-making in Africa.

4.4.2 Level of participation

This study provides evidence that PEM is changing over time; there is a significant rise in the number of PEM schemes over the last 25 years, however the proportion of schemes with high levels of participation remains the same. Many of the case studies in this review have a low level of local participation in the more influential scheme components; the design of the study and the analysis and interpretation of the results. This review suggests that there are barriers or a lack of commitment to fully engaging local people in monitoring activities. This been discussed by Palmer Fry (Palmer Fry 2014) and recognised in other types of conservation initiatives, where true engagement of local people can be difficult to achieve in practice (e.g. Wiseman & Bardsley 2015). Low participation levels may occur because people do not have a vested interest in the resource or there is an unfavourable political culture (Nielsen & Lund 2012); there may be a misalignment of goals and priorities between scheme implementers and local people (Funder et al. 2013); there are unintended costs or no benefits being involved and therefore little willingness to being participate in the scheme (Hockley et al. 2005); or because of power plays between stakeholders (Palmer Fry 2014). Even where participation or uptake in a scheme itself is good, the running costs may be so high that the lack of a sustainable financial mechanism to support activities in the long-term causes the scheme to cease (Topp-Jørgensen et al. 2005; Garcia & Lescuyer 2008).

Local participation and co-management has been strongly linked to project effectiveness and longevity (Schultz et al. 2011; Brooks et al. 2013). Therefore, a move towards greater participation in conservation initiatives is desired, as in theory, PEM is a win-win for conservation and development (see Chapter 2); where the data collected informs conservation initiatives whilst supporting local peoples' livelihoods within sustainable limits and engaging them in decision-making. For this potential to be realised, it is important that PEM progresses by becoming increasingly effective at providing useful information at all scales whilst simultaneously supporting communities and livelihoods.

Participation levels of local people varied with goals; there were higher levels of participation in schemes with goals relating to the social development and management of natural resources, with lower participation in schemes concerned with ecological knowledge (Table 4.4). If schemes have social development of the community as a goal, they are more likely to consider participation as important and be better at engaging local people.

There is some evidence from this study that the goals of PEM schemes are shifting from collecting data for the sole purpose of increasing ecological knowledge and understanding system state to incorporating the needs of communities reliant on natural resources by having development goals (Table 4.4). Furthermore, local people are more involved in the design and interpretation of schemes concerned with the management of natural resources and/or social development, compared to schemes with other goals (Table 4.4). The increase in social development as a goal probably reflects the importance of considering the wellbeing of local communities in conservation practice, as reflected in international policies agreed by most governments, such as the CBD (Robinson 2011; McShane et al. 2011; Milner-Gulland et al. 2014; Woodhouse et al. 2015; de Lange et al. 2016; Holmes & Cavanagh 2016).

This study shows no evidence of a rise in the number of schemes collecting socio-economic information that can be used to measure progress towards social and development goals (Table 4.6). This suggests that there is a gap between aspiration and reality, unless project implementers are collecting socio-economic information separately, rather than through the monitoring activities carried out by local people. Woodhouse et al. (2015) set out some guiding principles that provides clarity of the wellbeing concept and a structure that can measure and provide insight into the social impact of conservation initiatives such as PEM. If this framework was applied to a range of different PEM schemes over the long-term, not only would it enable a better understanding the overall effectiveness of PEM in meeting the needs of local people and benefitting communities, but also ensure that PEM is more in tune with local priorities and more able to assess whole system change.

4.4.3 PEM and technology

There is some weak evidence of an increase in the use of methods requiring medium and complex skill levels, including the use of technology (Table 4.5). However, this was not a strong as expected, given the reduction in cost of equipment and the increased use of technology (such as smart phones) for data collection in citizen science initiatives and in conservation research in general (Newman et al. 2012). A whole range of technology, such as smart phones, tablets, GPS devices, digital recorders and drones, is increasingly used in environmental data collection (Teacher et al. 2013; Acevedo & Villanueva-Rivera 2006; August et al. 2015; Arts et al. 2015). These high-tech data collection methods have numerous advantages over traditional methods if implemented correctly (Brammer et al. 2016; August et al. 2015): (1) they can often be simpler at the point of data collection, thus enabling low-skill people to engage, (2) the data are instantly digitised and the job of data entry made substainially easier and faster, (3) there is less margin for error in recording details such as GPS points, (4) they can be backed up ensuring the chance of losing data is minimised, (5) they give local people the chance to interpret data more easily which can increase ownership and understanding of PEM (6) they enable data to be made available to managers and policy makers in a more timely fashion and allow decisions to be made on current information and trends.

With the reduction of price and increased availability in technology and the advantages these can bring, there is an opportunity to develop this aspect of PEM, indeed, interest in this area is growing. Schemes using techonology are emerging; Larrazábal et al. (2012) describe community members using handheld computers with GPS attachments for mapping and Pratihast et al. (2012) describe the use of mobile devices to collect and transmit data in Vietnam. In addition, a research group at University College London, UK (UCL 2014) have coined the term 'extreme citizen science' to extend the citizen science approach and information communication technology towards a "situated, bottom-up practice that takes into account local needs, practices and culture and works with broad networks of people to design and build new devices and knowledge creation processes that can transform the world". By employing an interdisciplinary approach to the technological and cultural challanges of participatoty monitoring, sensing and modeling activities, this approach is much aligned to PEM, with the hope of engaging and supporting local people to understand and manage their own environment.

However, high technology schemes are currently heavily supervised and being conducted on a small scale (e.g. Pratihast et al. 2013). By contrast, several other PEM schemes with pencil and paper approaches have been sustained with little external support for more than a decade (e.g. Stuart-Hill et al. 2005). There may be a trade-off between using digital technology and keeping the costs of maintenance so low so that schemes can be operated autonomously by the communities themselves over the long-term. Another barrier to the widespread use of digital technology is the need to charge equipment, potential to lose data due to software or hardware failure, get the data out of the devices in an appropriate format by the users so they can be used for local interpretation and inform decision-making. Therefore, the are challenges that need to be overcome before PEM schemes become high tech and digitised over the long term.

4.4.4 Conclusion

This research demonstrates that participation in monitoring projects is variable and still low in many instances. This suggests that there are either barriers to participation or a lack of interest in engaging local people in monitoring. 'Participatory Environmental Monitoring' is not truly participatory until barriers to participation in all aspects of a monitoring scheme are overcome. As PEM continues to expand, further work to understand these issues and develop solutions should be a priority. Otherwise, PEM is in danger of being no more than a consultative 'top-down' approach, or worse still, the latest conservation fad (Redford et al. 2013). The root issues and causes of low participation could be further understood by doing thorough evaluations of schemes currently operating, but also, and perhaps more importantly, of those schemes that have ceased to operate to identify why they failed. The effectiveness of PEM schemes could be reviewed from a variety of other persepctives, such as scientific robustness and ensuring they are ethically acceptable and durable in the long term. This requires in depth impact evaluation of individuals schemes that is beyond the scope of this review. Where there is capacity and resources, conducting an evaluation of a scheme should be encouraged, as there is much still to learn. The realities of PEM are far away from the theoretical win-win that often set people off on the PEM route in the first instance.

Chapter 5 The power of participatory monitoring to detect biodiversity change

5.1 Introduction

5.1.1 Monitoring choices

Monitoring is defined as the systematic process of collecting data for the purpose of measuring how a policy, project or programme is performing and tracking changes in state over time or space (Yoccoz et al. 2001; Gerber et al. 2005; Jones et al. 2010). Given this, monitoring is not a stand-alone activity, rather it is part of an active intervention and decision-making process guided by a clear set of objectives and targets (Noss 1999; Bisbal 2001; MacKenzie & Royle 2005; Yoccoz et al. 2001) that is closely tied to decision making (Nichols & Williams 2006). Monitoring is a key part of conservation management where the goals are either to maintain the status quo, increase (or decrease) the abundance or distribution of species and habitat or decrease threats. Knowing whether to take action requires an understanding of when the ecosystem is departing from the desired state and the impact of management actions on the ecosystem. Therefore, a conservation manager might want to monitor threats (such as fire, logging animal traps) as well as species and habitats. However, not all species and threats can be monitored (they might be too elusive) or respond in the same way (Noss 1999). Setting conservation goals and targets, along with budgets and logistical restrictions, guides the selection of what and how to monitor (such as in Singh & Milner-Gulland 2011). Given the variety of ways to measure biodiversity and threats, making decisions about what and how to monitor can be challenging.

Project implementers should choose a monitoring programme that has the ability to meet their needs, management goals or answering their research question (Field et al. 2007). For this, a practitioner must take into account that despite statistical advances to account for sampling error, reliable inferences can only be made using data of adequate quality, and detecting true ecological change can be a difficult task (Welsh et al. 2013). Monitoring can require substantial resources that may redirect resources from on-the-ground activities, especially where conservation projects operate on small and limited budgets. For this reason, a key criterion for choosing a monitoring strategy should depend on the cost of the scheme and ensure that it can be implemented and sustained over the project timeline, given budgetary constraints. Gaidet-Drapier et al. (2006) compared wildlife census methods that were part of a long term monitoring programme involving local people (Gaidet et al. 2003). Comparisons were made in terms of the effort and costs to survey an area and the efficiency in data collection. They found that there were large differences between the methods, and that in the context of involving local people in the data collection, simple techniques (such as counts on foot and by bicycle) were the most suitable choice for their programme.

5.1.2 Occupancy models

In ecology, presence-absence data (presence or absence of a species in a defined area) are often the variable of choice for monitoring wildlife populations. This type of information can then be used in occupancy models, for a wide range of purposes; such as assessing habitat use and suitability (Odom et al. 2001), estimating area of occurrence for determining IUCN Red List assessments as part of criteria A and B (Fivaz & Gonseth 2014), characterising metapopulation dynamics (MacKenzie et al. 2003), distribution and spread of invasive species, (Muñoz & Real 2006), the response of wildlife to a conservation or management intervention (Russell et al. 2009) or to predict occurrence (Wiser et al. 1998). Occupancy analyses have been used in ecological studies of a wide range of taxa, including tigers in India (Karanth et al. 2011), amphibians in Spain (Gómez-Rodríguez et al. 2010), plants in China (Chen et al. 2009), birds in Australia (Fischer & Lindenmayer 2002) and multiple species at the landscape level in California, U.S. (Manley et al. 2004). Occupancy is often used as a metric instead of density or abundance (the number of individuals in a defined area or population) because it is easier to gather the data and therefore often more cost-effective. Occupancy may also produce more reliable and statistically robust estimates because the uncertainties in observations may be lower than when both presence and abundance must be recorded (MacKenzie et al. 2006; MacKenzie & Royle 2005; Joseph et al. 2006). There are three principal decisions to make during the design stage of an occupancy study: (1) what targets to monitor, driven by a clear objective of the monitoring programme; (2) the number of sites to be surveyed; and (3) the number of repeated surveys of each site (MacKenzie & Royle 2005).

5.1.3 Inventory studies

Observation data can also be used in measurement of species richness (number of species present) of an area or determining when a species or threat is absent or extinct. This approach differs from measuring occupancy at the landscape level because imperfect detection isn't taken into account, there are no inferences (and therefore fewer assumptions) made about a larger area, so that the question becomes: is a given location occupied by a particular indicator/species? Although a somewhat simpler metric than estimating occupancy at a landscape level, species presence might be important to conservation managers for spatial or temporal comparisons of species presence or richness (Grant et al. 2005; Russell et al. 2016; Weber et al. 2004).

5.1.4 Statistical power

In the context of conservation monitoring, calculating statistical power gives a manager the probability that an analysis will detect a true trend (Gerrodette 1987) and is one way to ensure that monitoring activities are not a waste of time and resources (Legg & Nagy 2006). Although important, ensuring adequate statistical power is by no means sufficient for effective monitoring, but should also be accompanied by careful consideration of indicators used, appropriate analyses and subsequent use of results.

Several factors affect statistical power; there is a positive relationship with (1) sample size, (2) effect size, (3) the risk of a false positive, also known as a type I error of mistakenly concluding that there is change when there is none (Field et al. 2007), and an inverse relationship with (1) the variability in the system (Di Stefano 2001), and (2) the probability of a type II error, of mistakenly assuming there is no trend when there is one. In the context of monitoring, Type I and Type II errors have important consequences that depend on the circumstances and the goal of monitoring or management. Mapstone (1995) describes monitoring environmental impact where a type II error may result in collapse of a fishery or pollution, because the effects of harmful activities go undetected and continue until irreversible damage is done. Conversely, a type I error of saying that a pest species is increasing or that an endangered species is in decline when there is no change, may trigger unnecessary and costly management actions. Therefore, the relative cost of making a type I or II error depend on the circumstances. Design of monitoring schemes need to take into account the differing costs of type I and type II errors and therefore the desired statistical power given the context and goals of a monitoring scheme.

For wildlife studies, power is traditionally set at 0.8 (i.e. an 80% chance of detecting a change of a given magnitude over a specified time period, should it be present), however the desired sensitivity of the monitoring program to detect a particular change depends on the research question (e.g. Bart et al. 2004; Hatch 2003). Power analysis has been used to evaluate the ability of monitoring programmes to detect trends for a range of taxa given the resources currently available or an intended monitoring scheme. For example, the number of breeding pairs of petrels in New Zealand (Buxton et al. 2016), seabird counts in Alaska (Hatch 2003) abundance of tropical bats (Meyer et al. 2010) and anthropogenic pressures such as crayfish harvesting in Madagascar (Hockley et al. 2005), python harvesting in Indonesia (Natusch et al. 2016), and the design of monitoring of threats and species as part of a payments for environmental services scheme in, Menabe, Madagascar (Sommerville et al. 2011).

For occupancy studies, reaching a desired statistical power depends on the number of sites and the number of repeat visits per site during a sampling season. Due to financial and logistical constraints there is a trade-off between the number of sites and repeated surveys that can be conducted. Field et al. (2005) evaluated the power of an occupancy study to detect a decline of two Australian woodland bird species over 3 years, where realistic budgetary constraints limited the number of sites and repeat surveys. They explored how a budget should be allocated between sites and surveys to reach the best compromise for monitoring all species simultaneously. They concluded that in multispecies monitoring projects, rarer and/or less detectable species require more effort and therefore a higher budget than common species to achieve the same power, so that their requirements determine the monitoring design. This is an example of the importance of taking into account the financial and logistical constraints during the design of a monitoring scheme, to ensure it is feasible to collect meaningful (i.e. conservation and/or management relevant) data in the real world (Legg & Nagy 2006).

5.1.5 Imperfect detection and statistical power

Generally, occupancy studies take account of imperfect detection by conducting repeated surveys at each site and using the detection history to model occupancy and detection probabilities (MacKenzie et al. 2006). Although there have been power analysis studies of presence-absence data (e.g. Field et al. 2005), imperfect detection (when species are present but not observed) has not been incorporated into the anayses. Including the probability of detection in occupancy studies can substantially affect the power of the data to detect trends based on occupancy models (MacKenzie 2005). To address this issue, Guillera-Arroita and Lahoz-Monfort (2012) developed and tested a formula for power analysis of occupancy data that takes into account both the occupancy and detection probabilities. However, their method has yet to be applied to a real-world empirical example. When conducting an inventory, imperfect detection is also problematic. However, Reed (1996) describe a formula to determine the number of repeat visits required to be statistically confident of an indicators absence. The required number of visits is dependent on the probability of detection of the indicator and the desired probability of a type I error (mistakenly concluding an indicator is not present when it is).

5.1.6 Research questions

The goal of this research is to explore the power of data collected by participatory monitoring to detect change, under a range of approaches and budgetary constraints. I use data collected from a participatory monitoring project in Menabe, where one of the main project goals was to collect information that would measure species and threat change over time, and provide the first empirical test for Guillera-Arroita and Lahoz-Montfort's (2012) method for power analysis of occupancy data. This research builds on research by Sommerville et al. (2011) who explore a payments for environmental services scheme that operated in the same area, Menabe, Madagascar. The main research questions are:

1. What is the statistical power to detect trends in species and threat indicators, given the realities of the PEM scheme?
2. How does the statistical power change with varying number of a) patrols (replicates) and b) villages (sites)?
3. What is a robust strategy that would detect change of a range of indicators on given a budget, in order to inform decision-making and management?

5.2 Methods

5.2.1 Data

A full description and background to the case study and the data collection protocol for the monitoring project is given in Chapter 3. The data analysed in this study was extracted from a year-round monitoring project that was started in 2011 by the Durrell Wildlife Conservation Trust (herein 'Durrell'). This project operates in various habitat types in five regions across Madagascar. For the purpose of this research, the dry deciduous region of Menabe in central western Madagascar was selected, because this area had particularly good monitoring coverage both within and between villages (see Chapter 3 for detailed information). This area has been designated a new Protected Area and the management has been devolved from central governments to local communities by Fanamby, a local NGO, with support from Durrell (see section 3.2). Types of management that have been put into place involve the designation of strictly protected zones alongside multi-use forest zones for local people, as well as increased enforcement and protection of the forest from logging, fire, slash and burn and illegal hunting. Given the conservation efforts, continued management and enforcement of forest laws in this area, one would to see an increase in the probability of occupancy of species and decrease in the probability of occupancy of threats over time, although the timescale over which these changes would occur is uncertain. Across 18 villages, there were 34 indicators monitored in this project, representing a range of birds, mammals, plants, reptiles and threats. However, 13 of these indicators were observed in less than four villages, and were consequently excluded from the occupancy modelling (see Appendix B.1 for a list of all indicators).

The indicators were selected by local communities, with guidance from Durrell, for a range of reasons such as conservation importance, in particular the flat-tailed tortoise, the active burrow of the giant jumping rat and a range of unspecified lemur species. These species are included in the formal Menabe Protected Area management plan as key species with the target of increasing their populations. Other species were selected as indicators because of local use value (such as the masonjoany plant, *Coptosperma madagascariense*, for makeup and medicine and the tree *Givotia* sp. to make pirogues), or because they were easy to detect (such as the crested coua with a distinctive call) or cryptic (such as the fossa or Madagascar crested ibis). Given the range of indicators used in this project, it unlikely they will all respond to the same conservation management in the same way; some species or threats may be more sensitive to a particular activity than others. However, there is a lack of explicit understanding of how each individual indicator might respond to threats or management actions, such as increased enforcement of strictly Protected Areas. Therefore, for this analysis I focus on the power to detect trends in the chosen indicator species without making assumptions about the expected direction of these trends, or considering how indicators could be combined by managers to produce indices of conservation success

5.2.2 Occupancy model

Occupancy modelling requires that a number of assumptions are met: (1) no species were misidentified, (2) the population is closed to immigration and emigration, (3) that detectability for each species is constant during the sampling period, (4) that the probability of occupancy is constant across sites (5) observations are independent (MacKenzie et al. 2006). If these assumptions are not met, the estimators of occupancy may be biased and inferences about occupancy or detection may be incorrect. The Menabe dataset required some compromises to meet these assumptions (Table 5.1).

Table 5.1. Summary of the assumptions of occupancy modelling and how these relate to the dataset with potential implications for the research.

Occupancy modelling assumption	The dataset	Steps to address the issue	Perceived likelihood of assumption holding true
1) No species were misidentified	34 indicators selected: species and threats. Indicators were selected in collaboration with the local people to ensure they were easily identifiable and recorded using local names. The monitors received training on conducting the monitoring at the start of the project.	Although the project started in 2011, data for 2012 have been used when local people are more familiar and potentially better at identifying species.	Likely
2) Population closed	The data have been collected year-round since 2011.	Two-month period (July and August) in 2012 selected for analyses to minimise immigration and emigration of species.	Likely
3) Constant probability of detection	The density of foliage in the dry deciduous forest varies throughout the year. The density of vegetation at each site is unknown and may vary between multi-use and Protected Areas. The effort (distance or time taken) or specific time of day of each patrol is unknown. Data were collected by teams of 3-6 people.	Data from the two-month period was used to ensure that temporal changes in vegetation did not affect detectability. July and August were selected because this is part of the dry season when the foliage and understorey density is low. During fieldwork in 9 of the 18 sites, all monitors were asked about the time and duration of patrols, all villages reported that patrols took 4-6 hours and were conducted in the morning. The number of people conducting the patrol was included as a covariate in the models.	Fairly likely
4) Constant probability of occupancy at each site	Data collected in dry deciduous forest and mangroves. The quality of the forest at each site was unknown.	Only data for the forest habitat was used. Three covariates (population of the village, forest cover and the cost-distance to the nearest road – see Table 2) were included in the model to account for village level variation.	Fairly unlikely
5) Independent observations	Villages and the locations of each patrol > 5km apart.	None required.	Likely

Despite the monitoring project operating year-round, only data for July and August 2012 were used in the occupancy modelling. This time period was likely to be sufficiently small to hold the assumption that the occupancy state of the sites does not change during the survey period, as well as having enough data, as ten villages had conducted at least seven patrols in that time. For the purpose of investigating the power of participatory monitoring to detect trends, the variable of interest was change in occupancy of a range of wildlife species and threat indicators over time. The area of interest lies at the landscape level, i.e. with respect to the performance of the PA as a whole. Therefore, villages can be treated as sites and repeated patrols as replicates within each site. This assumes that expected occupancy is homogenous across the landscape; this is unlikely to be true, but the data were inadequate for more detailed exploration. I used four covariates to control for village and patrol level variation (Table 5.2). Prior to analysis these variables were checked to rule out collinearity using variance inflation factors and pairwise scatterplots (Zuur et al. 2010).

Table 5.2. Description of the covariates used in the occupancy modelling.

Level of variation	Covariates	Description	Rationale	Source
Site covariate	**Population**	Population of the village[1].	Might be fewer species and more threats in villages where there is a higher population.	Official 2014 population data from INSTAT Madagascar Institut National de la Statistique - National Statistics Agency).
	Forest cover	Percentage of forest cover within 5km of the village in 2010.	Might be fewer species or threats in those villages with lower forest cover.	National Geomatics Center of China (2014) 30-meter Global Land Cover Dataset (GlobeLand30). www.globallandcover.com, DOI:10.11769/GlobeLand30.2010.db
	Cost-distance	Cost and distance it takes to travel from the village to the to the main office of the district. It is an indicator of the remoteness of the village.	Villages that are more remote might be less disturbed and have more species and/or fewer threats.	This is based on the average speed for travelling each type of road (secondary road, national road etc). This was obtained from H. Andrianandrasana and developed by Foibentaontsarintanin'i Madagasikara.
Observation covariate	**Number of observers**	Number of observers on each survey.	A higher number of observers may increase the chances of detecting a static indicator (e.g. threats, trees), or reduce it for mobile indicators (e.g. if animals respond to disturbance).	Individual survey records from the dataset.

1 .Population size varied from 416 to 1616, because these values are on very different scales of magnitude compared to forest cover (0.877 – 0.777) and cost-distance (0.89 – 4.73), the values were standardised 0 to 1 using the 'standardize' function in the 'arm' package in R (Gelman 2008).

Given the inclusion of these covariates in the occupancy model, I hope to reduce the likelihood of violating the assumptions of occupancy modelling. Despite the potential violation of the constant probability of occupancy assumption, as my interest does not lie in the estimates of occupancy of the indicators per se, but in using these data to understand the power of current indicators to detect change at the landscape level to understand if the data can tell conservationists whether management is having an impact on the ecosystem. Given this, the data still provide useful information which will allow potential future monitoring strategies to be explored.

The data were organised into detection histories for each indicator in each village. For each indicator, the initial proportion of patrols where the indicator was detected was calculated and the medians and standard deviations were checked to ensure there were no obvious data entry errors. For each indicator, single-season occupancy models were constructed in the 'unmarked' package in R. To quantify the relative importance of each variable in the models, the Akaike weights over the subset of models within 4 Akaike information criterion (AIC) of the top model that include that variable were summed (Burnham & Anderson 2002). Those variables that had relative variable importance of 0.5 or greater were included in the final model. The estimates of occupancy and detection probabilities from the final model for each indicator were extracted.

5.2.3 Power analysis of occupancy models

The estimates of occupancy and detection probabilities were extracted from the occupancy models for each of the indicators. The formula developed by Guillera-Arroita & Lahoz-Monfort (2012) was used in R for the power analysis. In all analyses the significance threshold alpha (α) was set at 0.05 and the desired power ($1 - \beta$) was 0.8, in keeping with the standard in ecology. The power analyses consisted of a three-stage process to answer the three research questions:

- *Question 1 – statistical power of the current regime to detect trends:* power of each indicator to detect trends between two sampling periods of 10%, 30%, 50% and 80% growth and decline (relative proportion of change = R, where $R > 0$ is a decline, $R < 0$ is growth), given the current regime of 18 villages and 6 patrols per village. Although the actual number of patrols varied in each village, this was the median number of patrols, and therefore used for the purpose of this analysis.
- *Question 2 – changes in statistical power with varying number of villages and patrols:* this was calculated using the same formula for answering question 1. However, the number of villages was halved (n = 9), doubled (n = 36) and tripled (n = 54) and the number of patrols was constant at 6 per village. Then the number of patrols was halved (n = 3), doubled (n = 12) and tripled (n = 24) while the number of villages stayed constant at 18.
- *Question 3 – a robust monitoring strategy to detect trends:* the minimum number of villages and patrols required to detect 80% power was calculated to detect decline and growth of 10%, 30%, 50% and 80%, and the costs of meeting the required number of villages and patrols to detect 50% growth

and decline were calculated. An inventory approach was also used as a comparison to the occupancy approach to address this question.

5.2.4 The inventory approach

This monitoring approach gives the presence-absence of an indicator at the village level, using the approach to power analysis described by Reed (1996). Using the probability of detections from the occupancy modelling, I calculated how many surveys without detecting the indicator are required to be statistically confident of its absence from the site. The formula requires (a) prior knowledge of probabilities of detection, (b) a desired type I error rate, which was selected at 0.05 in keeping with ecological convention. For those indicators where occupancy modelling was feasible (21 of 34), the probability of detection for each indicator was used. The minimum number of patrols required to declare a species 'absent' was calculated, along with the total number of indicators that could be monitored with increasing number of patrols.

For both modelled and non-modelled indicators, I assumed that they were correctly identified and recorded as "present", with no false positives. For modelled indicators, if the number of patrols conducted in a village exceeded the minimum number as determined by the formula and the indicator was not detected, it was declared 'absent' from the site. If the number of patrols did not reach the minimum number required, the absence of the indicator was declared as 'uncertain'. For those 13 indicators that were not modelled and not detected, the absence of the indicator was also declared as 'uncertain'. Un-modelled indicators could not be declared 'absent', because the probability of detection could not be calculated and therefore there was no information on the minimum number of patrols required to be confident that a non-detection meant the indicator was truly absent.

5.2.5 Cost data and monitoring strategies

The costs of achieving 80% power over a five-year monitoring period were calculated, based on the approximate current cost of the Durrell monitoring programme. There are differences in costs between villages depending on the travel distance to the village. However, we calculated running costs (disregarding start-up costs) for the project based on the average cost per village per year and per transect in consultation with project managers. Although the exact amount of money spent is likely to vary, this gives an indication of the overall costs and how they might vary according to the number of villages and number of repeated patrols required.

The formula to calculate C, the cost in US$ of a monitoring regime, was:

$$C = Y\,[q + (Sa) + (Kb)]$$

Where *Y* is the number of years the project is intended to operate, *S* is the number of villages (sites) and a is the cost per village, *K* is the number of patrols per year and *b* are the costs per patrol and q is the cost of an annual training workshop.

The data entry costs are estimated as $0.05 per patrol. Durrell's procedure for data management is collected the data from each village. The data from all regions were collated in their central office in Antananarivo, where people were paid to enter data from the paper datasheets into an excel spreadsheet using facilities at a local internet café. Given the transport of the data, staff time for training those entering the data and checking the digital records, is it is very likely that the cost of data management is far higher.

The cost of the current monitoring strategy was calculated (strategy A, below. Table 5.3) and three other potential strategies were created. In the other strategies the frequency of the monitoring (year-round or seasonal) and the intensity of the monitoring (the number of patrols, the number of monitors, the frequency of visits by Durrell and duration of a training workshop) were varied to represent different approaches to the monitoring project, based on discussions with Durrell field staff and programme managers (Table 5.3):

- ***Strategy A (occupancy approach, year-round, high intensity):*** this is the current scheme: year round monitoring by local people twice a month, with 6 local people trained and equipped to monitor in each village, with 2 visits from Durrell staff a month and one two-day workshop a year.
- ***Strategy B (occupancy approach, year-round, low intensity monitoring):*** year-round monitoring by local people once a month, with 3 local people trained and equipped to do the monitoring, visits from Durrell staff once every two months.
- ***Strategy C (occupancy approach, seasonal, high intensity monitoring):*** 6 patrols are conducted in only 2 months of each year, with 6 local people trained and equipped, with 3 visits from Durrell and 1 one-day workshop per year.
- ***Strategy D (occupancy approach, seasonal, low intensity monitoring):*** 4 patrols are conducted in 2 months of the year, 3 local people are trained and equipped, Durrell visits each village twice, in addition to 1 one-day workshop.
- ***Strategy E (inventory approach):*** 3 monitors in each village trained to collect the data, 2 visits from Durrell staff each year and a one-day workshop for training purposes. The number of patrols needed is unspecified because it varies by indicator depending on the minimum number of patrols needed to be statistically confident that a non-detection means the indicator is absent.

The amount of money spent visiting the villages and the intensity of the monitoring work decreased from strategy A to E. The most expensive parts of the monitoring programme are the costs of Durrell managers visiting the villages and the annual training workshop. When these components are reduced, there is a dramatic reduction in the cost of monitoring. Overall, the cheapest strategy for detecting trends at the landscape was C; strategy E was far cheaper but required a change in project goal.

Table 5.3. Description and cost per village per year for each of the strategies.

Payment	Details	Unit price (US$)	number of units required for strategy A (current)	number of units required for strategy B	number of units required for strategy C	number of units required for strategy D	number of units required for strategy E
Village gifts	$200 USD per village per year - food, cooking and building equipment/materials	200	1	1	0.5	0.5	1
Travel costs	240 litres for 1 visit to a village @1.07 USD per litre	256.8	12	6	3	2	2
Car maintenance	$200 per 12 months for the Durrell visits	200	1	0.75	0.5	0.5	0.5
Uniform	$20 per uniform for each monitor, per year	20	6	3	6	3	2
Bicycle maintenance	$100 per season	100	1	1	0.5	0.5	0.5
Durrell staff costs	$22 per person per day (3 staff members, total = $66 per day) for food and accommodation whilst visiting the village	66	12	6	3	2	2
Training	$1500 for each day of a workshop, once a year	1500	2	2	1	1	1
Monitor payment	$3 per monitor per transect, 3 monitors per patrol	9	24	12	6	4	14.05 per patrol
Photocopying and paper	$5 per patrol	5	24	12	6	4	
Data entry	$0.05 per patrol	0.05	24	12	6	4	
TOTAL COST PER VILLAGE PER YEAR (US$)			**7830.8**	**5615.4**	**2922.7**	**2511.8**	**1055.80[1]**

1. excluding the costs relating to the number of patrols, which is unspecified in the inventory approach because the number of patrols depends on the indicator/s.

5.3 Results

5.3.1 Occupancy models

Bearing in mind the limitations of the dataset, it is still interesting to see broadly which covariates are most influential in occupancy and detection. Of all the covariates in the occupancy model, forest cover was selected in 11 of 21 final occupancy models, for 7 of 8 bird species and 4 of 5 mammal species, but no plants, trees, reptiles or threats (Table 5.4). Forest cover mostly had a positive effect on the occupancy of species, except for three bird species (Humbolt's heron, Madagascar teal and sacred ibis), all of which inhabit wetland areas. The number of observers was selected in 7 models, mostly for birds (4 species in total), and one mammal, tree and reptile species. The number of observers had a positive effect on the detection of Humbolt's heron and the Madagascar Teal, but a negative effect on the fossa and white-breasted mesite and rosewood. Human population size featured in the final models for both threat indicators (logging and slash & burn) and two coua bird species, having a positive effect on occupancy for these indicators. The cost-distance of a village to the main road was not as important and only featured in the top model for one bird and one tree species.

Table 5.4. Description of the indicators, initial proportion of patrols where the indicator was observed (raw occupancy) and the outcomes of the occupancy model for each indicator, NA indicates that the variable was not used in the final model because variable importance <0.5 and the variable importance weights for those in the final model, the cells are coloured if population, forest cover or cost-distance had a positive (green) or negative (red) effect on probability of occupancy or number of observers had a positive (green) or negative (red) effect on probability of detection. Based on these models the probability of occupancy and detectability and their associated standard errors were calculated. IUCN Red List categories: LC = least concern, NT = near threatened, VU = vulnerable, EN = endangered, CR = critically endangered, '-' = not applicable.

Indicator Common Name	Scientific Name	Red List Cat.	Number of Villages with Detection	Raw occupancy	Variable Importance Weight				Prob of Occupancy	SE	Prob of Detection	SE
					Population	Forest Cover	Cost-Distance	Number of Observers				
Birds												
White-breasted mesite	*Mesitornis variegatus*	VU	8	0.189	NA	0.607	NA	0.573	0.439	0.138	0.358	0.089
Madagascar crested ibis	*Lophotibis cristata*	NT	7	0.174	NA	0.504	NA	NA	0.193	0.188	0.320	0.072
Coquerel's coua	*Coua coquereli*	LC	12	0.362	NA	0.786	NA	NA	0.747	0.130	0.522	0.061
Giant coua	*Coua gigas*	LC	13	0.346	0.712	0.961	NA	NA	0.982	0.046	0.449	0.571
Madagascar teal	*Anas bernieri*	EN	4	0.133	NA	0.802	NA	0.549	0.129	0.104	0.568	0.111
Crested coua	*Coua cristata*	LC	14	0.549	0.790	0.892	0.578	NA	1.000	0.001	0.697	0.052
Humbolts heron	*Ardea humbloti*	EN	5	0.205	NA	0.942	NA	0.561	0.186	0.122	0.706	0.089
Sacred ibis	*Threskiornis aethiopicus*	LC	5	0.169	NA	0.941	NA	NA	0.183	0.121	0.622	0.087
Mammals												
Red-tailed sportive lemur	*Lepilemur ruficaudatus*	VU	5	0.070	NA	NA	NA	NA	0.489	0.255	0.138	0.081
Narrow-striped mongoose	*Mungotictis decemlineata*	EN	5	0.108	NA	0.946	NA	NA	0.136	0.142	0.299	0.081
Fossa	*Cryptoprocta ferox*	VU	6	0.127	NA	0.835	NA	0.679	0.949	0.191	0.156	0.047
Red-fronted brown lemur	*Eulemur rufus*	VU	10	0.291	NA	0.649	NA	NA	0.579	0.137	0.472	0.070
Verreaux's sifaka	*Propithecus verreauxi*	EN	11	0.323	NA	0.760	NA	NA	0.669	0.138	0.458	0.066
Plants and Trees												
Givotia sp.	*Givotia sp.*	-	6	0.111	NA	NA	NA	NA	0.464	0.171	0.217	0.077
Viguieranthus sp.	*Viguieranthus sp.*	-	4	0.132	NA	NA	NA	NA	0.238	0.105	0.434	0.113
Madagascar rosewood	*Dalbergia greveana*	-	5	0.104	NA	NA	NA	0.746	0.330	0.129	0.230	0.083
Masonjoany	*Coptosperma madagascariensis*	-	4	0.097	NA	NA	0.639	NA	0.175	0.121	0.390	0.147
Reptiles												
Madagascar boa	*Acrantophis madagascariensis*	LC	4	0.040	NA	NA	NA	0.554	0.448	0.194	0.071	0.045
Chameleon	*Furcifer sp.*	-	5	0.137	NA	NA	NA	NA	0.308	0.118	0.388	0.097
Threats												
Logging	-	-	9	0.285	0.753	NA	NA	NA	0.559	0.150	0.501	0.066
Slash and burn	-	-	6	0.148	0.551	NA	NA	NA	0.340	0.139	0.330	0.088

The probabilities of occupancy and detection were plotted (Figure 5.1) to enable visual identification of which species had low or high occupancy and detectability. 11 of 21 indicators fall into the category of having both low probabilities of occupancy and detectability. Three bird species (Madagascar teal, Humbolt's heron and sacred Ibis) have a low occupancy and high detectability. Conversely, the fossa is widespread, but occurs at low densities (Hawkins & Racey 2005) thus accounting for the high probability of occupancy but low detectability. Furthermore, the crested coua and coquerel's coua have distinctive calls which make them easier to detect, and thus have a high probability of detection.

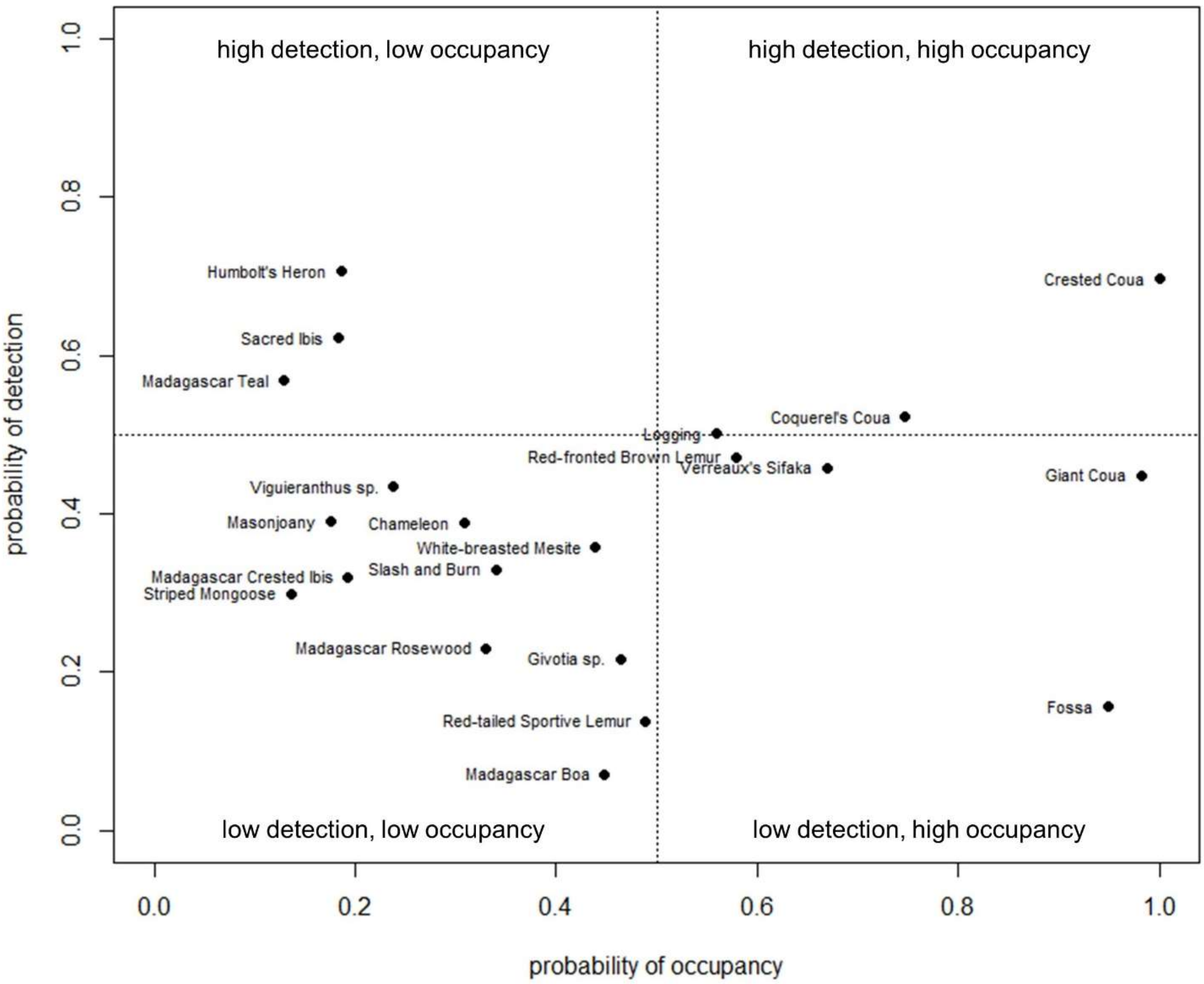


Figure 5.1. Estimates of occupancy and detectability probabilities for each indicator. The dotted line mark the occupancy and detection probabilities of 0.5 to characterise each indicator with low or high probabilities of occupancy and detection.

5.3.2 Question 1: what is the statistical power of the current regime to detect trends?

Some indicators are more powerful than others at detecting change, based on the current regime (Table 5.5). However, of the 21 indicators, only for 7 was the current monitoring regime able to detect some level of decline or growth with an 80% power: 4 of 8 bird species, 2 of 5 mammal species, 1 of 2 threat indicators and none of the 4 plant or 2 reptile species. A 10% growth in the indicator could only be detected in one indicator with 80% power (giant coua, Table 5.5) and a 10% decline could not be detected in any indicators. A 30% change (growth or decline) in three species could be detected with 80% power, a 50% change of a further 6 species could be detected and an 80% change detected in 7 species. Only those indicators with probability of occurrence and detection greater than 0.5 can have power to detect change with 80% power (Table 5.5).

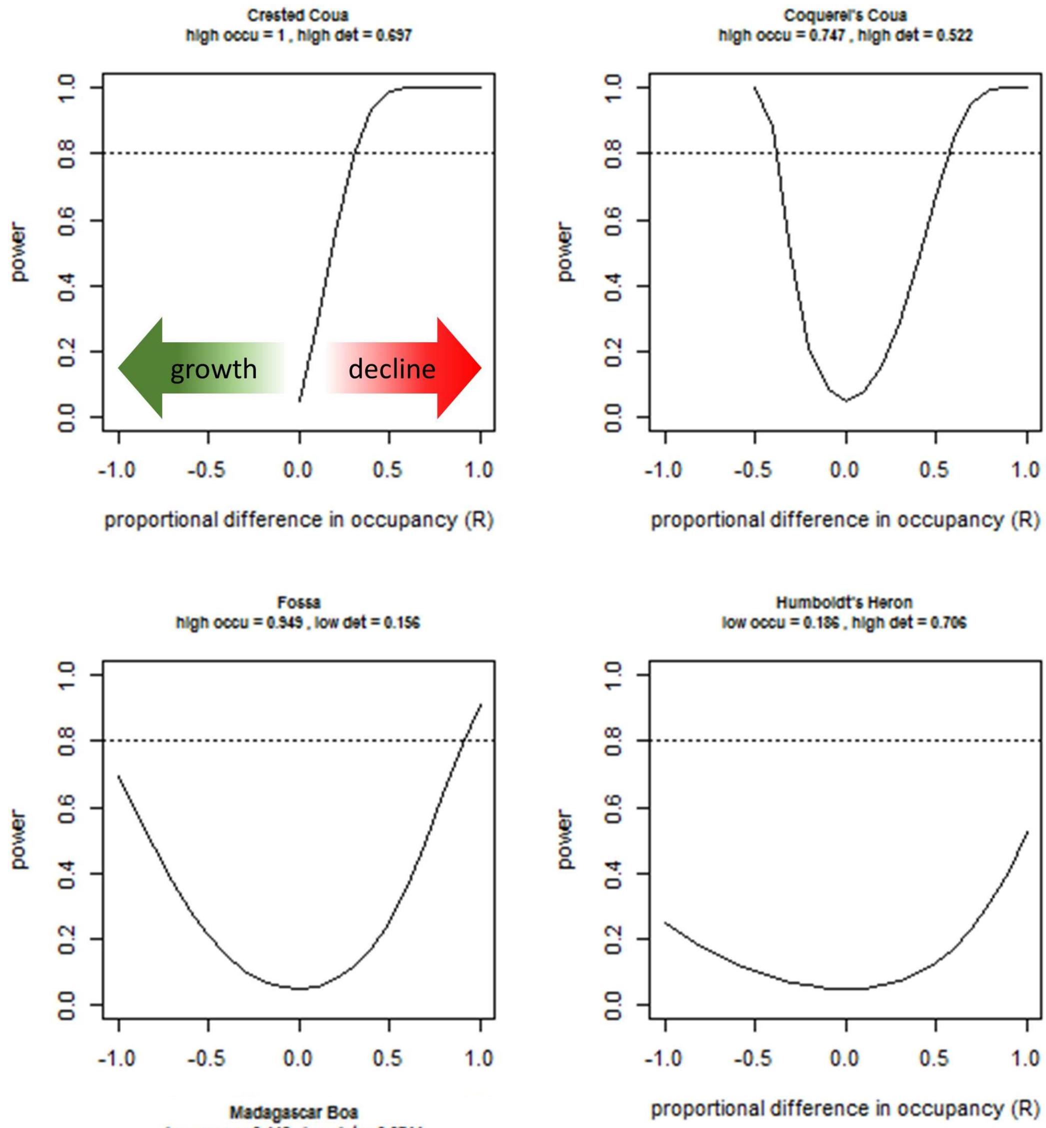
Table 5.5. Power of each indicator to detect growth and decline between two seasons under the current Durrell monitoring regime. Grey cells indicate power > 80%. NA = not applicable because the rate of growth or decline is not possible, given the estimated probability of occupancy. IUCN Red List categories: LC = least concern, NT = near threatened, VU = vulnerable, EN = endangered, CR = critically endangered, '-' = not applicable as occupancy = 1.

Indicator	IUCN red list category	Prob. of occu.	Prob. of det.	80% decline	50% decline	30% decline	10% decline	10% growth	30% growth	50% growth	80% growth
Birds											
White-breasted mesite	VU	0.439	0.358	0.823	0.523	0.268	0.057	0.057	0.231	0.417	0.648
Madagascar crested ibis	NT	0.193	0.320	0.365	0.209	0.119	0.052	0.052	0.095	0.135	0.187
Coquerel's coua	LC	0.747	0.522	1.000	0.952	0.668	0.077	0.083	1.000	NA	NA
Giant coua	LC	0.982	0.449	1.000	1.000	0.959	0.164	1.000	NA	NA	NA
Madagascar teal	EN	0.129	0.568	0.284	0.167	0.101	0.052	0.051	0.082	0.111	0.147
Crested coua	LC	1.000	0.697	1.000	1.000	0.988	0.289	NA	NA	NA	NA
Humbolts heron	EN	0.186	0.706	0.407	0.231	0.128	0.052	0.052	0.102	0.149	0.210
Sacred ibis	LC	0.183	0.622	0.399	0.227	0.127	0.052	0.052	0.101	0.147	0.206
Mammals											
Red-tailed sportive lemur	VU	0.489	0.138	0.347	0.199	0.114	0.052	0.052	0.092	0.129	0.177
Stripped mongoose	EN	0.136	0.299	0.253	0.151	0.094	0.051	0.051	0.078	0.102	0.132
Fossa	VU	0.949	0.156	0.789	0.489	0.250	0.056	0.056	0.211	0.374	0.584
Red-fronted brown lemur	VU	0.579	0.472	0.976	0.770	0.432	0.063	0.064	0.498	0.882	1.000
Verreaux's sifaka	EN	0.669	0.458	0.996	0.875	0.540	0.069	0.070	0.783	1.000	NA
Plants or Trees											
Givotia sp.	-	0.464	0.217	0.630	0.365	0.189	0.054	0.054	0.150	0.248	0.378
Viguieranthus sp.	-	0.238	0.434	0.500	0.283	0.151	0.053	0.053	0.119	0.184	0.270
Madagascar rosewood	-	0.330	0.230	0.481	0.273	0.147	0.053	0.053	0.116	0.177	0.257
Masonjoany	-	0.175	0.390	0.359	0.206	0.117	0.052	0.052	0.094	0.133	0.184
Reptiles											
Madagascar boa	LC	0.448	0.071	0.115	0.083	0.064	0.050	0.050	0.059	0.066	0.075
Chameleon	-	0.308	0.388	0.624	0.361	0.187	0.054	0.054	0.149	0.245	0.372
Threats											
Logging	-	0.559	0.501	0.970	0.748	0.415	0.063	0.063	0.461	0.835	0.997
Slash and burn	-	0.340	0.330	0.645	0.375	0.193	0.055	0.054	0.155	0.257	0.393

I selected four indicators to illustrate how the shape of the power curves changes according to low and high values of occupancy and detection probabilities, representing four corners of Figure 5.1. The crested coua (occupancy probability = 1, detection probability = 0.697) and Coquerels's coua (occupancy probability = 0.747 and detection probability = 0.522) are examples of both high occupancy and detection probabilities. The Madagascar boa is an example of both low occupancy and detection probabilities (0.448 and 0.071 respectively). The fossa has high occupancy (0.949), but low detectability, and Humboldt's heron has low occupancy (0.186) and high detectability (0.706). Power curves for these species (Figure 5.2) demonstrate that only for the Coquerel's coua and the fossa (both high occupancy probability species) is there 80% power to detect a population growth or decline in these species. Only a decline in the crested coua can be detected, as the probability of occupancy = 1. In contrast, detecting a decline or growth with 80% power was never reached for the Madagascar boa tree and Humbolt's heron. See Appendix B.2 for the power curves for all indicators.

Whether or not growth or decline of an indicator can be detected with 80% power depends on the probability of occupancy. For those indictors with low occupancy (e.g. logging and red-fronted brown Lemur), it is easier to detect population growth than decline, as occupancy is already low. Conversely, it is easier to detect a decline in species where occupancy is already high (e.g. crested coua and giant coua).

Four Endangered species and four Vulnerable species were monitored and observed in four or more villages. However, a 50% decline of the Verreaux's sifaka (endangered), and 80% decline of the red-fronted brown lemur (vulnerable) and white-breasted mesite (vulnerable) could be detected under the current monitoring strategy of 18 villages and 6 repeated patrols. A decline or growth of 80% or less could not be detected for the other five endangered species.



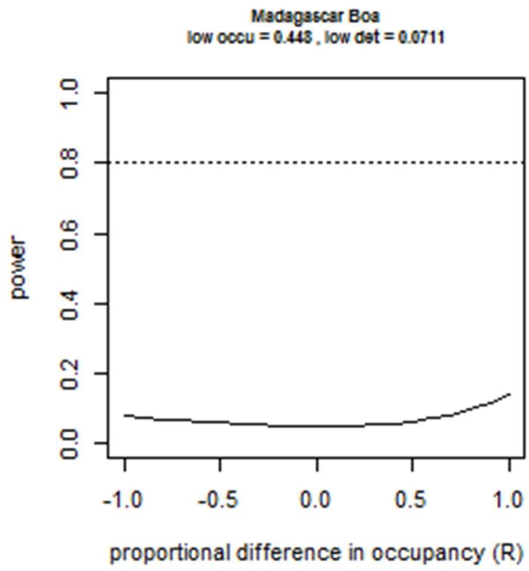


Figure 5.2 power curves (where α = 0.05) and the relative proportion of change in occupancy (R)[1] that can be detected between two sampling periods for selected indicators with range of high and low probabilities of occupancy and detection: high occupancy and detection = crested coua and Coquerel's coua; high occupancy, low detection = fossa; low occupancy, high detection = Humboldt's heron; low occupancy and detection = Madagascar boa. See Appendix B.2 for power curves for all indicators. Only a decline in the crested coua could be observed because occupancy = 1.

[1.] R = the proportional difference in occupancy (given occupancy is ψ) so that $\psi_2 = \psi_1 (1 - R)$, thus $R > 0$ represents a decline and $R < 0$ an increase (Guillera-Arroita & Lahoz-Monfort 2012).

5.3.3 Question 2: how does statistical power change with varying number of villages and patrols?

Of the 21 indicators, 13 would fail to reach 80% power to detect any level of growth or decline in the indicator even when the number of villages is increased from 18 to 54 or the number of patrols in each village increased from 6 to 24 (Figure 5.3 and Appendix B.2). Whether it is it worth improving effort (more villages or more transects per village) in an attempt to increase power to 80% depends on the combination of occurrence and detectability for each indicator. If an indicator has low occupancy or detectability (e.g. Madagascar boa or Humboldt's heron), 80% power to detect change is unlikely to ever be reached, regardless of any realistic increase in effort to monitor those indicators This suggests it is not worth monitoring these species in order to attempt to detect trends. For species with high occupancy but low detectability (e.g. fossa), increasing the number of patrols substantially improves power to detect change in the indicator. Therefore, it is probably worth increasing the number of patrols (and to a lesser extent the number of villages) to improve the ability to detect trends in these types of indicators. For a species with high occupancy and detectability (e.g. Coquerel's coua), increasing the number of villages and patrols would decrease the growth or decline that can be detected with 80% power. It might be worth increasing monitoring effort for these types of indicators – depending on the nature of the indicator (e.g. if it a species with high conservation interest), logistical and financial resources available. In summary, increasing the number of sites from the current number of 18 to 36 slightly improves power for those indicators where occupancy and detectability are above 0.4, but increasing the number of patrols per village from 6 to 12 substantially improves power for those species (such as the fossa) where occupancy is > 0.5, but detectability is < 0.5 (Figure 5.3).

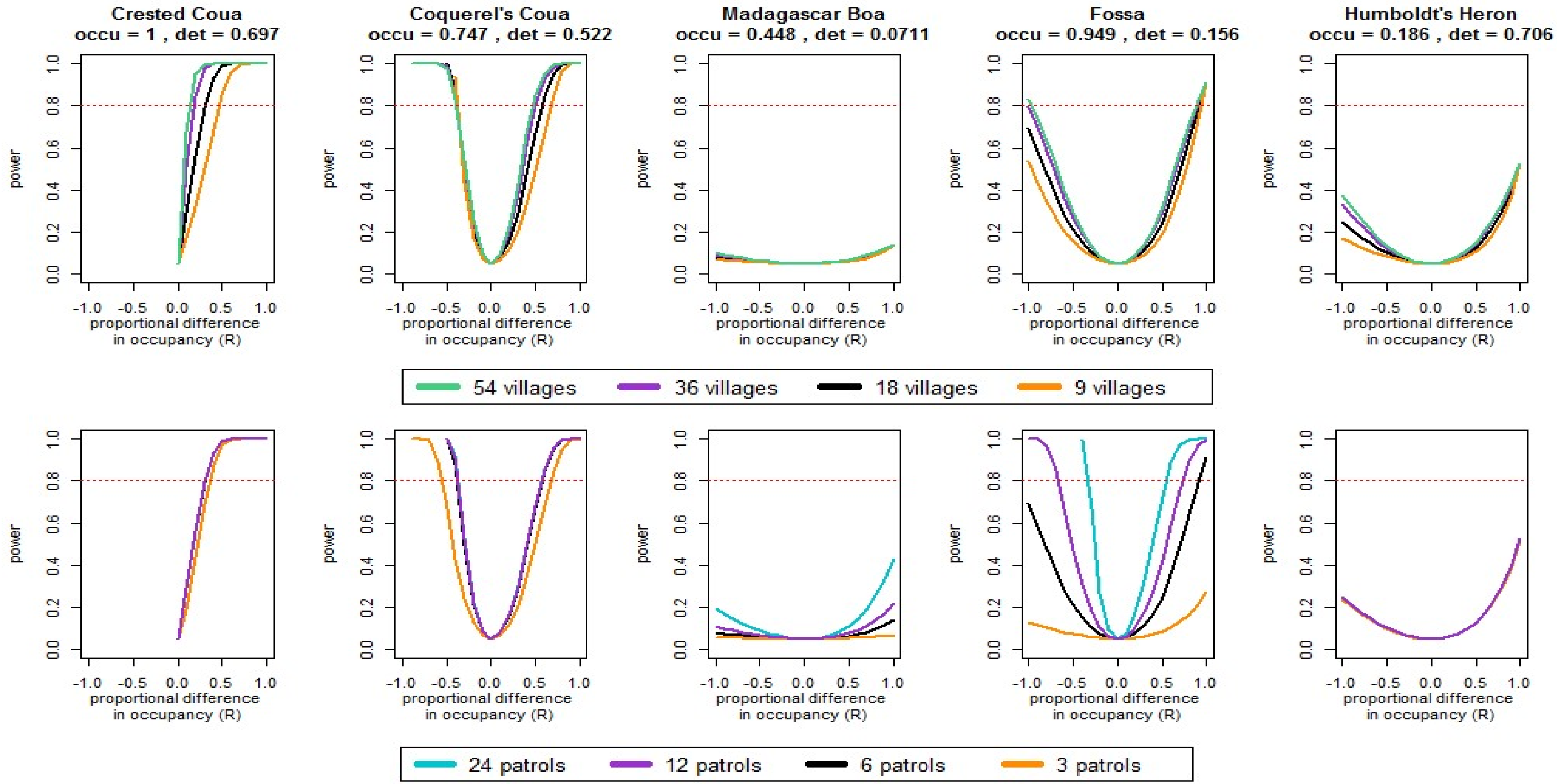


Figure 5.3 power curves for the relative proportion of change in occupancy that can be detected (R, where R > 0 is a decline, R < 0 is growth) for various number of villages (top row) and patrols (bottom row) for Crested Coua, Coquerel's Coua, Madagascar Boa, Fossa and Humboldt's Heron. See Appendix B for power curves for all indicators. Black lines indicate current strategy where S = 18 and K = 6. Red dotted line is a power of 0.8 to detect change between two periods.

5.3.4 Question 3: what is a robust monitoring regime to detect trends?

For species with a probability of occupancy of less than 0.6, detecting a decline in occupancy with 80% power requires fewer villages or fewer patrols than detecting growth (Figure 5.4, Appendix B.3). The cost of a monitoring strategy to detect change of an indicator decreases by increasing the number of patrols within a village from 2 to 6, hence requiring fewer villages. For those species with a probability of detection greater than 0.35, there is little to gain from increasing the number of patrols beyond 7.

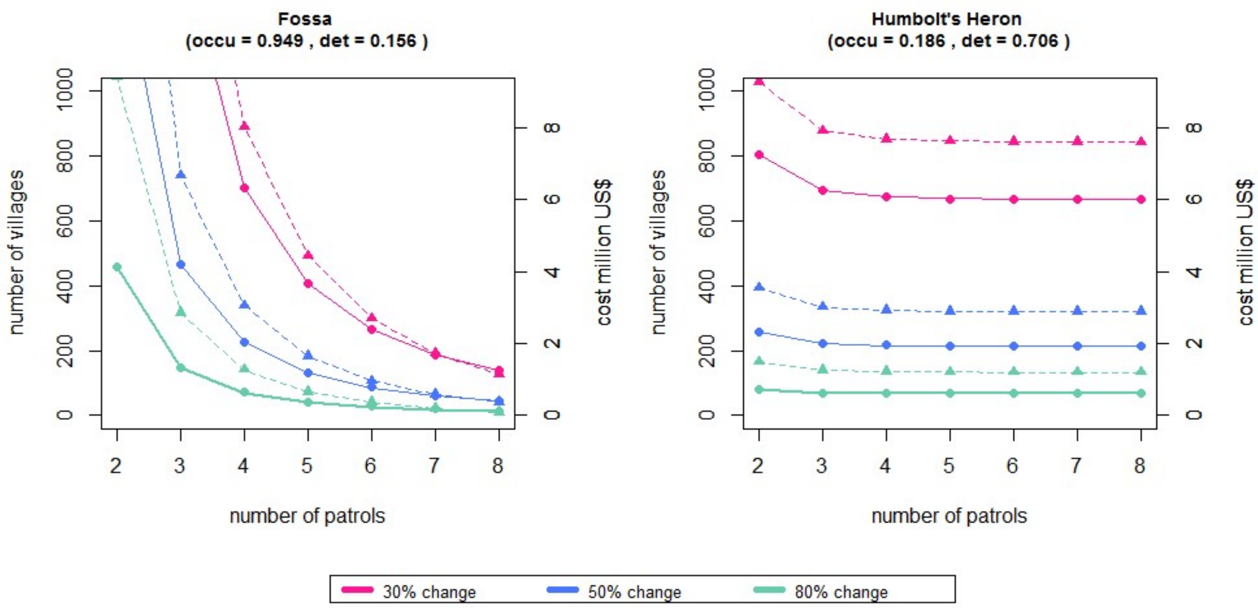


Figure 5.4 minimum number of villages and patrols required to achieve 80% power to detect growth (dashed line) and decline (solid line) at 80% (green), 50% (blue), 30% (pink) and the cost (triangle for decline, circles for growth) of monitoring for the given number of sites and patrols in two seasons for Fossa and Humboldt's heron.

The effort (number of villages or number of patrols) required to detect changes of less than 30% decline with 80% power is not only completely unrealistic requiring hundreds of villages (there are approximately 40 villages in the Menabe Protected Area) and is likely to be prohibitively expensive for all indicators; of 21 indicators, 17 required over 1000 sites to detect a 10% growth or decline. It may be feasible to detect declines of 50-80% for those indicators with high occupancy and high detectability (e.g. Giant coua and Coquerel's coua, see Figure 5.4 and Appendix B.3), although the project would have to be significantly scaled up in the landscape to include all villages in the area.

Given the prohibitively high cost of monitoring occupancy of these indicators at the landscape level (Figure 5.4), the effort and costs of monitoring indicator presence or absence to create an inventory at the village level was also explored. The indicators with a high probability of detection require fewer patrols than those with a low probability of detection to be sure of absence (Figure 5.5a). Four species with low probability of detection (fossa, red-tailed sportive lemur and Madagascar boa) required over 12 patrols (17, 20, and 40 respectively) in a site. In addition, increasing the number of patrols per season increases the number of indicators for which monitors could be sure that a non-detection means the indicator is absent from a site (Figure 5.5b). These calculations assume that there are no false positives, and that the species or threat is correctly identified and recorded.

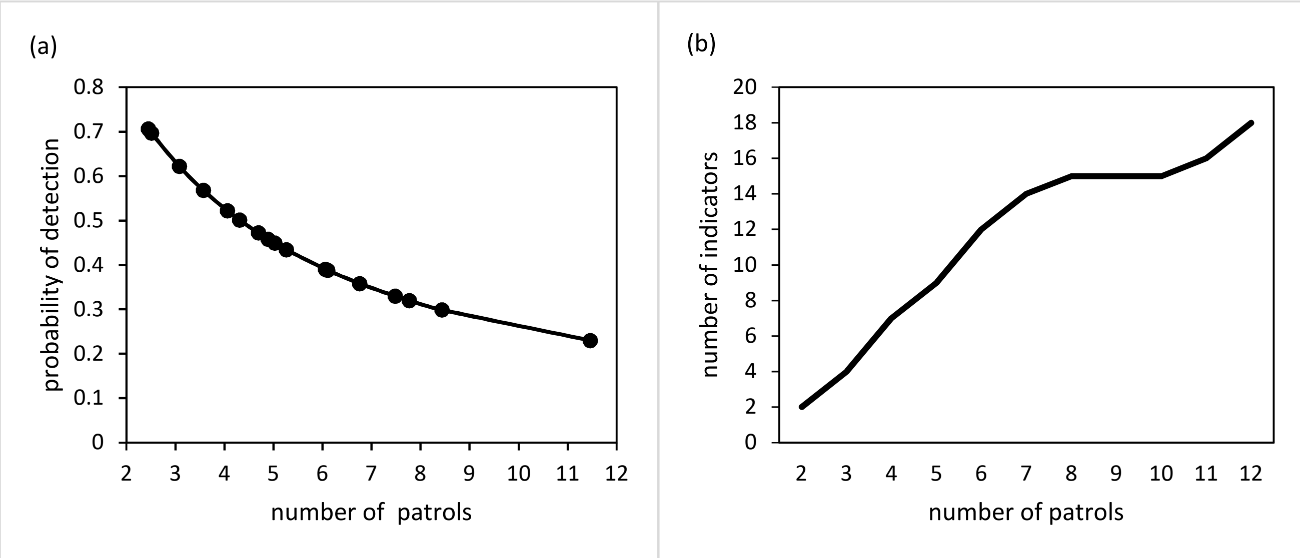


Figure 5.5 (a) The probability of detection of each indicator and (b) the cumulative number of indicators that could be confirmed as absent if not observed, as the number of patrols per season increases. This does not include fossa, red-tailed sportive lemur and Madagascar boa which required 17, 20 and 40 patrols respectively.

To illustrate how the inventory method could be used in combination with occupancy modelling to produce a robust, relatively low cost, monitoring scheme, Figure 5.6 shows the number of patrols each village actually conducted in the monitoring programme over the two-month period and whether each indicator was (a) observed, (b) very likely absent based on the number of patrols conducted and the probability of detectability or (c) whether it is uncertain whether the indicator was present or absent. Uncertainty arises where the number of patrols was too few to be confident that a non-detection meant the indicator was absent, or because the indicator was observed in fewer than 4 villages so that it was not feasible to model occupancy in order to calculate the probability of detection. As the number of patrols conducted in a village decreases, the number of species with uncertain presence-absence increases. If the sampling period for this study had been increased from the two months we chose to analyse, there would have been more patrols in each village within the sampling period, and therefore the uncertainty about species presence-absence would be reduced. Comparisons between the presence-absence of species and indicators between villages are difficult because of the range of number of patrols conducted and thus the varied levels of uncertainty. However, for those villages with seven or more patrols, two villages (Beroboka and Kivalo) had low numbers of confirmed species and high numbers of confirmed threats, so that one might tentatively suggest that conservation efforts may not be working so well in these areas. Conversely, Ankitapo and Kiboy had low number of threats and a high number of species observed.

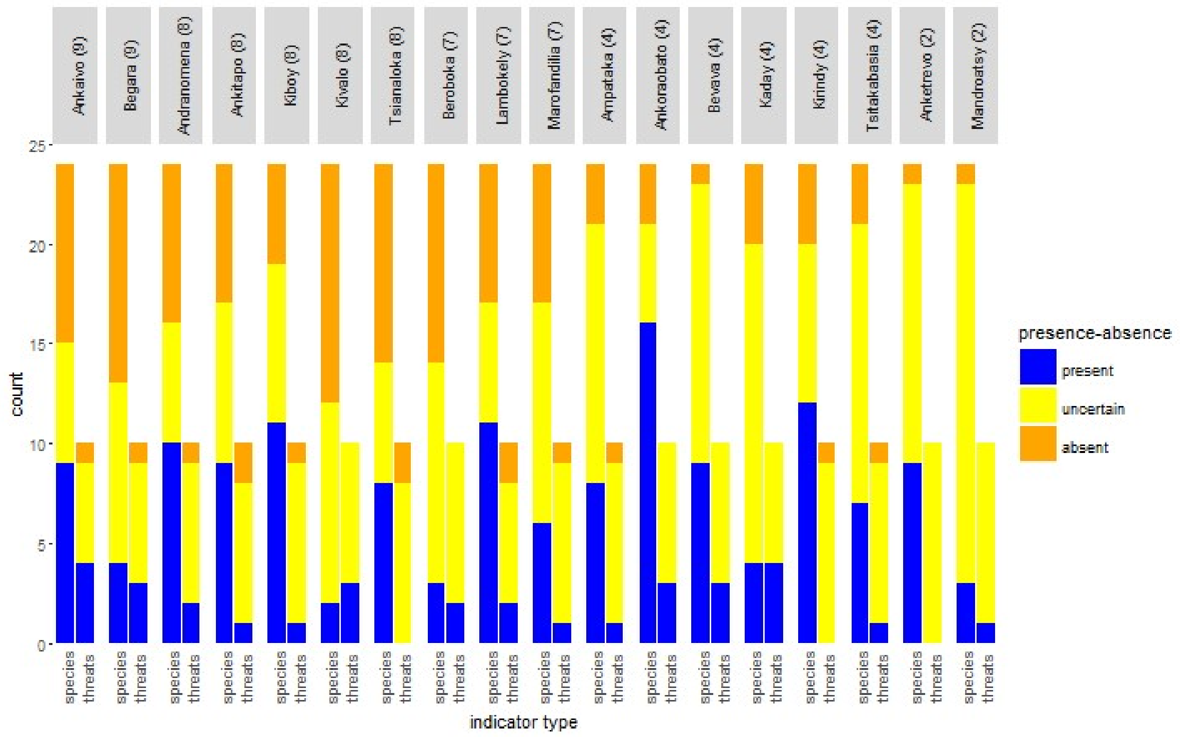


Figure 5.6. Village (with the number of patrols in parentheses) and the number of species and threat indicators where the species is present (it was observed), unknown (where there were too few patrols or the indicator was not modelled) or absent (where it was not observed and there were sufficient patrols conducted to say with confidence that the indicator was absent was met). Note: Kaday and Kivalo are mainly mangrove habitats, whereas all others are dry deciduous forest.

Table 5.6 shows the overall cost of a five-year monitoring project that would meet the effort needs to detect 50% growth or decline in the landscape-level occupancy of a given set of indicators with 80% power. For example, with a budget of $500,000 you could monitor for a 50% decline or growth in the crested coua and giant coua and 50% growth of Coquerel's coua over 5 years using the current monitoring strategy (A), but no other indicators would meet the 80% threshold for that budget. For most indicators the costs were likely to be prohibitively expensive to detect trends over time. Detecting a 50% change in 6 indicators over 5 years with 80% power would be possible with a budget of $750,000 using strategy C or D. The 3 most informative species (in terms of detecting change in occupancy) are common types of coua bird, all least concern and therefore not of particular conservation interest, although they might be of interest if they are good indicators of the health and state of the ecosystem. However, of potential conservation interest is that a 50% decline or growth in occupancy of the endangered Verreaux's sifaka and vulnerable Red-fronted brown lemur could be detected with a budget of $400 000 to $600 000 using strategy C or D. Apart from logging (with a large budget of around $600 000 - $700 000), none of the current threat indicators provide useful information on landscape-scale trends. Reptiles and plants are also poor indicators for detecting trends over time.

The inventory approach is substantially cheaper than the occupancy approach (Table 5.6). For less than $100,000, species and threat presence-absence can be determined across 18 villages over five years. In fact, this budget could incorporate monitoring of all 34 indicators that were originally recorded, but were not included in the data analysis because they were not observed in more than 4 villages. In addition, the inventory approach at the village level does not have a minimum requirement for the number of villages monitored and is therefore more adaptable if a budget varies between years.

Table 5.6 the total minimum cost (US$) of a five-year monitoring project with a strategy sufficient to detect a 50% decline or growth of each indicator with 80% statistical power of detecting a trend. Calculated for a range of scenarios with varying levels of investment and community involvement, from most (scenario A) to least (scenario D) and the inventory approach in all 18 villages. Strategies costing less than $250,000 are black, between $250,000 and $500,00 are dark grey, between $500,000 and $750,000 are light grey.

indicator	Red List Status	cost scenario A (US$)		cost scenario B (US$)		cost scenario C (US$)		cost scenario D (US$)		cost inventory approach (US$)
		50% decline	50% growth	50% decline	50% growth	50% decline	50% growth	50% decline	50% growth	
Crested coua	LC	**313,232**	**78,308**	**224,616**	**56,154**	**116,908**	**29,227**	**113,031**	**25,118**	**95,145**
Giant coua	LC	**430,694**	**78,308**	**308,847**	**56,154**	**160,749**	**29,227**	**200,944**	**25,118**	**95,355**
Coquerel's coua	LC	978,850	**430,694**	701,925	**140,385**	**365,338**	**73,068**	**364,211**	**138,149**	**95,285**
Verreaux's Sifaka	EN	1,331,236	1,252,928	954,618	533,463	**496,859**	**277,657**	514,919	**401,888**	**95,285**
Red-fronted Brown Lemur	VU	1,761,930	1,957,700	1,263,465	1,038,849	657,608	540,700	653,068	627,950	**95,285**
logging	-	1,840,238	2,036,008	1,319,619	1,151,157	686,835	599,154	665,627	653,068	**95,285**
White-breasted mesite	VU	3,093,166	5,677,330	2,218,083	2,667,315	1,154,467	1,388,283	1,368,931	1,821,055	**95,426**
Fossa	VU	3,367,244	13,273,206	2,414,622	3,004,239	1,256,761	1,563,645	2,825,775	4,257,501	**96,198**[1]
slash and burn	-	4,659,326	9,592,730	3,341,163	4,548,474	1,739,007	2,367,387	2,122,471	3,076,955	**95,496**
Givotia sp.	-	4,815,942	14,643,596	3,453,471	4,745,013	1,797,461	2,469,682	3,102,073	4,697,066	**95,847**
chameleon	-	4,894,250	8,770,496	3,509,625	4,801,167	1,826,688	2,498,909	1,971,763	2,813,216	**95,426**
Viguieranthus sp.	-	6,538,718	11,198,044	4,688,859	6,794,634	2,440,455	3,536,467	2,436,446	3,591,874	**95,355**
Madagascar rosewood	-	6,851,950	19,655,308	4,913,475	7,159,635	2,557,363	3,726,443	4,069,116	6,304,618	**95,777**
Humbolts heron	EN	8,418,110	12,685,896	6,036,555	9,012,717	3,141,903	4,690,934	2,712,744	4,069,116	**95,145**
Sacred Ibis	LC	8,574,726	13,234,052	6,148,863	9,237,333	3,200,357	4,807,842	2,825,775	4,244,942	**95,215**
Madagascar crested ibis	NT	9,553,576	20,829,928	6,850,788	10,388,490	3,565,694	5,406,995	4,282,619	6,681,388	**95,496**
Masonjoany	-	9,749,346	18,363,226	6,991,173	10,613,106	3,638,762	5,523,903	3,817,936	5,890,171	**95,426**
Red-tailed Sportive Lemur	VU	10,140,886	39,075,692	7,271,943	11,090,415	3,784,897	5,772,333	7,799,139	12,533,882	**96,409**[1]
Madagascar Teal	EN	12,881,666	20,908,236	9,237,333	14,347,347	4,807,842	7,467,499	4,307,737	6,706,506	**95,215**
Striped mongoose	EN	14,839,366	34,377,212	10,641,183	16,677,738	5,538,517	8,680,419	6,894,891	11,026,802	**95,566**
Madagascar boa	LC	44,870,484	188,369,894	32,176,242	52,588,221	16,747,071	27,371,086	36,534,131	60,421,349	**97,814**[1]

1. These indicators require >15 patrols for the inventory approach, which may not be feasible.

5.4 Discussion

5.4.1 Goals of conservation monitoring

For any given intervention, a manager will wish to monitor progress toward a project goal. In the context of conservation this might be an increase in species abundance or occupancy, or decrease in threats over space or time. It is important to understand the statistical power of data collected in order to know when a goal has been reached, and not waste time or resources on monitoring programmes that are highly unlikely to be able to detect a trend when one is present. A power analysis is a useful tool for measuring statistical power of a current regime or explore scenarios given budgetary constraints. Through a case study of a monitoring project in Menabe, Madagascar, this research demonstrates the importance of conducting power analysis to determine whether it is practical or feasible to detect changes in occupancy of species and threats at the landscape level. I found that overall, most indicators fell short of achieving adequate power to detect changes in their occupancy over time and make inference over a wider landscape. However, an inventory approach, focussed on ascertaining the presence-absence of indicators at the village level, might be a more cost-effective and feasible way of assessing change in space and time.

5.4.2 Inferring trends in occupancy at the landscape level

This study is different to other power analyses of occupancy models in that, for the first time, probability of detection is incorporated into the power analyses, using the formula developed by Guillera-Arroita & Lahoz-Monfort (2012). The most powerful, and therefore useful, indicators for detecting trends over time are those with a probability of occupancy > 0.45 and a probability of detection > 0.4. Of the 34 indicators used in the monitoring project, only six indicators met this criteria (Table 5.3). Even then, the percentage population change that could be detected was large; none of these indicators could detect 10% growth or decline in occupancy between two monitoring episodes, two indicators could detect 30% decline and the other four indicators could detect only a growth or decline of 50% or more (Table 5.4).

Increasing the number of villages and patrols conducted improved the power of some indicators to detect trends. However, a substantial and implausible, amount of money is required to detect change in most of the current set of indicators at the landscape level (Table 5.5). Aside from the cost, it is quite unrealistic to scale-up the monitoring to the required number of villages (100+) given that there are approximately 36 in the Menabe Protected Area. The monitoring could be made more cost-effective by reducing the number of visits by Durrell staff to the villages and decreasing the intensity of monitoring (such as in new strategies B and D) or reducing the monitoring period to a two-month season (such as in strategy C and D). But realistically, the number of indicators with sufficient power to detect meaningful trends remains low and costs remain high.

Conservation managers might be particularly interested in rare species and those that are included in management plans (such as the giant jumping rat, flat-tailed tortoise and Madame Berthe's mouse lemur for the Menabe Protected Area), however these can be difficult to monitor. In this study, these species were found in fewer than four villages, and were therefore not suitable for modelling occupancy. Sommerville et al. (2011) came to similar conclusions in research that examined the use of species and threat indicators in a community-based payments for ecosystem services (PES) scheme in the same area of Menabe as this case study. They explored a range of approaches to detect change in the proportions of sightings with observations of each indicator, such as looking for trends within sites, differences between sites and progress towards a target, and concluded that only the most common indicators had sufficient power on which to base a 'payments for environmental services' scheme.

This study is a retrospective power analysis, however, if they are conducted during the design phase of a monitoring scheme they can be invaluable in informing the design of monitoring. For example, Ellis et al. (2014) simulated a spatially explicit occupancy model of the wolverine in the Rocky Mountains, to assess the power of a potential monitoring regime to detect trends. They found that detecting population trends required large-scale intensive sampling, even for large changes of 50% decline over 10 years. In many of the scenarios they tested, sufficient statistical power to achieve their goal of detecting changes in population size could not be attained. As a result, this method of monitoring was not pursued and other approaches for monitoring wolverines were explored.

5.4.3 Inventory approach at the village level

The inventory approach requires fewer repeated patrols in each village than the occupancy scenarios. Using the probabilities of detection extrapolated from the occupancy models, for eight indicators (5 bird species, 2 mammal species and logging), only four repeated surveys would be needed in a season to determine whether non-detection of the indicator means that it is absent from the site.

Calculating the minimum number of patrols that should be conducted requires information about the probability of detection for each indicator. Where this information is not available for an indicator, a manager would ideally conduct a one-off occupancy study in order to get detectability and know how many patrols are required (Dorazio et al. 2006). Alternatively, an informed guess at detectability from detailed study of similar species or in a different site, would probably be sufficient. Despite the need and possible costs of gathering this information, there are practical and financial advantages to this presence-absence approach over the current regime of attempting to model and infer change at the landscape level. One advantage of the inventory approach over estimating trends in occupancy or abundance is that there are no strict assumptions with respect to population closure, so that patrols could be conducted over a longer time period or fit in around local people's existing livelihood activities. There are no minimum number of villages that need to be involved for the information to be useful to managers for detecting spatial or temporal differences in presence-absence of species or threat indicators. Selecting villages to be involved in the monitoring scheme might be based on those where the management and conservation activities are working well or less well, where there are known populations of species of conservation interest or because of concern about a particular threat in some villages, or purely for logistical, financial or political reasons. It is also worth noting that once all indicators have been detected, there is no need to continue patrols, so monitoring may not take as much effort as originally anticipated, thus making it even easier and cheaper than occupancy monitoring at the landscape level.

If patrolling effort was standardised across villages and conducted at the same time, the information could be used to compare the presence of species and threats over time and space. This would mean that the original monitoring goals would be met. If a manager intends to use the inventory approach to make comparisons between villages (Figure 5.6), the assumption needs to be made that the monitors in each village are equally motivated and enthusiastic to conduct patrols and record the information with diligence and accuracy. Ideally, there would also be similar effort put into each patrol across all villages, by conducting patrols at similar times of the day, over identical distances. This information could easily be included on the data entry sheets. If there are large differences between villages then advanced statistical techniques and could account for variable effort if desired. Currently, the patrol timing and duration are likely to differ between villages, but should this be standardised, this approach would be well suited to making some basic spatio-temporal comparisons.

5.4.4 The social aspect of participatory monitoring

In addition to the monitoring goal of informing management and understanding the system, most participatory monitoring projects, such as this case study, have social goals. This PEM scheme also seeks to engage local people in the control of natural resources, mainly because of the formal co-management arrangement of the new Menabe Protected Area system. In addition to this, increasing local participation is also linked to the effectiveness and longevity of schemes (Schultz et al. 2011; Brooks et al. 2013). There are aspects of the inventory approach that would be well suited to meeting some of the project's social goals. Mainly, there is an opportunity for local people to be involved in the data interpretation, because summarising which indicators were observed and which were not does not require complex statistical analyses to be performed by professional scientists. In practice, Durrell staff could coordinate participatory mapping of the results at the end of each sampling season as means of analysing the data and increasing the level of participation of local people, including opening up the project to the wider community. McCall & Minang (2005) describe the use of participatory mapping in community forest planning and management in Cameroon. They conclude that the participatory mapping process increased understanding, good governance, empowerment and improved the relationship between the community and the state. Applying participatory mapping to the Menabe PEM project may also have such a positive social impact. Furthermore, involving local people in interpreting the data would also reduce the amount of time and money spent on data management of this project and eliminate the bottle-neck that has inhibited the flow of data from the villages to analysis, interpretation and dissemination (see section 3.8). In addition, Durrell have good links with local, regional and national department of the Ministry for Environment, Ecology and Forests and are therefore well placed to facilitate communication and flow of information between communities and the authorities. Despite the cost-effectiveness of the inventory approach and limiting monitoring to a few months of the year, it may not be widely popular by the monitors, because of the loss of a small but regular year-round income. This will also limit the potential of the monitoring to trigger action and law enforcement by local government authorities when a new threat emerges or intensifies.

It is important to recognise the strategies explored in this chapter do not take the intangible costs and benefits into account. For example, although there is a financial cost to each Durrell visits, there are also benefits such as relationship building with communities and encourage to local people remain engaged with the scheme. However, these are difficult to quantify and include as a thorough cost-benefit analyses of each of the strategies, and beyond the scope of this research. If these other stratifies were financially feasible and were being pursued, there would need to be a thorough assessment of the social impacts of beyond the financial costs.

5.4.5 Species and threat indicators

The current 34 indicators were chosen by the local communities, with input from Durrell, for a range of reasons; because they were distinctive to identify, common, useful or of conservation interest. This research shows that it would be more cost-effective to only monitor those indicators with a high probability of occupancy and detection (such as the three coua bird species, Table 5.3). Although species of conservation interest (such as those on the IUCN Red List) or those of interest to local people as a natural resource might be obvious candidates for monitoring, they are not always suitable for a powerful statistical analysis of trends due to low detectability. As species indicators were not specifically selected for their known response to management, it is unclear how good they are at indicating the health of the ecosystem. A conservation practitioner needs to ensure that indicators are sensitive to management if they are intended to provide information that is useful in making informed decisions (Noss 1999; Failing & Gregory 2003; Simberloff 1999). A manger might assume that all indicators respond to management or enforcement in the same way (positively for species indicators, or negatively for threat indicators), in which case the number of indicators can be reduced. However, it is likely that some indicators are more sensitive to management than others (Noss 1999), in which case, using a wide range of indicators or recording as many species as possible and measuring species richness will improve understanding of the dynamics of the monitored system (Yoccoz et al. 2001)

On the other hand, threat indicators are a direct measure of anthropogenic pressure and the impact of management on the ecosystem. My study shows that of the 10 threat indicators monitored, only two were observed in four or more of 18 villages (Appendix B.1). This is problematic for occupancy modelling, where there is not enough information to make inferences about a wider area. However, this information can be useful for the inventory approach to understand what and where threats exist and to prioritise management, law enforcement or implement community-based conservation initiatives.

5.4.6 Conclusion

From the perspective of a conservation manager who wants to know whether species or threats are growing or decline, there are a myriad approaches and indicators to monitor changes over the landscape level. Trends in occupancy are increasingly seen in ecological studies, but less so in PEM schemes. This study used power analysis to show that gathering data with sufficient statistical power to detect changes in occupancy is challenging and prohibitively expensive. This is quite a concern for monitoring schemes, such as this and many other PEM schemes, where the sample size is small. For this reason, managers and project implementers should be encouraged to conduct power analysis of a monitoring scheme and ensure that they can detect change and meet their goals before committing large amounts of time and resources to a monitoring scheme. However, even more fundamental than power is the requirement for a sufficient budget for the management and analyses of the data that are produced. This has been a large stumbling block to this case study (see section 3.8) and therefore, the current data collection efforts are unable to provide anything other than superficial levels of information. Invariably, there will be other opportunities or approaches that might be suitable for monitoring that can contribute to management and decision-making. In exploring other options, I scaled-down the level of interest to the village level without inferring trends over a wider area and explored presence-absence of indicators as part of an inventory approach. The main advantage of the inventory approach at the village level is that there is no issue of sampling and making inference about a potential "infinite" super-population, but instead the focus is on the site-level situation. Although this does not attempt to measure change at a landscape level, a manager can determine whether a species or threat is present or absent from a site and make basic comparisons between villages or over time, with the addition of recording basic time and effort information. This information is substantially easier and cheaper to collect, whilst still being meaningful and useful for decision-making and management, by informing conservationists which species or threats are where and when. This does rely on an initial estimate of detectability, which may still need to come from an occupancy modelling approach, with the concomitant, but one-off, costs.

Chapter 6 Gaining local perspectives of participatory ecological monitoring for conservation

6.1 Introduction

Gathering local perspectives is a key way to monitor benefit and cost flows as part of a social impact assessment or a feasibility study of an intervention involving local people (Homewood 2013; van Heist et al. 2015). Bennett (2016) describes four ways that perceptions can be used to understand whether an initiative is undermining or generating the support of local people: (1) social impacts, (2) ecological outcomes, (3) legitimacy of conservation governance and (4) acceptability of management. However, within the scientific literature the point has been widely made that monitoring socio-economic impacts, local perceptions of interventions, as well as benefit and cost flows to local people is not done enough (Danielsen et al. 2007; Brechin et al. 2002). Many institutions, such as the World Bank (2003) have increasingly rigorous requirements that interventions (conservation or otherwise) consider the socio-economic situation and outcomes of their actions. At a time where there is drive to include local people in monitoring (participatory ecological monitoring, herein 'PEM', see Chapter 2) and control of their natural resources at the global level, it is especially important to understand the suitability and sustainability of this approach to contribute to the social development and wellbeing of people involved.

The only way to understand local peoples' perspective is to communicate with local people. There are some examples where the perceptions of local people have been sought, in relation to forest or protected area management (e.g. Ferreira & Freire 2009), payment for ecosystem services schemes (e.g. Hayes 2012) and ecotourism (e.g. Kolahi et al. 2014). However, there are no examples of studies capturing local perceptions of PEM schemes, which limits our understanding the effectiveness and potential of PEM to meet conservation and development goals, and adhere to ethical standards.

This study examines local perceptions of a PEM schemes in Menabe in western Madagascar. This project, implemented by the Durrell Wildlife Conservation Trust (herein 'Durrell'), is an ideal case study for this research because it is well established and its implementation coincided with the creation of community managed Protected Areas across Madagascar. See Chapter 3 for a full description of the national and regional context, plus a detailed description of the history, development and current status of the PEM scheme.

The overall aim of this study is to understand local perspectives on the Durrell monitoring project from across all sectors of the community. The specific questions to be addressed are:

- How much knowledge is there of the monitoring project in the villages; who has heard about it and who hasn't?
- How do different segments of society (monitors, village committee members and others) perceive themselves and others to: (a) benefit or (b) lose out from the monitoring project, and what reasons do they give?
- How do these perceptions vary by village, are there village level characteristics that might explain this variation, and how do these perceptions relate to external assessments of the success of the project in engaging local people?

Based on my understanding and knowledge of Durrell's work in Madagascar and the PEM scheme in Menabe, I have the following a priori expectations. Firstly, I expect the project to have brought a variety of tangible and non-tangible benefits to local people. Due to the nature of the project, not all benefits (such as payments to the monitors) are available to everyone in the village, therefore it is likely that there will be differences in the benefit and cost flows that people feel they get and perceive others to get. As a result of enhanced enforcement and reporting of infractions of forest laws through regular patrols by the monitors, it is expected that some sectors of the community (illegal forest users) might lose out from the project. I expect the project to be more or less successful in meetings its aims in different villages. This may be due to the inherent characteristics of the village (such as the effectiveness of the VOI association (village committee)), or the commitment and enthusiasm of the monitors. Where the project is regarded by external assessors as most successful, I expect that the local people will have a more positive perception and feel more benefit with fewer costs than villages where the project is perceived to be less successful.

6.2 Methods

6.2.1 Data collection

This study focusses on the Menabe region of dry forest and savannah in central western Madagascar (see Chapter 3 for a full description of the case study). Of a possible 18 villages that are part of the Durrell project in Menabe, 9 were selected for this study based on their accessibility and security situation, and therefore the appropriateness for conducting fieldwork. In addition, two villages, Kaday and Kivalo, were ruled out on account of being predominately mangrove habitat with different livelihoods, compared to all other villages inhabiting dry deciduous forest. Data were collected between March and September 2015. During February and March the author and a Malagasy researcher hired and trained two people from the region, who spoke the regional dialect, but were not from the study villages themselves. Over three weeks, these two Research Assistants (RAs) were trained to understand the aims of the research, the nature of the monitoring project and data collection methods. Following this period of intensive training the research team spent six days in the first pilot village, Ankorabato, followed shortly by 12 days in

Andranomena village. During these pilot surveys the protocols and questionnaires were tweaked to ensure the phrasing was appropriate and the questions were comprehensive and clearly understood by the RAs and respondents. This also served as an opportunity to finalise the training of the RAs.

Approximately one week of the training period was spent translating the English versions of the questionnaire into the local language (see Appendix C.1. for the English and Malagasy dialect questionnaires). An experienced Malagasy researcher trained to conduct social surveys worked closely with two research assistants that spoke the local dialect and would be conducting the surveys in each of the villages. Once the Malagasy versions were made, they were sent to a senior project manager at Durrell for backtranslation and to check that they were appropriate and correctly phrased.

Following the pilot survey the two RAs spent 12 days in each of the 7 study villages (Figure 6.1): Ampataka, Beroboka, Kiboy, Kirindy, Lambokeley, Marofandilia and Tsianaloka. Prior to commencing data collection a trip was made to each village to meet the village President. During this meeting the RAs would describe the nature of the research and seek permission to visit and stay in the village for 12 days to start on a mutually suitable date. No-one refused them access to the village for the purposes of this research and there were no social tensions or difficulties that hindered or delayed the data collection.

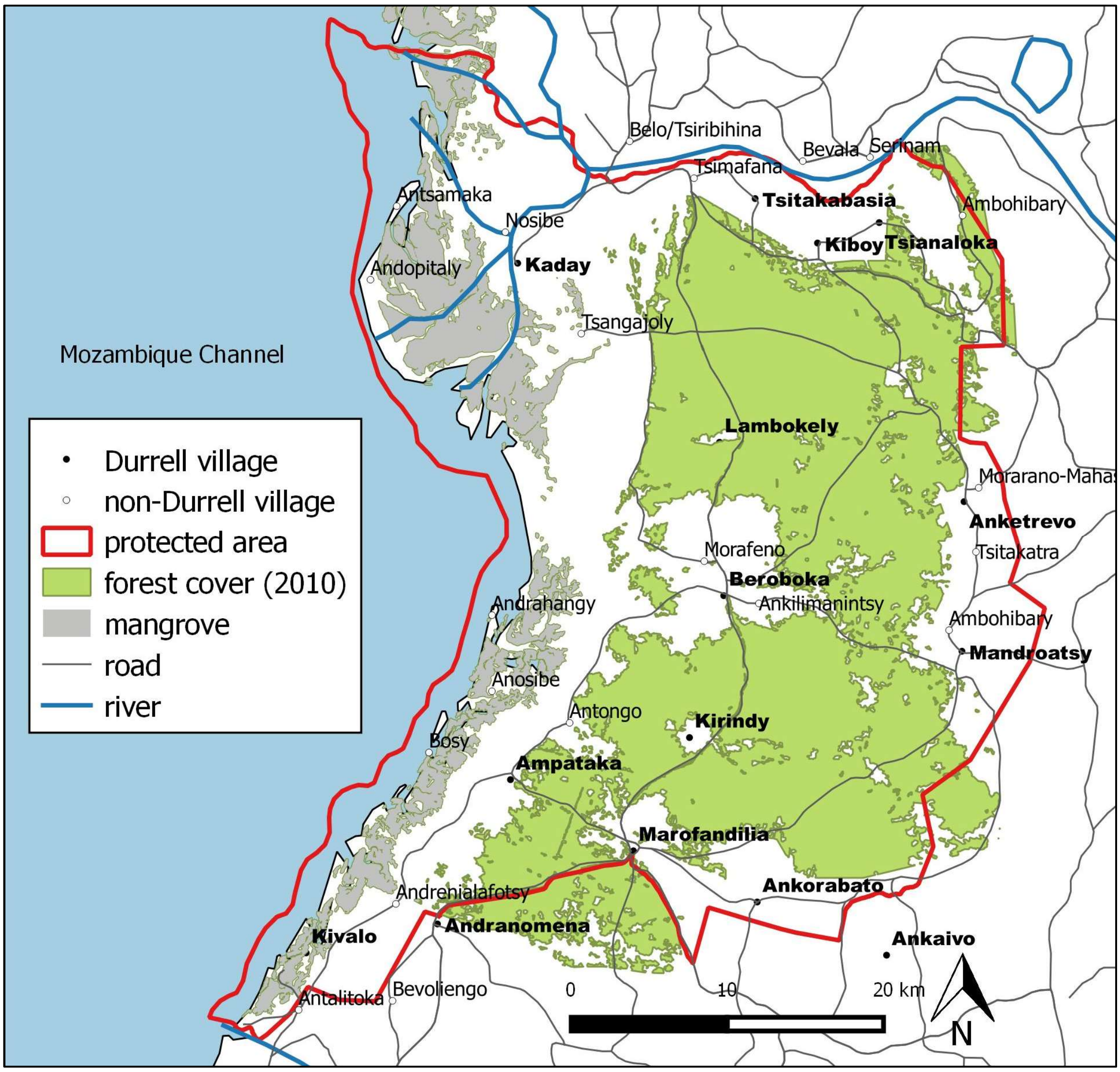


Figure 6.1. Map of the Menabe region in Madagascar and the location of the Durrell villages, 2 pilot (Andranomena and Ankorabato) and 7 study villages (Ampataka, Beroboka, Kiboy, Kirindy, Lambokeley, Marofandilia and Tsianaloka).

Maps of the households in each village or a current census list of the village were not available in either of the pilot villages. We did not have adequate time or resources to gather our own GPS data and compile a map for the sampling framework. Therefore, during the first few days, the extent of the village was established on foot. Once this was known, random households were selected for interview, ensuring that they were evenly selected throughout the village. During these scouting trips, the variation in the quality of housing was also observed and graded into three categories (A, B and C) based on the following characteristics:

A) Houses with two of the following features: tin roof, cement flooring or rendered external walls.
B) Houses with less than or none of the above features, but generally intact.
C) Houses with holes in walls or roof, partially collapsed.

The aim was to conduct 50-60 household surveys in each village, with and even spread of category houses, where possible.

During each village visit five types of meetings/surveys were conducted:

a) *Initial village meeting*: when the RAs arrived in the village a general meeting was called in the village so the RAs could introduce themselves and organise participants, time and locations for focus group discussions (see below).
b) *Informal meeting with the village President*: this was conducted at the President's home as a sign of respect and a means to clarify the intention of the RAs and the research, whilst also providing an opportunity for the President to ask any questions about the research. This meeting also provided the opportunity to gather data on the village characteristics, by asking questions about the main livelihoods, the security situation and anything else relevant to the study.
c) *Focus groups*: discussions were held at a time and location convenient to the participants. During the initial village meeting the RAs requested volunteers for three focus group discussions. The purpose of the focus group was to introduce the RAs to the villagers and to put the local people at ease concerning the nature of the RAs visit, whilst also being an opportunity to get some background information on the village. One group consisted of men only, one group of women only and one group made up of members of the VOI association. Each group consisted of 8-10 participants. A series of 13 open-ended questions was discussed (see Appendix C.1.1). At the start of the focus group the RAs distributed drinks to the participants. Each focus group lasted 1.5 hours on average, but no longer than two hours.
d) *Household survey*: After a few days familiarising themselves with the village, each house was assigned a score on a three-point scale (A – C) depending on the quality of the house (intactness, whether the walls were plastered or painted, type of roof, type of flooring). Approximately 50 households were selected for interview in each village, with an even spread of house categories where possible (although there were often fewer high quality houses in each village). The households selected for interview were evenly spread throughout the village. Households were approached at different times of the day to allow for those that were absent from their homes. If a household was approached and the head of the house or partner was not available, a time was arranged when they could return to the house to complete the survey. Where possible all interviews were conducted in the interviewee's house and out of earshot of other households. The interview consisted of 37 closed and open-ended questions (see Appendix C.1.2). No-one refused to answer any of the questions.
e) *Monitor meetings and interviews*: following the initial village meeting, the monitors were identified and greeted. A convenient time and place were arranged for an informal meeting with all the monitors, who numbered 4-6 per village. During this discussion the RAs asked a series of general questions about the monitoring project and how they conduct their patrols, collect and record the data. A one-to-one interview was arranged with each monitor where they were asked

a series of 64 open and closed questions (see Appendix C.1.3). No-one refused to answer any of the questions.

For each question asked, 'unsure' was a valid answer. For the variable about the project making life easier, the unsure responses (n=2) were removed from the dataset for modelling as there were so few. For questions about the benefits and losses of the scheme, there were more unsure answers (n = 20, n= 23 respectively), therefore these were taken as 'no benefits/losses', to be conservative whilst also being able to retain these data in the analyses.

At the end of each meeting or interview, the participants were given a food bundle (of salt, sugar and coffee) as a token of appreciation and compensation for their time. At the end of every household survey, the RAs recorded how relaxed and willing the respondents were in answering questions and whether they felt the answers were honest and reliable (see Appendices C.1.2 and C.1.3). Based on this, three surveys were removed from the analyses because the respondents seemed tense or uneasy, and provided answers or responses that seemed unreliable.

During the interview or discussion group all answers were written on paper data sheets or in notebooks in the local language. During the focus groups one RA was responsible for facilitating the discussion, whilst the other recorded the responses in note format in the local language. Within one week of each interview, these notes were read out in English and verbally recorded onto a tablet using a recording application. These files were then sent to the author for analysis. The author listened to the audio files, wrote down and coded relevant information in a Microsoft Word document. Within one week, all answers from the questionnaires (written in the local dialect) were translated into English by the research assistants and simultaneously entered onto tablet devices using the Open Data Kit Software (www.opendatakit.org). The answers from the questionnaires were exported from the Open Data Kit Software to Microsoft Excel where they were checked and cleaned by the author prior to analysis. The paper records were handed over to S. Earle for secure storage in the UK.

6.2.2 Wealth index

The wealth of each household is likely to influence how they see the costs and benefits of the project. However, wealth cannot be measured in purely monetary terms, and particularly in rural areas of developing countries there may be an important distinction between productive assets that contribute to livelihoods of different kinds, and assets which contribute more directly to lifestyle and wellbeing. Therefore an asset-based approach is often used (e.g. Howe et al. 2008; Vyas & Kumaranayake 2006). During the household surveys, data on different wealth indicators were collected; whether anyone in the household had a paid job, number of zebu (cattle) owned by the household, whether anyone in the household owned land and a subjective three-point score of how wealthy they considered their household to be relative to the village. These data are not independent, therefore selecting one or several to include in the model would be inappropriate. Therefore a Factorial Analysis on Mixed Data (a type of Principal

Component Analysis) was conducted using the FactoMineR package in R (Le et al. 2008) in order to create a wealth index for each household. The analysis reached 100% variation with 6 dimensions. Dimension 1 captured physical assets such as land and zebu ownership (representing 26% of the variation), whilst dimension 2 captured income-related measures as a result of someone in the household having a job and perceived wealth relative to others in their village (representing 21%). Dimensions 1 and 2 were chosen as variables because there were clear differences between the two dimensions (see Appendix C.2). The third dimension was less clear-cut in interpretation and only captured 16% of the variation.

6.2.3 Project success score

The RAs and two members of Durrell staff familiar with the project were asked independently to use their expert judgement to subjectively measure 'project success' in each village based on the definition above. The project was defined for this study as "successful" in a given village if (1) there were frequent and regular patrols and the forest laws were enforced, (2) the monitors were motivated to conduct the patrols, and (3) there was general enthusiasm for the project throughout the village. All assessors agreed that the project was more successful in some villages than others. The RAs ranked the villages and the Durrell staff scored them. Their assessments were similar (Kendall, tau = -0.744, p value < 0.001), so an overall score for each village was produced by scaling the RA rank to give equal weighting to the views of both sets of assessors and summing the scores (see Appendix C.3).

6.2.4 Data analyses

All data exploration and analyses were conducted in R (R Core Team 2015). There are four binary response variables, whether: (1) the respondent had heard of the project, (2) it made life easier[3], (3) anyone benefits, and (4) anyone loses out because of the project. See Appendix C.4. for a full description of each variable. All the variables were plotted to check for normality and identify outliers. Dot charts were used for continuous variables and histograms were plotted for categorical variables. There were no obvious outliers that needed to be removed. The continuous explanatory variables were plotted against each other to test for collinearity, both at the individual and household level and the village level. The results did not suggest that these variables are collinear, with the exception of forest cover and population size at the village level. To explore this further, all the variables, variance inflation factors were calculated using one explanatory variable as a response variable and all others as an explanatory variable set within linear regression (see Appendix C.5). This also demonstrated a link between population size and forest cover, so an interaction term was added to capture this relationship.

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[3] The five-point Likert scale in answer to the question "does the project make life easier or harder for your household?" was collapsed into a binary yes (the project makes life easier) or no.

Generalised Linear Mixed Models were run with binomial errors for all models using the 'glmer' function of the lme4 package in R (Bates et al. 2015). Village was included in the models as a random effect to account for hierarchical nature of the dataset. An interaction term was added to capture the inversely proportional relationship between forest cover and population size. An automated model selection function, 'dredge' in the MuMIn package (Barton 2016), was used to identify the top performing models from all the variables. Due to small sample sizes Akaike information criterion (AICc) was used for model selection.

Qualitative information from open-ended questions was used to provide insights and mechanisms of the responses. Throughout the results and discussion of this chapter, I include some quotes as examples of the types of positive and negative responses that were given to explain why people thought the project made life easier or harder for them, and who benefits and loses out and how.

6.2.5 Assumptions

Although there were no sensitive questions relating to illegal behaviour, there were some questions asking about people's opinion on organisations, particularly Durrell. Some respondents may not wish to criticise someone or an organisation for fear it will get back to them. Neither of the RAs had any affiliations with Durrell or any other NGO working in the area. The author and field assistants also ensured they did not arrive in Durrell or any other NGO vehicles or Durrell branded clothing or equipment. This was important as it allowed the RAs to retain a level of independence during the data collection. This independence was underlined in the preliminary statement, as well as SE's position as a student rather than a Durrell employee.

When asking about the impact of a project on people's lives it is possible that answers relate to other, simultaneous forest management and community-based development initiatives that currently or have recently operated in the area. However, during the data collection process there were no other organisations currently working with the local communities aside from Durrell. In addition to this, each question was carefully worded to make specific reference to the monitoring project rather than other conservation and/or development initiatives. Therefore, it is a reasonable assumption that the answers given reflect the monitoring project and associated activities by Durrell.

6.2.6 Ethical standards

Prior to data collection, all protocols and questionnaires were submitted and approved by Imperial College London Ethics Committee (reference number 15IC2451). At the start of each meeting, discussion or interview the research assistants gave a statement to describe the purpose of the research, confirm the anonymity of responses and reassure participants that they could stop the interview at any moment. No-one refused to participate in the research or answer any questions. Despite this research being undertaken in collaboration with Durrell, the author made all attempts to remain independent – as described above. The personal information of each respondent (such as name and year of birth) was recorded on a different sheet to the questionnaire answers. The personal information record was allocated an ID number that was written on questionnaire answer sheets to ensure that if someone came across the questionnaire datasheets the respondent could not be identified. The personal identification sheet and questionnaire were stored separately, before handed over to S. Earle for secure storage in the UK. As a token of appreciation and compensation for interviewees' time, a small food bundle of coffee, sugar and salt was given to every respondent at the end of each interview.

6.3 Results

6.3.1 Knowledge of the monitoring project

Of 348 non-monitors interviewed in the 7 villages, 304 (87%) said they had heard of the monitoring project and were able to describe it. Whether or not they knew of the project depended mostly on whether they were native to the village (Table 6.1.a). For the 70 people that were not native to the village, there was a significant relationship between whether they had heard of the project and the number of years they have lived in the village (t test, $t = -3.1903$, $df = 67.895$, p-value = 0.002). The mean number of years those who had not heard of the project had been in the village was 4.4, compared to 9.9 years for those that had heard of the project, which has been running for 5 years. In addition, the people most likely to have heard of the project are men, use the forest regularly, have more assets (wealth 1) and live in a village with a high forest cover per villager.

All respondents who had heard of the project stated that its goal was to protect and guard the forest. Three respondents also stated that in addition to forest protection, the project is intended to change the villagers' behaviour and attitudes towards using the forest. The respondents viewed the monitoring teams as patrols that enforced forest laws and stop people (both from within the village and neighbouring villages) 'stealing' timber, food or other resources from the forest.

No-one mentioned the ecological or infraction data that the monitors collected during their patrols, despite one of the project's intended goals being to using these data to measure change and report illegal activities. During discussions with the monitors themselves, it became clear that they were unsure how the data were used by Durrell and that there was no feedback of information. In every village they also spoke of their frustration of the lack of response by the local government authorities when they reported infractions of the forest laws:

"Durrell just come and collect the data sheets, but I have no idea what happens to it."

Monitor in Beroboka

"We used to report what we have seen in the forest to DREEF [local government authorities], but they didn't listen to us, nothing happened, so we stopped."

Monitor in Ankorabato

Table 6.1. Results for binomial response GLMMs for (a) the respondent has heard of the project, (b) the project makes life easier, (c) the project benefits someone and (d) someone loses out as a result of the project. See Appendix C.6 for model selection tables. P-value codes: (-) = not in the model, NA = not applicable because the variable was not included in the model selection process, p-value range: 0 '***' 0.001 '**' 0.01 '*' 0.05 'NS' 1.0

	explanatory variable	baseline for categorical variables	response variable											
			(a) heard of the project			(b) makes life easier			(c) someone benefits			(d) someone loses out		
			est.	SE	p-value	est.	SE	p-value	est.	SE	p-value	est.	SE	p-value
individual level variable	involvement - monitor	other	NA	NA	NA	-1.36	0.416	**0.001****	2.413	1.054	**0.022***	1.461	0.42	**0.001*****
	involvement - VOI member	other	-	-	-	1.044	0.501	**0.037***	1.221	0.515	**0.018***	0.031	0.284	0.912
	forest use frequency - never	high	-0.932	0.431	**0.031***	-0.920	0.359	**0.010***	-1.092	0.392	**0.005****	-0.512	0.307	0.097
	forest use frequency - low	high	-0.904	0.538	0.093	-0.425	0.444	0.338	-0.172	0.524	0.743	0.303	0.33	0.358
	wealth 1 (assets dimension)		0.452	0.176	**0.010***	-	-	-	-	-	-	-	-	-
	wealth 2 (income dimension)		-	-	-	-	-	-	-	-	-	-	-	-
	number of people in household		-	-	-	-	-	-	-0.135	0.059	**0.021***	-0.091	0.045	**0.044***
	gender	male	0.911	0.399	**0.022***	-	-	-	-	-	-	-	-	-
	age		-	-	-	-	-	-	0.029	0.015	**0.047***	-0.006	0.01	0.594
	native to the village	no	1.53	0.379	**<0.000*****	-	-	-	-	-	-	-	-	-
village level variable	population size		-	-	-	-	-	-	-	-	-	0.119	0.045	**0.008****
	success score		0.368	0.2	0.066	-	-	-	-	-	-	-0.292	0.106	**0.006****
	number of village associations		-	-	-	-	-	-	-	-	-	-	-	-
	surrounding forest cover		-	-	-	-	-	-	-	-	-	-	-	-
	numbers of days since Durrell's last visit		-	-	-	-	-	-	-	-	-	-	-	-
	population size with forest cover		-0.164	0.044	**<0.000*****	-	-	-	-	-	-	-	-	-

6.3.2 Does the project make life easier?

Those people that have heard of the monitoring project and the monitors themselves were asked if the project makes their lives easier or harder. In total, 283 people (83%) said that the project makes life easier, 54 people (16%) did not think the project makes life easier and 2 (1%) were unsure (these were removed from the dataset for modelling).

Monitors were least likely to say that the project makes life easier compared to other villagers, while VOI members were more likely to say that the project makes life easier for them (Figure 6.2). Proportionally, more monitors thought the project makes life hard/harder (44% of 36 people) compared to non-monitors (2% of 305 people). There is some evidence to suggest that people that never or infrequently use the forest are less likely to say that the project makes life easier than those who use the forest a lot (Table 6.1.b).

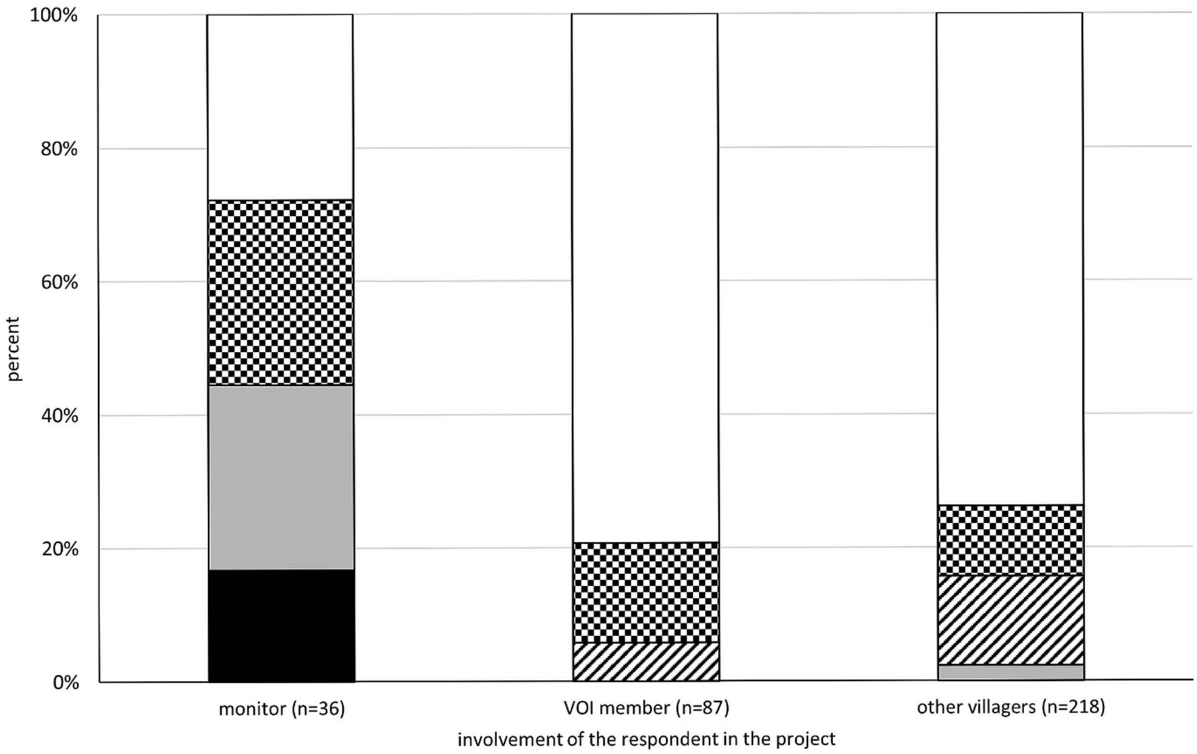

Figure 6.2. Percent of monitors, VOI members and other villagers that thought that the project makes life much easier (white), easier (chequered), no difference (striped), harder (grey) or much harder (black).

From the non-monitors' perspective the explanations for why the project makes life easier or harder were mostly related to livelihoods or ecology (Table 6.2). The main explanation by non-monitors for the project making life easier was that the villagers were able to collect natural resources from the forest (47% of all responses). Other popular reasons were related to the existence of the forest to provide rain (26%) and that the forest in general was protected (16%) and that it will benefit future generations (7%):

"If there is forest, there is rain and there will be good harvests."

Villager in Kirindy

These reasons suggest that they are thinking about life in the long-term and reflecting on their reliance on the forest for their livelihoods. On the other hand, some people also observed a continued deterioration in the quality of the forest:

"Getting a livelihood from the forest is difficult because the forest is getting thinner, and is now more than 5km away"

Villager in Beroboka

Four monitors thought that the project makes life easier because they are able to continue working in their fields as well as having a second job as a monitor. One monitor explained that the project made life much easier because his role protecting the forest was supported by most of the villagers:

"I work for the villagers to protect the forest, and most of the villagers encourage us [the monitors] to continue our work"

Monitor in Tsianaloka

Of the 16 monitors that stated that the project makes life harder, 9 said that payments were insufficient or irregular. Five monitors said that the work is hard. Seven people in four different villages were concerned that they had "made enemies", making their job dangerous.

Table 6.2. Explanations and frequencies for why the project makes life easier or harder for monitors, VOI members and other villagers. * = only applicable to monitors.

life	type	explanation	respondent: monitor	respondent: VOI member	respondent: other villager	TOTAL
life is easier	livelihoods	can continue to collect natural resources	0	40	122	**162**
	ecology	ensuring the forest means there is rain	0	20	67	**87**
	ecology	forest protected/laws enforced	3	20	35	**58**
	ecology	benefits future generations	2	11	14	**27**
	livelihoods	not disruptive to my life/can continue to work	4	3	11	**18**
	livelihoods	resources to build house	0	6	4	**10**
	other	general unspecified benefits	0	0	4	**4**
	material	employment/salary opportunity*	3	NA	NA	**3**
	wellbeing	life is ok/good	2	0	0	**2**
indifferent	other	remain worried about the future/life continues to be hard	1	4	14	**19**
	wellbeing	makes no difference to my life	0	2	10	**12**
	project	unsure about the project success/achievement	1	1	4	**6**
life is harder	material	payments are too small/irregular*	11	NA	NA	**11**
	livelihoods	made enemies/dangerous job*	10	NA	NA	**10**
	livelihoods	restricts access to part of the forest	0	0	2	**2**
	livelihoods	disturbs my work/livelihood activities	0	0	2	**2**
	ecology	forest cover/quality is decreasing	0	0	1	**1**
TOTAL NUMBER OF RESPONDENTS			**36**	**87**	**218**	**341**

6.3.3 Who benefits from the project and how?

288 people (85%) said that the project benefits someone; 31 (9%) people said that no-one benefitted from the project and 20 (6%) were unsure (these responses were categorised as 'no' for the binomial model).

The variables that are most important in the model are involvement in the project, household size and frequency of forest use (Table 6.1.c). Monitors, and to a lesser degree VOI members, were significantly more likely than other villagers to say that someone benefits from the project. Those that never went into the forest were significantly less likely to think that someone benefits from the project than people that frequently used the forest.

The qualitative data show that different groups of people (monitors, VOI members and other people in the village) perceive different people to benefit from the project in different ways (Table 6.3). The monitors perceived an equal spread of beneficiaries across the whole village:

"All the villagers benefit, the forest is protected, there is a good harvest and there are agricultural equipment and tools to use."

Monitor in Ampataka

However, VOI members and other people thought that monitors benefit most from the project:

"Only the monitor benefit, they get things like a uniform and salary."

VOI member in Tsianaloka

Material benefits such as the provision of cooking and agricultural equipment were perceived to be most important. Other material benefits include money and equipment given to monitors.

Table 6.3. The perception of monitors, VOI members and other villagers as proportions of who benefits and how, (-) indicates this is not applicable to that group. The three main columns represent the answers given by the respondent group, with a subsidiary column to explain who the respondent thinks benefits, and rows for the different benefits described. For example, there were 61 different explanations given by the 35 monitors (see [a]). 33%[b] of these explanations were about the monitors benefiting from the project, whilst 31%[c] and 36%[d] said that only VOI members and everyone else benefited. Of the explanations given by monitors of the benefits, 31%[e] said they benefited by being given a bike, and 2%[f] the money they get as a stipend.

Responses to who benefits from the project and how do they benefit?	**MONITORS' PERCEPTION** (number of respondents = 35, total number of explanations given = 61) [a]			**VOI-MEMBERS' PERCEPTION** (number of respondents = 84, total number of explanations given = 138)			**OTHER VILLAGERS' PERCEPTION** (number of respondents = 174, total number of explanations given = 309)		
WHO BENEFITS	**monitor only**	**VOI member only**	**everyone**	**monitor only**	**VOI member only**	**everyone**	**monitor only**	**VOI member only**	**everyone**
	0.33 [b]	**0.31** [c]	**0.36** [d]	**0.52**	**0.09**	**0.38**	**0.78**	**0.03**	**0.19**
HOW THEY BENEFIT									
ecological benefits									
forest protection	0.00	0.00	0.06	0.00	0.00	0.06	0.00	0.00	0.06
rain	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.02
material benefits									
agricultural & cooking equipment	0.00	0.31	0.26	0.11	0.07	0.15	0.06	0.02	0.04
bike	0.31 [e]	-	-	0.19	-	-	0.24	-	-
uniform	0.00	-	-	0.10	-	-	0.30	-	-
money	0.02 [f]	-	-	0.09	-	-	0.17	-	-
natural resources e.g. timber, food, fuel	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.01
land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
phone	0.00	-	-	0.01			0.00	-	-
other benefits									
livelihoods	0.00	0.00	0.02	0.00	0.00	0.06	0.00	0.00	0.05
unspecified	0.00	0.00	0.00	0.03	0.02	0.05	0.00	0.01	0.01

6.3.4 Who loses out and how?

A total of 165 people (52%) said that no-one loses out because of the project, whilst 130 (41%) people felt that someone did lose out, 23 people (7%) were unsure whether someone lost out or not (unsure responses were categorised as 'no-one loses out' for the binomial model).

The model that best described perceptions that someone loses out included six variables: the involvement of the respondent in the project, the frequency of forest use, the number of people in the household, age of the respondent, village population size and success score (Table 6.1.d). However, only involvement of the respondent had strong explanatory power. Monitors were significantly more likely than other villagers to think that someone loses out as a result of the project. VOI members and other villagers did not significantly differ in their perception of whether anyone loses out. There is some evidence that fewer respondents in villages with a high success score thought that someone loses out as a result of the project.

For those that thought someone loses out, they concur that the average villager loses out the most (Table 6.4). In addition, the monitors thought they lose out because of problems with the project, either because of a lack of support or resources to do the job:

"We do not get any help and we haven't had a salary since last year."

Monitor

However, VOI members and other villagers thought that the monitors did not lose out in any way:

"The monitors and VOI members get to keep all the gifts for themselves. We get nothing."

Monitor

One monitor and 6 villagers had very negative views of the project, thinking that no-one benefitted from the project and that someone loses out. There were no consistent patterns in this group of people; they were 4 men and 3 women aged 20-50 from five different villages, to which they are native.

Table 6.4. The perception of monitors, VOI members and other villagers as proportions of who loses out and how, (-) indicates this is not applicable to that group. The three main columns represent the answers given by the respondent group, with a subsidiary column to explain who the respondent thinks loses out and rows for the different losses described. For example, there were 29 different explanations given by the 23 monitors (see [a]). 28%[b] of these explanations described that the monitors lose out from the project, whilst 0%[c] and 72%[d] said that only VOI members and everyone else lose out. Of the explanations given by monitors of the ways in which monitors lose out, 17%e explained it was because there is not enough support to do the job, and 10%[f] think there is not enough resources or equipment to do the job properly.

Responses to who loses out from the project and how do they lose out?		**MONITORS' PERCEPTION** (number of respondents = 23, number of explanation of who loses out and how = 29) [a]			**VOI MEMBERS' PERCEPTION** (number of respondents = 30, number of explanations of who loses out and how = 30)			**OTHER PEOPLES' PERCEPTION** (number of respondents = 80, number of explanations given of who loses out and how = 81)		
WHO LOSES OUT		**monitor only**	**VOI member only**	**everyone else**	**monitor only**	**VOI member only**	**everyone else**	**monitor only**	**VOI member only**	**everyone else**
		0.28 [b]	**0.00** [c]	**0.72**[d]	**0.00**	**0.00**	**1.00**	**0.00**	**0.00**	**1.00**
HOW THEY LOSE OUT	**lack of benefits**									
	can't access the material/equipment	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
	get no help or receive benefits	0.00	0.00	0.55	0.00	0.00	1.00	0.00	0.00	0.91
	livelihood									
	damages forest livelihoods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
	stops me/them working	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	there are no jobs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	project									
	don't like the project	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
	there are a lack of resources to do the job	0.10 [f]	-	-	0.00	-	-	0.00	-	-
	there is no/not enough support to do the job	0.17 [e]	-	-	0.00	-	-	0.00	-	-
	unspecified	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01

6.3.5 Village-level variations

Due to the nature of the data being collected in each village, the statistical models used in this study are Generalised Linear Mixed Effect models, with village as a nested random effect. However, the variance of the random effect was very small in each of the models. A lack of village-level variation is further supported by the low number of village-level explanatory variables within 4 AICc values of the top model (see Appendix C.6). This indicates that there is little consistent variation between villages across the responses; the responses in one village are not more similar to each other than responses from different villages. This is despite there being substantial differences between villages in externally perceived project success.

6.4 Discussion

6.4.1 Overall perception of the project

From Durrell's perspective, the provision of cooking and agricultural equipment is separate to the PEM scheme, but part of Durrell's long-term and ongoing community-based conservation activities and wider development support (see Chapter 3). However, it is clear that local people merge these parallel activities together, as they are both implemented by Durrell. Given this, Durrell's work is well known and is positively perceived in all villages as a whole. There is some evidence to suggest that this positive perception can, at least partly, be attributed to the long-term relationship and trust that Durrell have built with these communities over the past 15 years. For example, during a focus group discussion in Kirindy village, the interviewees were discussing the range of development projects and organisations that have operated in the village. One member of the group said:

> *"Only the Durrell project has improved our lives because they are the only ones who give us equipment and materials every year for many years and is still working in our village today."*
>
> Villager in Kirindy

One of the most common problems with conservation and development initiatives is a lack of a strong and trusting relationship to support long term activities in communities, because this takes a long time (Richard & Ratsirarson 2013). It is widely acknowledged that building a rapport and relationship within the communities should be the solid foundation to any initiative involving local people (Peterson et al. 2010) and this study suggests that Durrell have been successful in this regard.

In terms of the perceived goal of the project, everyone stated that the goal of the project was to protect the forest; no-one mentioned the collection and analyses of species and threat data (see Chapter 5), which suggests that local people believe that the project is more about policing and protecting the forest for them. Although the research was not specifically designed to evaluate the performance of the project to enforce forest laws, there is some evidence of the effect it has had on local people, for example:

"Before the patrols, there used to be lots of people from neighbouring villages coming into our forest to collect firewood. But since we have done the patrols, this is not a problem anymore."

VOI member in Marofandilia

As a result of increased patrolling and enforcement of forest laws it is expected that illegal forest users lose out from the project, however only 5 of 339 people interviewed mentioned that the patrols made life harder for illegal forest users. One person interviewed stated that restricted access to the forest or law enforcement had a negative impact on their own livelihoods:

"The monitors disturb my charcoal production work in the forest."

Villager in Beroboka

Overall, the low number of people mentioning the disruption of illegal forest activities by monitors and their patrols, either to themselves or in relation to other peoples, indicates that either illegal forest use by villagers is not currently a widespread issue or the patrols are not affecting it. However, this research was not specifically designed to collect sensitive information, and so local people may not have felt comfortable discussing this sensitive information with the RAs. Further work would be needed using methods specifically designed to collect sensitive information (e.g. Nuno & St. John 2015) would be needed to understand illegal forest use with certainty.

6.4.2 Benefit and cost flows as a way to identify underlying problems

This study assumes that the flow of benefits and costs throughout the community are an indication of the impact of the project on local people. There are a range of benefits and costs of the project, affecting different sectors of the community in different ways (the main benefits and flows are summarised in Figure 6.3). For example, people that use the forest less frequently were less likely to say the project makes life easier for their household and less likely to think that someone benefits from the project. This is probably because they do not come into contact with the patrols in situ, the project appears more abstract and they therefore understand less about what the patrols and project achieve in practice. On the other hand, those people that are more invested in the scheme and see the patrols conducted, such as the monitors and the VOI members, were more likely to say that someone benefits from the scheme.

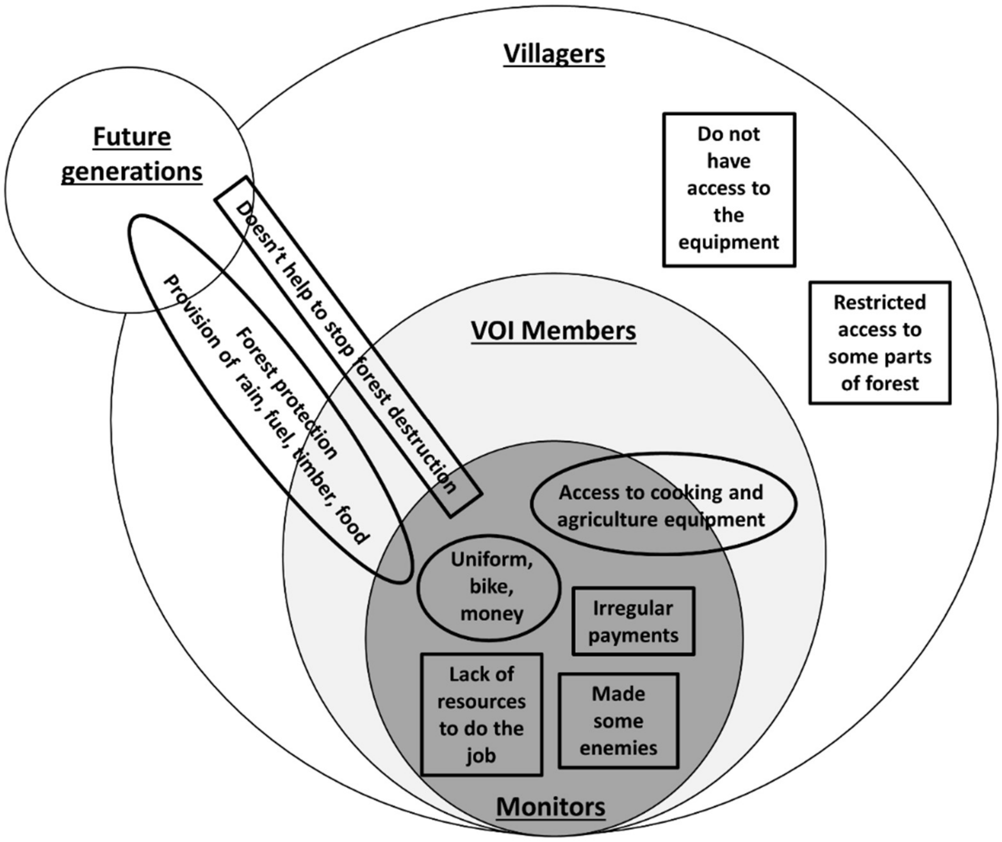

Figure 6.3. Schematic diagram summarising the benefits (elliptical) and cost (rectangular) flows as perceived to monitors, VOI members and other villagers.

Although this project is based on a long-standing positive relationship with the local community and was designed with significant input from the local people, this research has highlighted negative unintended consequences such as the irregularity of payments to monitors and their perceived poor security situation and the feeling of having "made enemies" with a few people in some villages. Unequal distribution of benefits has also been identified as a problem in most villages, where access to cooking and agricultural equipment provided as part of Durrell's wider community development activities, was being monopolised by VOI members instead of being available to all villagers, as was intended. This case study is an example of how the realities and social consequences of project implementation can differ from expectations. Often this is due to a lack of regular feedback on project progress from the project targets themselves (Barrett et al. 2011). In the case of the Durrell PEM scheme. More regular and frequent visits to the villages by Durrell staff (mostly limited for logistical and financial reasons) may have been able to address some of these problems (pers. comm. H. Andrianandrasana) and is a priority for the future.

Despite the rapid and simple approach to understanding local perceptions of this scheme, this study demonstrates that there is value in using basic social research techniques as a means of identifying underlying issues or problems that can be addressed and exploring the sustainability and suitability of approach. Further work to build upon this research would be valuable to improve understanding of the social impacts of this scheme. For example, Chapman (2014) set out a framework to monitor and evaluate any collaborative environmental intervention that is expected to have social benefits to local communities. This framework has three components: program need, program activities, the process and outcomes. It requires organisations to engage anthropologists or other social scientists to apply their expertise in a long-term, holistic and in-depth approach to monitoring the social aspects of an intervention, in addition to ecological aspects. This approach would go some way towards responding to criticism that conservation organisations either completely lack or execute poor quality social science research (Peterson et al. 2010).

6.4.3 Mismatch between local perceptions and expert opinion

The measure of project success (as determined by Durrell staff and the RAs) was expected to be related to the overall perception of the project by people in a given village. However, there is no evidence to show that this is the case. The lack of predictive power of the success scores may be explained by the fact that the experts' opinions, especially those of the Durrell staff, may be influenced by a few individuals in each village and are not representative of the villagers as a whole. Durrell managers visit the project villages and usually meet with the monitors, plus the village President and committee, but little time is currently spent within the wider community. Therefore, expert opinion risks being based on discussions with key project participants in addition to anyone else who is particularly vocal – some of whom think the project is good and works well and others who think the project does not work so well.

The influence of individuals has also been seen in other studies, especially in relation to natural resource management. For example Bodin & Crona (2008) identified key individuals that possessed links with external agencies in relation to a fisheries management scheme. As a result, there was a lack of co-ordinated resource regulation of fisheries stock because those most impacted by a decline in fish stocks were not represented. Malla et al. (2003) describe a situation in Nepal in which the socially dominant influenced decisions on forest management, although the marginalised members of the community were most depend on forest livelihoods.

In this case study, as the perception of the project in the wider community was largely positive, only listening to particularly powerful or engaged individuals is not likely to lead Durrell staff to a false understanding of how the project is viewed on-the-ground. However, in some situations the implications of gaining only one perspective on an intervention may be severe, resulting in negative human or wildlife impacts or failure of the initiative altogether. This is especially pertinent to complex and challenging conservation and development initiatives, where unintended feedbacks and consequences of conservation interventions may occur (Larrosa et al. 2016), where flawed assumptions lead to potentially negative consequences (Wright et al. 2016) and the livelihoods of local people are at stake.

6.4.4 Contributions to the theory of change

This research can be used in conjunction with the theory of change described in section 2.6 to identify where the project is working or not working, and where evidence is lacking (Figure 6.4). It shows that this approach continues to allow people access to the resources they need, and that, to most people, there is no harm done to the communities involved in the scheme and that social outcomes are in progress to being met. This highlights the need for further research of the link between attitudes, threat reduction and improvement in the state of the forest, which is particularly crucial, although poorly understood in most conservation initiatives (Heberlein 2012; Karki & Hubacek 2015).

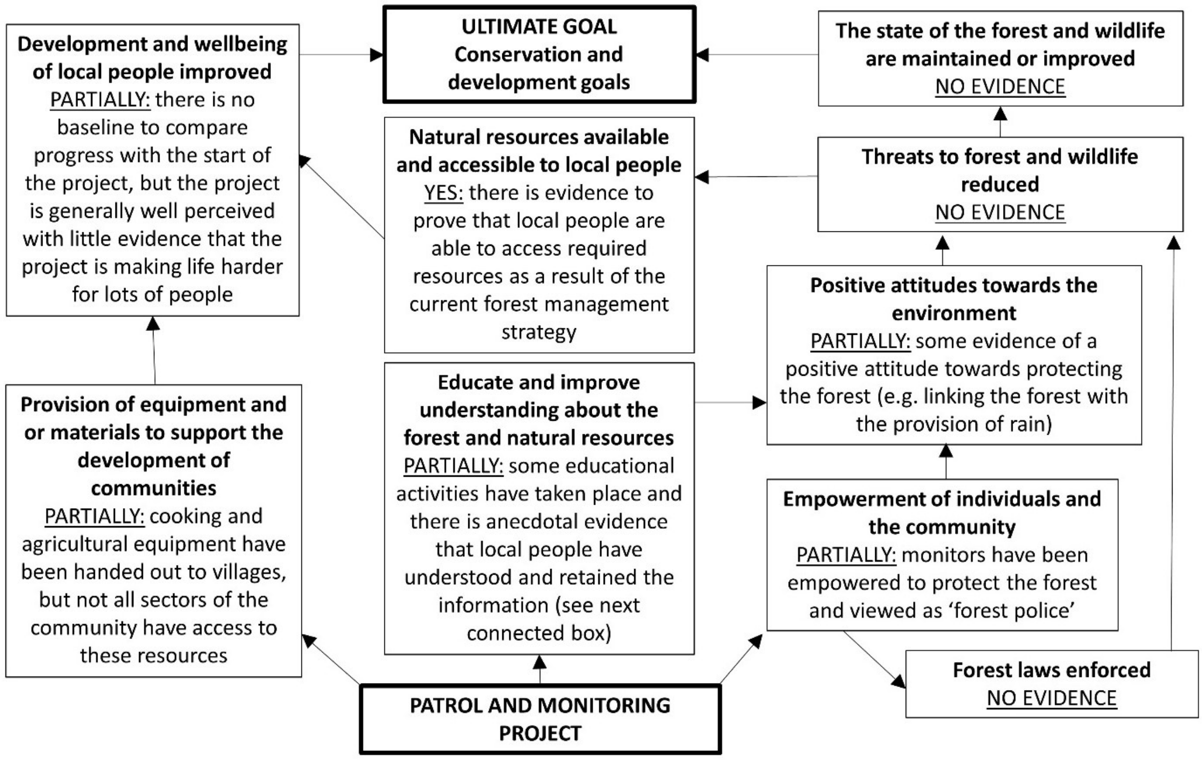

Figure 6.4. The theory of change (see Figure 2.3) and the evidence from this chapter that suggests aspects of the project that are working, failing or where there is no evidence.

6.4.5 Conclusion

The results of extensive interviews with monitors, VOI members and the general public in villages involved in PEM have enabled and exploration of the positive and negative attitudes, and possible predictors. Overall, local people's postive perception of the project outweighed the issues and challenges, although there were no clear predictors for peoples' attitudes either at the individual or village level. Despite the long-term relationship that Durrell had built with these communities over the past 15 years and substantial investment in the PEM, it is not without it's challenges and difficulties. Some of which are not easy to solve, such as the feeling of having made enemies with a small number of people. Whilst it is encouraging that these negative impacts are in the minority, the process of exploring perceptions of the scheme have identified those problems that hinder the overall success of the scheme in the long-term. This serves as a warning to managers of conservation and development projects that PEM is not a simple or particularly straightforward way of engaging local people in conservation activities, but that continued investment is required in order to make progress towards conservation and development goals over the long-term.

Chapter 7 Introducing a decision framework for participatory monitoring project practitioners

7.1 Introduction

7.1.1 Applying scientific knowledge to action in conservation

For a practitioner designing and implementing a conservation activity, there is a range of decisions that need to be made based on available information and experience. In the context of participatory environmental monitoring (PEM) schemes where local people are involved in monitoring projects (see Chapter 2 for a full description), decisions centre around the objective of the monitoring, how and what to monitor and how to engage local people in the monitoring activities. Due to the rising popularity of PEM there is much information in the published literature that describe PEM schemes (Chapter 3) and discuss the ideal characteristics of a scheme (Danielsen et al. 2009), identify what works well (e.g. Holck 2008) and some challenges to the approach (e.g. Boissière et al. 2014). Given the widespread use of PEM, there is also substantial knowledge and experience of PEM that is locked up within individuals and organisations that is not widely available. Gathering and synthesising this information from a range of sources and using it to guide future PEM schemes can be difficult, especially for those practitioners with poor English language skills and limited access to the scientific journals and peer-reviewed literature. In recognition of this, an initiative called 'The Participatory Monitoring and Management Partnership' was set up to provide a collaborative and international platform for practitioners to discuss PEM and the management of natural resources. The website (www.pmmpartnership.com) contains useful information and links to other websites, as well as having a community forum for exchange of knowledge and ideas. The challenge of gathering and synthesising scientific information is not restricted to PEM schemes; the application of scientific knowledge and understanding to real-world action and management is difficult to achieve in conservation generally and is often referred to as the science-action gap or research-implementation gap (Campbell 2007; Knight et al. 2008; Milner-Gulland et al. 2012).

Within the scientific literature there is discussion about the science-action gap and the need for evidence-based conservation, where conservation action is informed by available scientific data and evidence, rather than based on intuition (Milner-Gulland et al. 2012; Pullin et al. 2004; Sutherland et al. 2004). Scientific knowledge and understanding can take the form of academic research in peer-reviewed literature of individual projects or systematic reviews, grey literature, new data, personal experience or discussions with other academics and practitioners. Expert judgement (T. G. Martin et al. 2012) and experiential knowledge (Fazey et al. 2006), based on personal experience about the effectiveness of conservation actions, are also useful in conservation, however, especially when combined with scientific understanding (e.g. Murray et al. 2009). If knowledge is to truly inform action, all these types and sources of information and insight need to be recognised and combined in ways to make this knowledge valid to science and useful for the practitioner implementing and managing conservation initiatives.

Conservation science, where scientific knowledge is applied to solve real-world conservation problems, is referred to as a boundary science that "crosses the boundary between scholarship and application" (Cook et al. 2013). According to Cash et al. (2003) this requires the scientific knowledge produced by conservationists to be salient (relevant and timely), credible (believable and trusted) and legitimate (developed by a process that involves multiple stakeholders involved in the conservation problem). Furthermore, they describe three essential elements for linking knowledge to action: (1) active communication between scientists and practitioners; (2) translation of information between stakeholders in a way that everyone can understand each other; (3) mediation of conflicting perspectives and possible trade-offs between salience, credibility and legitimacy. The science-action or research-implementation gap literature is largely concerned with using scientific evidence to make decisions on a range of competing options, such as systematic conservation planning (Knight et al. 2008), however the same issues apply to any type of conservation activity where decisions need to be made about the design, implementation and ways of evaluating progress towards goals.

Applying scientific knowledge to action can be achieved in a range of ways: either by a boundary conservation organisation that straddles academia and policy or management (such as the British Ecological Society), or by embedding scientists in conservation agencies, formal links between researchers and decision makers, bodies or societies that provide scientific advice for policy (such as the Royal Society and Natural England), by training conservation professionals in an academic setting and online resources that summarise scientific literature, such as www.conservationevidence.com (Cook et al. 2013). Whichever approach is adopted, management decisions about what to do and how, should be based on scientific experimentation or research (Pullin et al. 2004; Sutherland et al. 2004) or elicited from experts (Burgman et al. 2001; T. G. Martin et al. 2012). This information can be transmitted from experts or scientists to conservation practitioners in a range of ways, such as systematic reviews (Stewart et al. 2005), scenarios and modelling (IPBES 2016; Schwartz 2012), policy briefs or decision support tools (McDonald-Madden et al. 2010).

7.1.2 The use of frameworks to guide practitioners

Frameworks are "*a basic structure underlying a system, concept, or text*" (OED 2016). There are different kinds of frameworks for different purposes, such as to guide decision-making (decision framework), to explain ideas, theories or systems (conceptual framework) or to evaluate the effectiveness of an action or intervention (evaluation framework) or to guide project implementation through describing activities, outputs, purpose and goals (logical framework). One example of a framework that has been widely used by practitioners is the Open Standards for the Practice of Conservation and its software platform Miradi developed by the Conservation Measures Partnership (CMP 2016; Schwartz et al. 2012). This conceptual framework is design to assist conservation practitioners to prioritise, plan, implement and monitor conservation actions based on priorities, likelihood of success, the cost of implementation and links between action and outcomes (CMP 2016).

A decision tree is a specific type of decision framework that is characterised by a branching network based on a series of decisions that take you in one direction or another. Other approaches to decision-making framework can also be linear (e.g. McDonald-Madden et al. 2010) or take the form of a scoring system (e.g. Richardson et al. 2009). Decision frameworks explore problems or uncertainties concerning a course of action, in a systematic way based on scientific knowledge and/or expert opinion in order to guide management (McDonald-Madden et al. 2010). Decision trees have been developed by researchers in the hope that they will be used by practitioners used in range of conservation interventions, for example Strindberg and O'Brien (2012) designed a decision tree to select a method for monitoring wildlife to assess the effectiveness of conservation interventions. Woodhouse et al. (2016) provide a decision tree as part of guidance to practitioners on how to evaluate the impact of conservation interventions on human wellbeing. McDonald-Madden et al. (2010) describe a decision tree used to decide when wildlife monitoring can improve management and what type of monitoring to implement. The degree to which these frameworks have been used by practitioners to guide real life decisions are largely unknown.

7.1.3 Implementation decisions for a PEM scheme

In relation to PEM schemes, there are decisions that need to be made when designing and implementing a scheme, relating to fulfilling both ecological goals and goals related to the social development of local people. For example, social development considerations include the relationship with the community, intended levels of participation of local people, the benefits of being involved in the monitoring and the level of local expertise available to conduct monitoring. Ecological considerations include deciding what to monitor and how, depending on the ecological variable of interest. Danielsen et al. (2005) provide six key steps that a practitioner should consider when setting up a PEM scheme: (1) discussion of the potential scheme with stakeholders, (2) assessing existing knowledge to develop a model of the system, (3) how the information will be used, (4) what and how to monitor, (5) beginning implementation on-the-ground, (6) discussing the results. This usefully highlights the key points in the implementation of a PEM scheme. A decision framework that incorporates the ecological and social elements is important to help implementers decide whether PEM is appropriate and decide what to do based on existing scientific knowledge in the literature would be useful to narrow the science-action gap. This framework could also be used retrospectively to review current PEM schemes, especially where things aren't working so well, as a way to identify specific aspects of a scheme that could be improved.

7.1.4 Aims and objectives

The aim of the study is to create a simple framework, drawing on a range of scientific knowledge, experience and understanding of PEM, that will allow managers to make decisions about when to invest in PEM and which type of approach to undertake, or to conduct a retrospective review of an existing scheme.

The study's objectives are to give guidance on:

1. identifying whether PEM is appropriate;
2. recognising the financial, logistical, social and political constraints to a PEM scheme, so they can be mitigated;
3. exploring approaches and methods and that may be suitable for a PEM scheme;
4. taking a retrospective review of an existing project to identify areas that can be improved.

The framework is validated using a prospective PEM scheme in Papua New Guinea and a retrospectives review of an existing scheme in Madagascar. I focus on PEM with the principal objectives of informing decision-making for management and/or engaging local people and improving their capacity to monitor and manage their own resources. There are a range of other reasons for PEM, such as to audit management interventions, for ethical or for legal reasons, but this framework is not designed to guide implementation for these types of PEM projects.

7.2 Designing and validating the framework

The framework was designed based a review of the PEM literature and a global survey of PEM practitioners and academics (Chapter 4), first-hand experience with a PEM project in Madagascar (Chapters 5 and 6) and discussions with practitioners. To demonstrate the utility and validity of the framework, it is applied to two real-life cases studies. The first is a prospective study of a potential PEM scheme in Papua New Guinea by UK NGO Cool Earth. The second case study is a retrospective review of an existing project run by the Durrell Wildlife and Conservation Trust (herein 'Durrell') in Madagascar (see Chapters 3, 5 and 6).

7.2.1 Case study 1 – prospective use of the framework for a PEM scheme in Papua New Guinea

Cool Earth (www.coolearth.org) are a small UK NGO working with communities in Peru, Democratic Republic of Congo and Papua New Guinea (PNG). Cool Earth are considering the design and implementation of a more formal participatory monitoring scheme which serves to monitor biodiversity as well as engage local people in PNG as well as Peru and DR Congo. However, for the purpose of this study, I focus on the potential implementation of a PEM scheme in PNG.

The ultimate goal for the project in Milne Bay, PNG, is to work with local communities to protect their forests, as well as contribute to the development and livelihoods of the rural communities. Cool Earth started working with two rural villages in May 2014 and February 2016, with a total population of just over 300 people. The land is owned by members of the community, split between five clans. The communities have full tenure of the land and forests on which they rely, and a formal process of registering the land with Government is under way. The main pressure in the area comes from commercial loggers who intend to clear land for timber and palm oil production. So far, Cool Earth have supported and facilitated the development of community-based livelihoods such as cocoa and coconut production, sewing and bakery business groups. When Cool Earth started working in the communities, they facilitated the creation of a committee of 8-9 elected members to make decisions about which livelihood activities they would like to develop and to manage the finances and activities on the ground. One person from each committee serves as the point of contact between Cool Earth and the communities. A pilot camera trapping project was initiated in February 2016 to explore biodiversity in the area. Despite a lack of prior knowledge or experience with this sort of biodiversity monitoring the local people have quickly grasped the concept and the activity has been successful, although the sustainability of this approach in the long-term is uncertain.

The planning and design of a potential PEM scheme is in the very early stages, so although there may be uncertainty over some of the answers in the framework, it is an ideal case study to demonstrate the decisions that must be made and explore the sort of approach that might be suitable. The framework was discussed with Cool Earth staff familiar with the communities and responsible for developing the PEM scheme.

7.2.2 Case study 2 – retrospective review of project in Madagascar

This PEM scheme is the topic of chapters 4 and 5 of this thesis. As discussed in detail in Chapter 2, there have been several challenges to this project and the scheme is currently under review. For this reason, it is an ideal case study to show how the framework can be used to review a current project, identify specific steps that did not work so well and explore ways that an existing scheme could be tweaked and improved. The framework was discussed with Durrell project staff and based on my first-hand experience of the project in Menabe, Madagascar.

7.3 The framework

The framework consists of two parts. The first (Figure 1) is a decision tree where the user is guided through a series of questions. The purpose of this first part is to explore whether PEM is appropriate, and aspects a practitioner might consider during and planning and implementation of the scheme. For some answers in the framework the user is directed to a blue answer box, labelled with an A, B or C. The tally of the As, Bs and Cs should be recorded as the user works through the scheme, as these guide the user to the second part of the framework (Table 1) called the 'approaches table'.

7.3.1 The framework part 1: decision framework

Figure 1 shows the decision tree, composed of 14 questions (green diamonds) and action points (red ovals and yellow rectangles). Each question has two or three possible answers, which lead to an action point or to the next question in the series. The blue boxes represent answers to a question where the response relates to an approach A, B or C. The red action points identify answers to questions that require significant consideration or essential action before proceeding through the framework, they may even question whether PEM is appropriate at all. The yellow rectangles are also action points, where an implementer might like to consider additional activities, but as these are more advisory than essential, they do not hinder progress through the framework and therefore follow on to the next question.

In the first few questions, a series of questions is asked to ensure that PEM is appropriate and feasible. Progress through the framework may be halted because there may not be specific monitoring goals (Q1), there are no clear benefits to local people (Q3), no clear idea how the monitoring fits into the wider conservation intervention (Q4), or not enough time (Q5) or resources (Q6) are available. The nature of the relationship with local people (Q7) and the political and social culture (Q8) in which the project will operate also determine the feasibility and success of a PEM scheme and the sort of approach that might be appropriate. Ensuring that people are willing to be involved and being explicit about how people will benefit (Q9-11) is important, and will also affect the type of approach a practitioner might take, as well as other logistical situations, such as external expertise (Q12) and managing and feeding back information to local people (Q13 & 14).

Q1: Do you have a specific goal?

A monitoring project should have a clear set of goals in order to guide the design and development of a scheme, but also to understand how to measure success of the monitoring scheme. This is an essential component of any project, such that progress should not continue until there is a clear understanding of why monitoring is needed. Like all management or conservation interventions, effective monitoring requires goals that are specific, measurable and time relevant (Mccarthy 2014). Yoccoz et al. (2001) describe two goals for monitoring, science and management, but in the context of PEM projects, there is a third relating to social goals concerning the involvement and engagement with local people. Therefore, the framework has three broad categories for the type of goals that a project may have: (1) science goals where the objective is to learn about and understand the state of the ecosystem, also to detect spatial and temporal changes; (2) management goals which aim to understand the impact of interventions and inform-decision-making, such as the Event Book System in Namibia which influenced hunting quotas and national policy on the sale of ivory stockpiles (Stuart-Hill et al. 2005); (3) social goals concerned with engaging and empowering local communities to enhance their understanding and ability to manage natural resources. Danielsen et al. (2000) describe a scheme where the capacity of Protected Area staff in the Philippines was strengthened in response to PEM. It is likely that a project will have more than one goal, in which case the user can select more than one goal type and tally the approach codes as appropriate.

Q2: Do you intend to collect environmental data and interpret it or measure system state or trend?

Ideally, a PEM project is interested in collecting environmental information and using this information in some way. However, there may be other reason for the project where the manager is not interested in the environmental data per se, such as for publicity, auditing of a conservation project or the opportunity to engage with local people. These are valid reasons to conduct a PEM project, but given the high cost of

PEM projects over the long term, funds might be better spent on other community-based activities such as alternative livelihoods, or social impact evaluation (de Lange et al. 2016), or audits or socio-economic surveys of households by project personnel.

Q3: Are there concrete benefits to local people and no cost to participate?

There should be some clear benefits to people for participating in a PEM scheme, that ensure the local people do not bear costs from participating (Hockley et al. 2005). These benefits can range from financial payments, gifts or intangible benefits (see Q10). These should be established with the communities at the outset of the scheme, and agreed by all stakeholders. It is important to be realistic and not raise the expectations of local people beyond what is realistically and financially sustainable. If monitoring is intended to run self-sustainably and external support will be withdrawn at some point, it is important to make that clear and incorporate that into the benefit structure from the outset, so that people do not expect and come to rely on benefits that cannot be provided once external support ceases to exist.

Q4: Is there a theory of change of the project?

A theory of change of the system or conservation intervention sets out the rationale for the conservation activity of which PEM is a part. It demonstrates the links between the inputs, outputs, outcomes and influence on the ecosystem and is essential to understand how the monitoring fits into the broader conservation scheme (Boissière et al. 2014). Margoluis et al. (2009b) provide useful guidance on constructing a theory of change for a project and for real-life examples on how they look.

Q5: Over what timescale will the project operate?

In most cases, monitoring is usually a long-term activity, especially where local people require training and one or more pilot surveys to test the monitoring methods. As a result, within the first two years of a new project, there are often problems that take time to correct or parts of the project need tweaking. This, in conjunction with training reduces the time available to collect and analyse the data itself. Given this, a PEM project of only two years may not be realistic, unless the local people already have the experience, skills and equipment for the monitoring activities and little additional training is required. Boissière et al. (Boissière et al. 2014) discuss the limitations of what can be achieved in two years, based on a participatory non timber forest product monitoring system in Laos. They found that only the process could be tested in the two-year timeframe. More time was required to refine the methods, scale-up the approach and fully integrate the monitoring into national land use policies.

Q6: How much financial support is secured?

Many managers set up PEM projects with the intention of creating a self-funding mechanism so that monitoring and the links to management can continue indefinitely. Monitoring can be self-sustaining where communities realise the benefits of the scheme and the methods are relatively simple (Constantino et al. 2012). However, this is often far more difficult to achieve in practice and most projects rely on external funds. When these funds run out, monitoring activities often cease to exist due to insufficient capacity, see Poulsen and Luanglath (2005) for an example in PEM in Laos where funding and consequently monitoring and co-management activities ceased at the end of a three year project.

Q7: What is the current relationship with the community?

Establishing a good working relationship with the community is essential for a successful PEM scheme, to develop mutual trust and understanding between the managers, communities and other stakeholders. Building a strong relationship with the community and ensuring there is an open and regular channel of communication ensures that uncertainties and issues can be discussed and dealt with promptly. This is important because there can be a mismatch between ideas and benefits of community-based conservation efforts between stakeholders (van Rijsoort & Jinfeng 2005). Developing a strong relationship with the community can be done by holding community meetings, focus groups discussions, interviews and surveys (Boissière et al. 2014). Akinsoji (2013) describe a project in Nigeria which started with capacity building (training workshops, awareness campaigns, demonstration exercises, lectures, adult literacy programmes) for all stakeholders which established a clear understanding of the governance structure and the roles of stakeholders, a good relationship with all stakeholders and provide valuable information for the design of the PEM project.

Q8: Is the political and social culture of the community and management stable?

If there are conflicts within the community and other stakeholders this indicates that there may be some issues over tenure, access to natural resources, substantial external pressures or local leadership issues leading to power plays. Under these conditions it is unlikely that PEM will be successful. It may result in a lack of motivation or enthusiasm for project activities (Boissière et al. 2014) or problems related to the distribution of benefits or increased susceptibility to elite capture (Topp-Jørgensen et al. 2005). The level of local leadership is also important for community based interventions. Danielsen et al. (Danielsen et al. 2011) describe how strong leadership within a well organised community ensure a good level of communication, accountability and representation which had more success at influencing decision-making and were more empowering.

Q9: What is the intended level of participation with the community?

If only a few local people are involved in collecting the data, then it might be necessary to consider if PEM is appropriate. The level of participation has a positive impact on the success and effectiveness of PEM. For this reason, it is worth considering how to involve marginalised sectors of the community. For example, Aswani and Weiant (2004) partly attributed the success of a shellfish monitoring and management programme in the Soloman Islands to targeting the involvement of women and children (who were not normally involved in fisheries) which boosted their understanding and impact of the project on resource management. Finding ways of involving people at all stages of the project, such as design and data interpretation (Stuart-Hill et al. 2005) increases buy-in and may help to sustain motivation over the long-term (Danielsen et al. 2009). There is also evidence to show that the level of participation is related to increased flow of information to stakeholder and increased speed of decision-making resulting from the data collected (Danielsen et al. 2010).

Q10: What are the benefits to local people?

Benefits to local people from participating in PEM schemes can range from financial payments, to the provision of materials, equipment or other gifts or other intangible benefits such as improved social capital, security, wellbeing, understanding of the ecosystem or enhanced capacity to control natural resources. Deciding whether to pay people is an important consideration, but at the very minimum it is essential that communities do not bear a cost to being involved in a PEM scheme (Q3). Payments can be small and seen as more like compensation to offset the opportunity cost of not engaging in other livelihood activities. Constantino et al. (2012) showed that for PEM projects with a focus on science and conservation, rather than social development, the monitors felt empowered by being paid for their services. Poulsen and Luanglath (2005) explain that in a PEM project in Laos, the daily allowances for collecting the data ensured there was enough people to do the monitoring. Setty et al. (2008) describe requests from communities for compensation for their time and effort taken to do the monitoring of fruit harvesting in India. Compensation was agreed and funds were set aside each year to ensure continuation of the project in the long term. For those benefits that are intangible, there must be consideration of how these benefits can be surveyed to demonstrate that they are true.

Q11: What is the local level of expertise and willingness to contribute?

There might be a high level of expertise in collecting the data if the community have been or are currently involved in some kind of monitoring. This will impact the amount of training required at the outset of the project and the type of approach that is most appropriate. For example, a project intending to use technology (such as tablets or GPS) or specific scientific techniques (such as distance sampling or camera trapping) might not be appropriate in rural communities where familiarity with smart phones is poor and people have no prior experience collecting environmental data or identifying species. In this scenario, simpler methods, such as an inventory or count of species observed and recorded using pencil and paper might be more feasible. In addition to expertise, a community should be willing to be involved in monitoring activities (Hockley et al. 2005), and managers should be realistic about what is expected of the communities and in turn, what the communities expect from the project – this is also related to the benefits to communities (Q3 and Q9).

Q12: What level of external expertise and support is available?

This is related to the level of participation and local expertise (Q8 and Q9), where some communities may need substantial support and regular contact with monitoring managers to execute the monitoring, especially if advanced scientific methods and technology (approaches A-B) will be used. If the implementing organisation does not have the capacity to provide regular support or advice, a manager should consider using low-tech methods requiring a low level of skills or expertise (approaches B-C) where less support may be needed.

Q13: Do you have a plan and budget for managing and analyses the data?

This step is frequently overlooked, but if data management and analysing plans are not in place, a mounting pile of data on paper can serve as a bottleneck where data entry, analyses, feedback to managers and stakeholders are delayed or fails to take place at all. It is also important to have a sufficient budget and the capacity to enter, "clean" and manipulate a dataset before conducting complex statistical analysis. In many cases this requires scientific expertise limited to a small number of people within the implementing or supporting organisation (as might be the case with approach A) that may take place far away from the monitoring site, where is may be difficult to communicate with the communities to clarify any issues with the data. On the other hand, where simple methods are used and analyse requires little expertise data interpretation can be conducted by the local people either independently or with assistance from external agents or managers (approach C). For example, the Event Book System in Namibia has a series of data sheets to collect, analyse and present data over months and years. Data are presented as frequencies and mapped by community rangers (Stuart-Hill et al. 2005). Ultimately managers in monitoring and research projects need to ensure that data are stored in a way that enables access for current research but also so that they can be re-used by others in the future.

Q14: Are there plans to feedback results/information to the community?

This is another step that is frequently overlooked, despite the fact that feeding results back to the community helps empowerment and motivate people to become and remain involved in the scheme (Constantino et al. 2012). This is easiest to do where local people themselves are responsible for data management and interpretation (approach C). However, there are a range of ways information can be fed-back, such as through village meeting, assemblies and by making the data themselves available to local people (Topp-Jørgensen et al. 2005). Bellfield et al. (2015) describe the importance of data ownership and knowledge sharing through discussions within a community involved in a PEM scheme that formed part of a REDD+ project in Guyana. Similarly, data management and interpretation (Q12), it important that sufficient time and resources are budgeted in order that this final stage of the PEM project process can be completed.

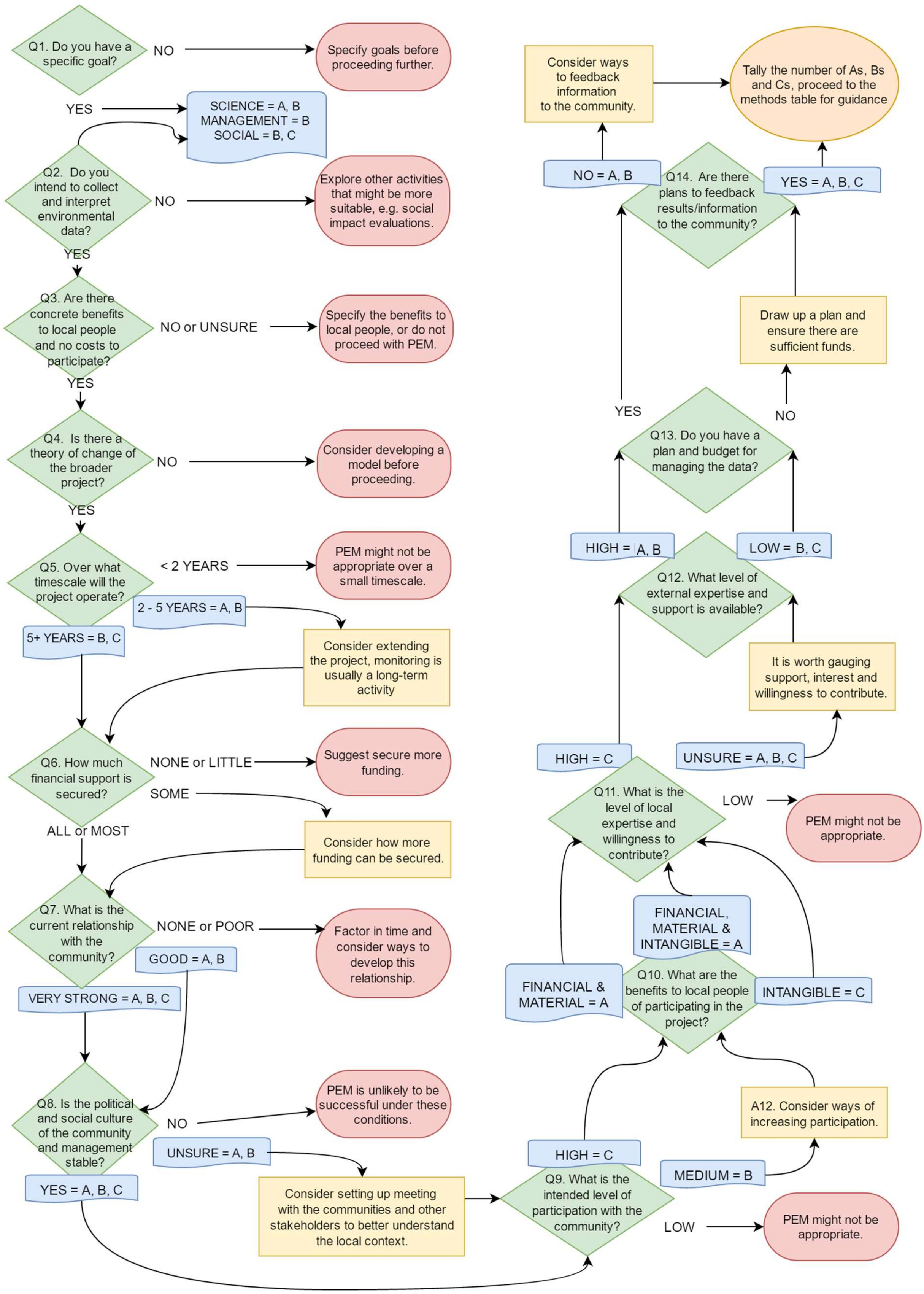

Figure 7.1. The decision framework. The green triangles represent decisions or questions, the red ovals are conditions where PEM may not be appropriate or where is might be prudent to delay project implementation whilst an additional activity is completed, yellow rectangles represent considerations or activities that are advised but ultimately do not stop implementation and blue boxes represent choices that are associated with an approach "A", "B" or "C".

7.3.2 The framework part 2: approaches table

The tally of As, Bs and Cs from the decision tree directs the user to the appropriate column in the approaches table (Table 1). Approach A represents a product approach where greatest interest in the PEM project lies in the data and analysis of the data and focussed on the contribution of knowledge and science to better understand the ecosystem. This approach is characterised as externally driven (such as professional scientists), with local data collectors, category 2 according Danielsen et al. (2009). There may not necessarily be a link to decision-making. Advanced scientific methods can be used to collect the data, which may require specific equipment or technology (such as cameras for camera trapping or water quality measurement equipment). Complex statistical analyses may be required, which are commonly conducted away from the monitoring site.

By contrast, approach C represents a process approach where local people are central to the PEM scheme, with the aim of engaging local communities, empowering and strengthening community-based resource management systems. This approach is characterised as collaborative monitoring with local data interpretation or autonomous local monitoring (category 4 or 5) by Danielsen et al. (2009). The data are likely to recorded in simple form (e.g. on paper), and retained within the community. Methods of data collection and analyses are generally basic and presented as simple graphs or maps.

As an intermediate between approaches A and C, approach B has an action focus, where information from the monitoring is applied to management, as well having a mixture of scientific and social goals. This approach is characterised as collaborative monitoring with either external (category 3) or local data interpretation (category 4) according to Danielsen et al. (2009). The types of methods that might be most suited to this approach may require some equipment and training, such as walking transects, recording catches, point counts, scientific knowledge for accurately identifying species.

The division of approaches into these three distinct categories is illustrative. I recognise that in the real world, schemes may not be stereotyped and could be a mix of these approaches, depending on the circumstances and the context. However, developing a scheme which contains extreme approaches (A and C) may not be feasible. For example, having a project that aims to monitor small changes in detail, over time and space, that require complex data analyses techniques (an 'A' approach) may not be feasible for a project also wishing to focus on local engagement and involving local people in data analyses (a 'C' approach).

Table 7.1. Approaches table – the tally of As, Bs and Cs should be used to guide the user to the appropriate approach columns which suggests a range of possible methods that might be suitable, and references to relevant examples. These categories are illustrative, a scheme could be a mix of the approaches depending on the circumstances.

Continued on next page.

	aspect	**Approach**		
		A: product approach	**B: product and participation approach**	**C: participation approach**
approach description	**Type of conservation goal**	Science based on a priori hypothesis or experimentation.	Mix of both science and social goals for management.	Social development goals.
	Participation level according to Danielsen et al. 2009	Category 2: externally driven, with local data collectors.	Category 3: collaborative monitoring with external data interpretation; or category 4: collaborative monitoring with local data interpretation.	Category 4: collaborative monitoring with local data interpretation; or category 5: autonomous local monitoring.
	Project description based on Jones et al. 2010	Knowledge-focused: information collected might not have a direct link to management actions.	Action focused: information can be directly applied to management action.	NA
methods	**Possible methods**	Methods grounded in natural science: participatory GIS mapping, camera trapping, measuring biomass/forest carbon stocks, mist netting, distance sampling, capture-recapture, photography, water quality equipment.	Intermediate methods; transects, nest occupancy, recording fish catches, species lists/richness, participatory rural appraisals.	Methods grounded in social science: self-reporter hunting, traditional resource management, participatory rural appraisals, patrol records, village group discussions where the data are stored and remain accessible locally.
	Tools	High tech: tablets, GPS, specific measuring apparatus, camera traps.	Low: smart phones, cameras, measuring tapes	None: pencil and paper, participatory rural appraisal tools (such as beans, matrices and sketches/maps on paper).
	Training & payment	A high amount of specific training is required; local people are usually paid for their time.	Some basic training is required and may need to be refreshed throughout the life of the project. Local people might be paid or given in-kind payments or gifts.	Very little training is required to conduct the monitoring itself, but may require assistance with keeping accounts, managing finances, storing data or other capacity building activities. Local people are not paid from external agents, but might be paid by the community and/or given small in-kind benefits.
	Data management	Data managed and owned by an external agency (e.g. NGO), local people unlikely to have any ownership or responsibility in managing, entering and using the data. The data are not stored locally.	The data could be owned by local people and external agents, but most likely managed by external agents. The data might be stored locally and/or externally.	The data are owned by local people, and it stays within the community. The data are stored locally. This could be achieved by appointing a person to take responsibility for the management of the data, such as storing and organising sheets in folders.

	aspect (continued)	Approach (continued)		
		A: product approach	**B: product and participation approach**	**C: participation approach**
methods	**Data analysis**	This approach is related to traditional ecology and biological conservation, where there is a sampling strategy and where detection, spatial and temporal errors have been included in biodiversity estimates. Ideally a statistical power analysis has been conducted a priori to ensure that the monitoring is able to meet monitoring goals (e.g. detect a trend with specified power - see Chapter 4).	For this, some statistics are used to interpret and analyse the data by an external agency. However, any statistics used should be relatively basic and ensure there is sufficient capacity and resources to manage and analyse the data, rather than requiring specialist statistical knowledge and use of advanced techniques that can cause a bottleneck in the data processing. This ensures that information and results can be fed back to the local people and used for decision-making and management of the ecosystem.	No statistics are required to interpret these data, but simple summaries, graphs or maps maybe be produced with the communities, either independently or with the support of external agents.
	Use of the data	The statistical results might not be closely linked to decision-making but do provide a relatively strong understanding of the system, with the power to detect spatial or temporal trends.	The data are used to understand the impact of activities/interventions on the system state, learning to improve practices and move towards adaptive management or co-management approach.	This process-based approach has the main goal of engaging local communities, empowering and strengthening community-based resource management systems, rather than formal analysis or interpretation of the data for regional or national levels.
	Examples	Using mobile devices in Vietnam (Pratihast et al. 2012); GPS to monitor map turtle tracks in the Seychelles (Mortimer et al. 2011); mist-netting and fog capture in Ecuador (Becker et al. 2005).	Transects on bicycles to count large mammals in Zimbabwe (Gaidet et al. 2003); fish catches in South Africa (Carvalho et al. 2009); species richness of ferns in Ecuador (Oldekop et al. 2011).	Local protection and management of natural resources in Indonesia (Sheil & Beaudoin 2015); Event Book System of recording observation and conflict in Namibia (Stuart-Hill et al. 2005).

7.3.3 Case study 1 – prospective design of PEM project in Papua New Guinea

There are a range of vague monitoring goals, currently encompassing all three categories science, management and social (**Q1 yes = A, B, C**) with the intention of collecting biodiversity data on species (**Q2 yes**). Specific benefits of involving the local people in monitoring have yet to be discussed with the communities, but this is a top priority for the next field visit to discuss the scheme (**Q3 not yet**). Improving the specificity of the monitoring goals and how monitoring fits into a conceptual model of the wider project is currently in progress (**Q4 yes**). The project is 2.5 years into a 6-8 year project (**Q5 5+ years = B, C**), after which time Cool Earth will cease operations in the three villages according to an exit strategy that has been agreed with the local communities. The funding for the field activities for the duration of the project has been secured (**Q6 all**). Since Cool Earth have been operating in the villages they have developed a strong and positive working relationship with the communities (**Q7 very strong = A, B, C**). As a result, there is a good understanding of the social and political context, which also identified one person who was causing problems within the committee. This person has been removed from the committee and the project operates in both villages in a stable conflict-free environment (**Q8 yes = A, B, C**). It is the intention of Cool Earth to involve local people in the design of the monitoring activities, data collection and ideally some aspects of the data interpretation and analyses (**Q9 high = C**). At present, it is unclear whether the local people will be financially compensated and/or given gifts to incentivise participation in the monitoring (**Q10 undetermined**). This is dependent on the data collection methods and the terms under which the PEM scheme operates in the villages. Although the communities have not been involved in biodiversity-related activities prior to working with Cool Earth, they have taken to camera trapping techniques easily and with interest. There have been some discussions within the communities about biodiversity monitoring, although the concept of 'biodiversity' and why it is interesting to measure is new, there is willingness and interest across the community to be involved in some kind of monitoring activity (**Q11 high = C**). Cool Earth are based in the UK and do not have staff or a permanent base in PNG. However, they have been working with local NGOs and other experts in PNG. Despite the rural location, there are regular communications (via email and SMS) between the main committee member in each village and Cool Earth. In addition, staff members travel out to PNG for a period of approximately one month every six months to ensure that the communities are well supported and the project is progressing well (**Q12 high = B, C**). A plan for managing and analysing the data largely depends on the methods Cool Earth choose to initiate. In discussions with project staff, the importance of having a management plan was realised as a way to avoid a bottleneck in the management and processing of the data (**Q13 not yet**). Currently the photos from the camera trapping are shown to the local people in feedback and discussions sessions. Likewise, Cool Earth intend to feedback the results and information within the villages, who may be directly involved in the data analyses and interpretation of the data anyway (**Q14 yes = A, B, C**).

The total scores are: A = 4, B = 6 and C = 8. Based on this score and the information about the project the proposed monitoring scheme is probably a good fit for the C category (Table 2), taking mostly a process approach where local people are very involved in design, data collection and simple data analyses, although initial implementation will be largely externally lead and driven. Referring to the approaches table, some suggestions about the sort of PEM scheme that might be suitable can be explored. If the data are collected by writing into notebooks or onto paper sheets, the data will need to be stored locally for extended periods of time because Cool Earth do not have in-country staff or premises. For this reason, there should be consideration about how the data will be recorded, managed and stored whilst making it accessible to local people. As there is a regular electricity supply owing to generators, phone signal, and the local people are familiar with using mobile technology to send emails, there might be some opportunity for digital data entry using smart phones, perhaps with the capacity to submit the data to an online database that can be accessed from Cool Earth staff in the UK. However, it might be prudent to have a written copy of all data collected in case data may get lost due to device failure or communication problems. Given the lack of year-round physical presence of Cool Earth on the ground, training and pilot surveys should be able to take place over a short period of time when project staff are in PNG. This limits the complexity of the data collection techniques that are suitable. As experience of being involved in some sort of biodiversity monitoring through the camera trapping is only very recent, the most appropriate techniques are likely to be records of the number of different species seen. Ideally, there should also be some standardisation of effort between the three villages, such as time of day the monitoring is conducted and the duration/distance walked, or at least record the start and finish times so that effort and time of day can be taken into account. A first level data analysis could be conducted with the communities, by filling in basic graphs, and perhaps using participatory mapping techniques to draw approximate location of the routes used for analyses and where observations were made. The selection of indicators largely depends on the knowledge and identification skills of the participants, but they may be an opportunity to utilise the photos from the camera-trapping to clarify nomenclature (especially where there might be multiple names for one species) and species identification.

These are purely suggestions of the sort of approach that might be realistic and feasible for this project, and by no means the only way of conducting biodiversity monitoring in PNG. Certainly, the local context and situation will determine which of these suggestions are possible. Naturally, some things will work better than others, therefore a pilot study testing the data collection and analyses are essential, and should be conducted prior to substantial investment of effort, time and resources to the scheme.

7.3.4 Case study 2 – retrospective review of project in Menabe, Madagascar

As discussed in Chapter 2 and 4, the scheme has run into challenges, which might be attributed to trying to meet (but ultimately compromising) all three types of goal. For example, at the outset of the project Durrell were trying to engage local people in the control of natural resources, collect data for scientific analyses as well as increasing enforcement of forest laws through a mechanism to report information of illegal activities. This has not altogether been successful (as Chapter 5 and 6 demonstrate) and Durrell need to decide on specific realistic goals that and activities to support the enforcement of the Protected

Area and empower the local communities to co-manage their forests over the long-term (**Q1 management and social** = **B, C**). Species and threat data have previously been collected and this will continue, although there may be a change in the indicators (**Q2 yes**). There are some concrete benefits to some local people, such as the monitors (see Chapter 5 for details), but a review of the current benefit structure is required to ensure that most people in a community benefit from the scheme in some way (**Q3 yes**). It is clear how the monitoring fits into the theory of change, as described in Chapter 2 (**Q4 yes**). Durrell have been working with these communities in Menabe for 10+ years, and there are no current plans to withdraw support or stop working with the communities in the near future (**Q5 5+ years** = **B, C**). As part of an ongoing countrywide programme, funding to support the implementation of the project as well as Durrell staff visits is partially secure (**Q6 some**), it is unlikely that a lack of funds will cause the project to suddenly stop operating. The working relationship with the community is very good (**Q7 very strong** = **A, B, C**) and the social and political culture within the communities are stable (**Q8 yes** = **A, B, C**). Previously, local people were only involved in some aspects of the design process (such as indicator selection) and the data collection. However, in focussing more on the social goals of the monitoring project the level of participation is planned to increase. Local people will be included in disscussions and consultation with the current monitors and the wider community over the future of the PEM scheme, and how local people can be involved in the data analysis and interpretation (**Q9 high** = **C**). Previously the benefits to local people have comprised mostly financial payments and provision of uniform to every monitor and some bicycles to the community. Cooking and agricultural equipment were also provided to the management committee of each village. Although the intention was for everyone to have access to this equipment, this was not the case and some people felt the benefits were not equally shared (Chapter 5). Although the provision of these materials were part of a separate scheme (from Durrell's perspective), this was largely perceived as relating to the monitoring activities. Specifying the expected benefits to the community is an essential part of the review of this PEM project and is currently uncertain, but the benefits are likely to include a mixture of all types (**Q10 financial, material, intangible** = **B**). As local people have already been involved in PEM since 2011, there is considerable local expertise in identifying species and conducting patrols. There is also significant willingness to contribute; despite delay in payments on occasion, the monitors have continued conducting patrols and collecting the data (**Q11 high** = **C**). Durrell staff regularly visit the villages; this is easiest during the dry season May – November. Some villages become difficult to access during the wet season and so the frequency of these visits decreases during this period (**Q12 high** = **B, C**). Previously the monitors recorded observations on sheets of paper which Durrell regularly collects. However, soon the amount of data collected exceeded the capacity for entering the data to a database and analysing the information, as such there was a bottleneck in the data processing and data did not get analysed. The failure to adequately manage the data produced from this project and underestimate management costs has prevented the data from being useful. Such effort and financial resources are now required to enter these data from thousands of paper forms into a digital format and clean the data into a useable form (such as ironing out discrepenacies in village and species names) that it is unlikely data collected in 76 villages across five regions in Madagascar since 2011 will ever be useful, unless a team of people are employed to take on the task. Therefore, it is critically important that a new way of managing and analysing data generated from the patrols is found if the project is to continue (**Q13 no**). Durrell staff regularly visit the villages to meet with the village heads and the monitors, but the data management bottleneck prevented the feedback and discussion of results of the monitoring. However, there is capacity and opportunity to regularly feedback the results of future monitoring. Specific plans of what and how to feed the information back to the community need to be identified (**Q14 no = A, B**).

The total scores are: A = 3, B = 7, C = 7. Based on this score, the project should aim towards a B/C approach in future. Working through the framework has helped to identify the specific areas of the project that need altering (Q1 - setting a goal, Q10 - benefits to local people and Q13 - plan and budget for data management). At the outset of any project it is fundamentally important to develop specific goals and determine a means of measuring progress to understand when the goals have been met (Margoluis et al. 2013). Given this, I suggest that the current goals of the monitoring should be made more explicit. For example, a specific management goal might be to provide information to Durrell and local government authorities about which species were observed over a two-month period in each of the villages. This might be achieved by working with the communities to review and summarise their data when Durrell staff visit each village, so that a basic report of the numbers of different threats and species can be passed onto local government authorities, facilitated by Durrell staff. For the data collected to be comparable between villages (for example indicate areas where threats are highest and more enforcement may be required) there should be some standardisation of the data collection. This can be simple, such as ensuring that each patrol takes approximately the same time. For this, the monitors will need a watch and record the start and finish times of each patrol. A social goal might be to facilitate the engagement of the local people with the local government authorities in making decisions about the management of the PA system. This might be done by organising meetings with the authorities in several villages.

Regarding the benefits to local people of being involved in the monitoring scheme, an alternative mechanism to continue the distribution of these benefits should be identified, or a review of the benefit system should be undertaken. The monitors who are directly involved in the scheme should continue to be compensated for their time and provided with the uniforms and bicycles to improve their ability and incentivise them to continue collecting the data. Regarding the intended social benefits of the scheme in the project (such as access to natural resources, empowerment and involvement in decision-making), there needs to be some way of measuring whether these intangible benefits are being felt across the communities. Chapter 5 provides some guidance as to how this could be achieved, such as conducting regular meetings with different sectors of the community (such as women, or those not directly involved in the monitoring) and doing some surveys of perceptions of the project with randomly selected households.

Improving the data management and interpretation is probably the key to continuing the future of this PEM scheme. A lack of resources and sufficient budget planning has resulted in the data collected being rendered useless. It is evident that there needs to be a substantial increase the data management budget and to hire personnel to specifically manage the data collected by the monitors. In addition, one way to avoid the bottleneck of data whilst also increasing participation might be to discuss and summarise, with the monitors, the data that have been collected. Flip-chart sized paper and marker pens could be used to draw basic graphs of the number of species and threats detected in a participatory manner, and could also involve a wider section of the community such as school teachers and pupils. Knowing that the data collected have been checked for inaccuracies and summarised with the monitors enables this information to be quickly processed by Durrell staff and distributed to local government authorities in a timely manner, so the information is relevant to immediate decisions that might be made, such as allocation of enforcement activities.

These suggestions for the alteration and improvement of the PEM project are by no means the only options available. Referring to approaches B and C in Table 2 gives further ideas and suggestions about the types of methods or approaches that might be suitable, for example, the storage of data and the level of training that might be required.

7.4 Discussion

7.4.1 Rationale for using PEM

A practitioner wishing to implement a PEM scheme faces a range of decisions about the why, what and how of monitoring. This framework aims to provide guidance to conservation managers, helping them to decide whether PEM is appropriate and the sorts of tools and approaches that might be suitable based on their circumstances. This is important because PEM might not be appropriate for a variety of situations, such as if there are no clear benefits to local people of participating in the scheme, or if there are political or social conflicts within a community or between stakeholders. In such as situations, it might be better to forego PEM and focus resources on other activities or creating a suitable environment in which to return to the design and implementation of a PEM scheme at a later date. Secondly, there are a range of decisions regarding the design and implementation of the scheme itself. These include the data collection method, level of participation by local people, or how to incentivise local involvement. Finally, a manager will need a process that ensures the information is meaningful and can used in decision-making or fed back to the community, thereby achieving the goal of the monitoring.

7.4.2 Practical use

This framework aims to assist practitioners to decide whether a PEM scheme is appropriate and help design and implement a scheme (such as case study 1). However, there can be conflicts between scientific and theoretical ideals and the realities of monitoring. As a result, despite best intentions during the design of a scheme, things may change during the project lifetime and the monitoring tweaked. In this situation, case study 2 demonstrates the utility of the framework in a retrospective review of an existing scheme in order to identify areas that could be tweaked and give ideas as to new ways of approaching a PEM intervention.

The approaches table provides a range of ideas and tools, but deciding how to do the monitoring is ultimately context-specific. There may be different circumstances between neighbouring villages that warrant a slightly different approach. For example, in the Papua New Guinea case study, one village has a poor phone signal, therefore the UK office communicates with the village committee members through a local coordinator in a nearby town. The other village has good signal and the village facilitator can be contacted directly through emails and SMS. This has implications if Cool Earth wanted to implement a digital data collection, entry and management system which may only be feasible in one of the two villages.

7.4.3 Future potential of the framework

Although this research has been conducted as part of an academic thesis, I have been working closely with Durrell Wildlife Conservation Trust and thus have tried to include a range of perspectives from the academic and practitioner community in this framework. However, I do acknowledge that tools should be developed with practitioners and based on what their needs, rather than simply promoting it post-hoc to a practitioner. For this reason, I do not envisage that this is the final framework, but a first step towards a fuller, easily accessible and useful tool. It would be well suited as a starting point in participatory workshops with practitioners and academics or perhaps could be developed in affiliation with the Participatory Monitoring and Measurement Partnership. It is important to engage with practitioners in this way to ensure that the needs of practitioners are met and increase the chance of this framework being usefully applied to translate various forms of scientific knowledge and experience into action. By offering this framework to the wider community, it could be tested and validated with practitioners so that it is useful for real world decisions. Further work to develop this strategy could include creating a more digestible format, such as an easier to read working paper or an interactive online tool, thereby increasing the accessibility of the framework to all practitioners beyond the academic literature. If the framework was translated into other languages, this would further increase the accessibility and usefulness of this tool.

7.4.4 Conclusion

Considerable planning and preparation must go into a project prior to any training or data collection taking place, but rarely do conservationists critically assess the value of gathering more information (McDonald-Madden et al. 2010) or make decisions on what to do and how based on scientific evidence (Knight et al. 2008; Laurance et al. 2012). Knowledge and experience from peer-reviewed literature, grey literature, first-hand experience and discussions with practitioners have been used to develop this framework. Synthesising these forms of knowledge, experience and type of boundary work is needed if science is to become relevant to real-world problems and make an impact. By drawing on various knowledge and experience, this framework has attempted to simplify the complex process of implementing and managing a PEM scheme. It is intended to provide some support and be useful to practitioners navigating a range of decisions in a systematic manner to order to develop or improve a PEM scheme that is successful, meaningful and sustainable. However, given the complexities of PEM schemes, this framework is simplistic and needs to be developed with practitioners to ensure it can be useful and contribute to narrowing the science-action gap leading to more effective PEM schemes in the future.

Chapter 8 Discussion

8.1 Main findings

In working towards the thesis research objectives, I explore the role of PEM in conservation and development initiatives in various ways. In this final chapter, I draw on my experience, understanding and findings from all the chapters in order to discuss the contributions my research has made to understanding the issues raised by the case study, and to conservation science more broadly. I also discuss the most promising avenues for future research on this topic.

Figure 2.3 (in Chapter 2) describes and discusses a theoretical framework for how PEM may contribute to both conservation and development goals, resulting in a win-win strategy with positive feedbacks between the two dimensions. The case study in Madagascar is an example of a project aiming to achieve a win-win by using PEM as a mechanism to provide development support and empower communities to manage their own resources in return for collecting data that can be used by external actors (Durrell and government agencies) to detect and act on trends in species of concern and threats. However, as Chapter 5 and 6 demonstrate, the win-win is not straightforward to achieve. Figure 8.1 summarises how the findings from my case study chapters relate to parts of the PEM theoretical framework.

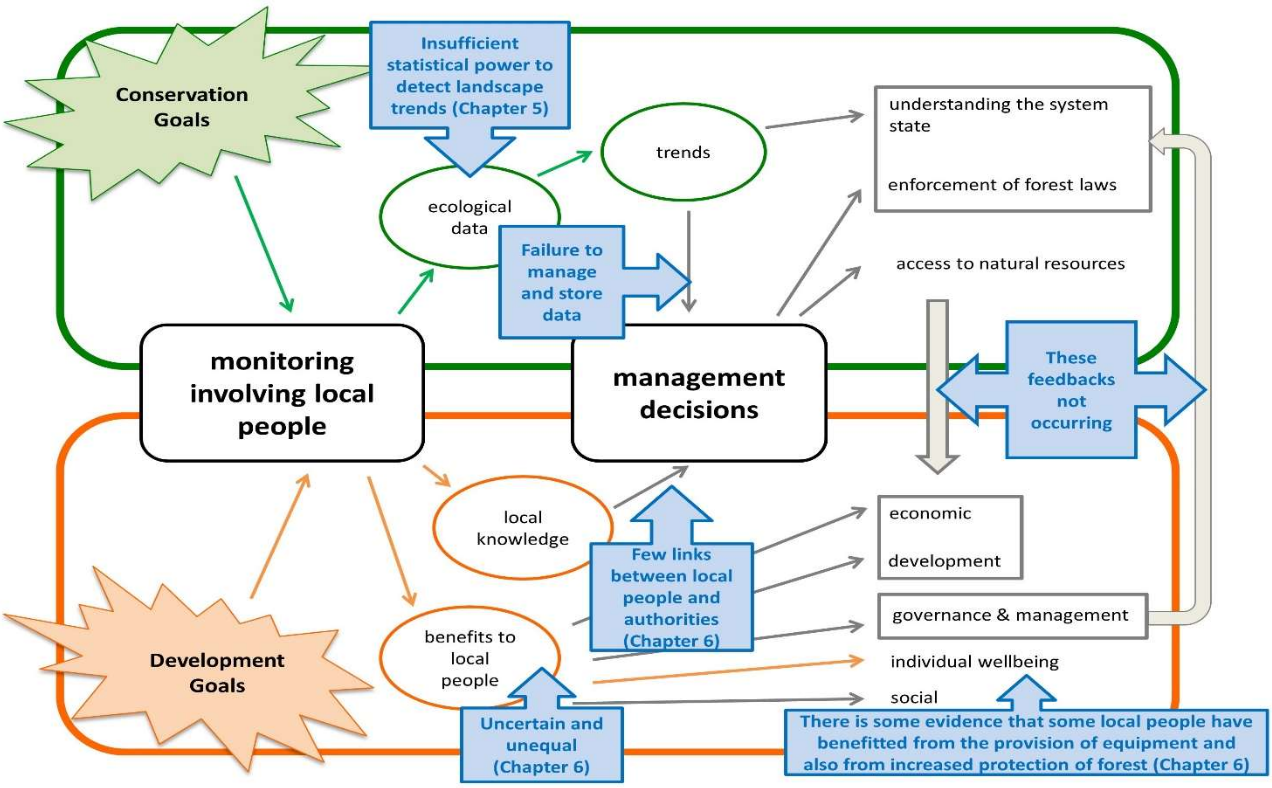

Figure 8.1. The conservation (green) and development (orange) components of PEM schemes taken from Figure 2.3 of Chapter 2 and a summary of the key points from Chapters 5 and 6 from the case study in Madagascar (blue). Grey arrows indicate a lack of evidence for that link.

Chapter 5 showed that the data collected by the PEM scheme are not currently suitable for detecting landscape level changes in occupancy because of the high number of patrols and sites needed for a statistical power of 80% to detect growth or decline in the current indicators. This lack of power means that detecting trends in occupancy over are too ambituous and unlikely to ever be achieved. Added to this, Chapter 6 also highlighted some implementation issues at various points in the PEM process. Within the communities, the benefits of the scheme were not equal or widely distributed, and there were some difficulties in providing regular payment to the monitors. In addition, monitors felt vulnerable about their unofficial status as law enforcers.

The feedbacks in figure 8.1 depend on communication and collaboration between the local people and local government authorities responsible for forest management. I identified a data management bottleneck that impeded the flow of data to local government authorities and back to the communities. Because of this, currently local people are uncertain about how their data and information are used and do not feel that are actively involved in the governance and management of natural resources (section 6.3.1). Although initially monthly reports summarising forest law infractions were passed on to local government authorities, the monitors did not feel that the authorities were acting on the information they were reporting, as a result motivation to produce the reports waned and gradually ceased in all villages. Because of these issues, the feedbacks between the conservation and development dimensions do not occur, so the scheme falls short of its intended contribution to link with management decisions.

However, Chapters 5 and 6 also highlighted some positive aspects of the current scheme. For example, despite the unequal distribution of benefits, the scheme is well known and largely positively perceived throughout the communities, and there is widespread awareness of the benefits of conserving the forest. Added to this, during interviews, some monitors described how they had continued patrolling and data collection even when they had not received payment for many months.

As demonstrated in Chapter 4, PEM is widely used throughout the world (section 4.3) and the number of schemes is rising and demonstrating a shift from collecting data for the sole purpose of increasing ecological knowledge and understanding system state to incorporating the needs of local people. Although levels of participation in PEM schemes vary (section 4.3.1), there are schemes where participation is high and schemes are sustainable over the long-term (e.g. Stuart-Hill et al. 2005). It is important that conservationists learn from these successes and identify the contexts in which a PEM project is operating well. Equally, following-up on those projects that have ceased to exist would be a valuable contribution to understanding the success factors for PEM projects.

8.2 Contributions to the case study

8.2.1 Data collection

Currently, the project falls short of achieving a win-win for both conservation and development dimensions, although that is not to say that it should be withdrawn altogether. Based on the positive perceptions of the scheme and the motivation and enthusiasm of the monitors to conduct the patrols, I suggest in Chapters 6 and 7 that Durrell should simplify their data collection and analyses by taking an inventory approach to monitoring at the village level, with the potential to compare between villages. This requires changes to the current system such as standardisation across all villages. This should include recording the start and finish times of the patrols, recording whether the patrols are taking place in a multi-use or strictly Protected Area of the forest, and recording whether the species has been seen or not (rather than the current system of counting or estimating the number of individuals). If the data collection was standardised to be similar across all villages, the information could be scaled up to the landscape level to get an overview of the state of the system as a whole.

8.2.2 Data management

The case study is an example of a lack of adequate data management which has resulted in only two-three years of data being available from 2011, despite data ongoing and regular data collection at the time of writing. The main problem has been affording to pay people to enter the data from paper datasheets into a Microsoft Excel spreadsheet and for staff time to train people to enter the data and check for errors and inconsistencies. Consequently, scientific analysis, beyond modelling of a small part of the data collected in chapter 5, could not be conducted. Due to the substantial underestimate of the costs of data management in this case study, the data are currently unusable and likely to remain so for the near future. Future data management and storage requires urgent, immediate attention as the project continues so that the current data collected can be useful.

This serves to highlight the importance of data management for the success of a project. Data management of a PEM scheme may be more difficult than research conducted by professional scientists. For instance, professional scientists are often responsible for data entry and data management of their own data. However, in PEM the data collectors may not have the skills or resources for data entry, and therefore a large part of a budget must be available for someone else to enter and clean data so that it is available to use and share within the organisation and wider scientific community.

The importance of data management and archiving is increasingly being recognised (Applegate 2015; Rüegg et al. 2014), only a few papers on that describe and discuss data management strategies for ecological data have been published. For example, Solymos et al. (2015) describing data management of the Alberta Biodiversity Monitoring Institute, Canada, they identify four characteristics that are required for long-term ecological datasets to provide credible, useable information and support decision-making: (1) data publicaly accessible, (2) standardise methods and terminology used during data collection, analysis and reporting, (3) flexible system that allows for modifications of components of the scheme, and (4) sufficient to support input, storage and retrieval of an increasing amount of data. Furthermore, Sutter et al. (2015) provide guidance for the development of effective data management for long-term ecological monitoring projects. They address a range of topics from consistent data collection, data completeness and quality to archiving of data and evaluating data from other sources. The framework presented encourages a proactive planned approach to data management to ensure that data are available and useable in the long-term to answer ecological questions and advance scientific understanding. As has been discussed with Durrell, data management of the PEM projects needs an overhaul and this framework would be particularly useful for that purpose.

8.2.3 Data analyses and interpretation

Given Durrell's long-standing work in these communities (Chapter 3), as part of a review of the overall data management, I also suggest that Durrell involve local people in the analyses and interpretation of the data which they are gathering. I anticipate that the monitors and other local people would enthusiastically receive training on how to interpret the data (such as drawing basic graphs). Not only would this increase participation in data interpretation, increasing local ownership of the data, it would also demonstrate the usefulness of the datasets to the local people. In addition, and reduce the burden of and solve the issues with the data management bottleneck. During this research, the author has discussed these ideas with the Durrell staff, who are currently refining the goals of the PEM scheme and reviewing data collection, analyses and interpretation.

8.2.4 Linking communities with local government authorities

Trading off the intended scientific aspects of the scheme (that have largely failed) for more local ownership would increase the opportunity for facilitating the communication of this information to local government authorities to ensure that the data can trigger law enforcement action and management where problems arise. For example, if a sudden rise in logging were detected in a village, this mechanism has potential to raise the alarm and trigger a response from the local government authorities to investigate and deal with the threat. In this way, the PEM scheme has potential to involve people in the enforcement and control of their natural resources. Currently, forest law enforcement is largely ineffective (section 3.2.1), however Durrell are ideally suited to facilitate the flow of information between the communities and local government authorities. Not only do they have a good working relationship with the communities as demonstrated in Chapter 6, they also have the political connections to national, regional and local government authorities responsible for the environment and control enforcement (pers. comm., H. Andrianandrasana). In this sense, there is potential for PEM to contribute to the new Protected Area in Menabe and other new Protected Areas, as a mechanism for the engagement and involvement of local people in management of forests and a reporting mechanism to the local authorities. It would be possible to set up a procedure where local people collect the data and report data infractions (threats such as fire, illegal animal hunting etc) to local authorities in a timely manner. This depends on capacity and willingness to act on the information provided to them on the part of the authorities. Indeed, a response from local government authorities to forest has been lacking in the past few years in Menabe. However, this is currently one of Durrell's main focus in the immediate future, as they are currently reviewing their strategy for linking local people with local government agencies and increase enforcement of forest laws.

8.3 Contributions to conservation practice

8.3.1 Realistic pre-project planning

Given the positive findings, there are reasons to be optimistic about the potential for synergy between the conservation and development dimensions in the future of PEM schemes. However, this requires that conservationists look hard at potential trade-offs in and have a clear picture of the goal of each scheme and how this can be realistically achieved, in advance of implementation. This requires substantial foresight, being upfront about assumptions and having an approach that is flexible and adaptive to incorporate learning and retrospectively review the design and implementation of a project (Chapter 7). In particular, the case study has demonstrated that there needs to be a clear set of goals and objectives that are realistic and not overambitious (see section 7.3.4). For a conservation practitioner, the challenge of designing and implementing an intervention is to ensure that it is successful in its context, conducted in the best way and using available resources effectively (Margoluis et al. 2013). Because conservation is an emergency discipline that operates in dynamic complex socio-ecological systems, action must usually be taken in the face on uncertainty. Added to this, many conservation initiatives operate with low personnel capacity, small budgets and limited resources to collect verifiable scientific evidence. As a result, historically, much conservation practice acts on intuition, common sense or anecdote (Sutherland et al. 2004). However, in recent years there have been developments in evidence-based conservation, for example through online information resources such as www.conservationevidence.com and open access journals, such as Conservation Evidence.

A prospective review of the power of the data to detect change should be a fundamental part of the planning and design phase of a monitoring project that are specifically intended to be analysed to detect trends. Chapter 5 demonstrates the importance of ensuring that a monitoring scheme has sufficient power to detect change. The evidence that the indicators used in this case study were far off being able to detect change with reasonable power is a concern for conservation practitioners generally. The new method developed by Guillera-Arroita and Lahoz-Monfort (2012) to measure the power of occupancy studies casts doubt on the suitability of occupancy modelling with small sample sizes, such as is the case in the majority of PEM schemes. For this reason, conservationists should conduct a priori power analyses to ensure that the monitoring they propose is powerful enough to detect trends, as has been widely been discussed in the scientific literature for some years now (Legg & Nagy 2006). The power analysis should be done during the design stage of a scheme so that realistic targets are set based on what is achievable and required. However, I suspect that power analyses are rarely conducted in monitoring interventions involving local people (but see Jones et al. 2008 for a power analysis on interview data), given the difficulty

NGOs have in allocating time and resources to scientific research. A review of the power of different types of PEM scheme to detect change in different circumstances would improve understanding of the potential of PEM to contribute to ecological knowledge and guide the practice of PEM.

8.4 Contributions to conservation science

8.4.1 Opportunities to learn from REDD+

Since 2005 a program to reduce emissions from deforestation and forest degradation and increase carbon removals and other biodiversity co-benefits (REDD+) has been in development as part of the United Nations Framework on the Convention on Climate Change (UNFCCC). REDD+ is continuing to evolve as it becomes established as a mechanism for mitigating climate change. REDD+ relies upon detailed data on carbon reservoirs and changes in stocks at the local level (Torres 2014). Given that monitoring by professionals is largely regarded as being prohibitively costly (Balmford et al. 2003), community-based monitoring has much potential to become an important part of the monitoring, reporting and verification (MRV) of carbon stocks (Palmer Fry 2011). Indeed, there is some evidence from Chapter 4 that there is interest in involving local people in the MRV of REDD+, of the 117 projects reviewed, 18% of PEM schemes were related to REDD+ schemes. Due to the international nature of REDD+, the next few years are likely to yield a substantial amount of interest and research in the PEM aspects of this mechanism. Given that the monitoring conducted by local people for REDD+ is a specific type of PEM, as REDD+ evolves and spreads, there are opportunities to feed this information into the wider discussions about the role of local people, but also forest management programmes. As the case study in Madagascar demonstrates, REDD+ practitioners and managers will need to ensure they have resources for an efficient data management system and the budget for storing and sharing data for analysis, also that the data collected are powerful enough to meet the need of REDD+ and that local people can generally have a positive attitude to monitoring.

8.4.2 PEM as a foundation for CBNRM

PEM, by definition, is a form of monitoring, whilst community-based natural resource management (CBNRM) is management. Those PEM schemes where management and decision-making power are devolved to local communities might be considered as a foundation and first step towards CBNRM, if challenges in data management and statistical power can be overcome. Legislation or policies for the devolution and decentralisation of natural resource management to local communities have been drafted throughout the world (Balooni & Inoue 2007; Ribot et al. 2006). In a study constituting 82% of global land area, 18% is formally recognised as either owned by, or designated for, indigenous peoples and local communities (Rights and Resources Initiative 2015). Despite the prevalence of CBNRM, there is scant historical evidence that CBNRM or community forest management is successful either ecologically or for the development of local people (Bowler et al. 2012; Lund & Treue 2008). This has been largely attributed to the complex and dynamic relationship between ecological and socio-economic systems (Persha et al. 2011).

Recently, evidence of the positive benefits of community forests have begun to emerge. For example, Measham and Lumbasi (2013) discuss two successful case studies of CBNRM in Kenya and Australia and Gbedomon et al. (2016) explore the socio-economic and ecological outcomes of community-forest management in Benin. Success in these case studies was attributed to the strong attachments local people had with their environments, high level of ownership and strong institutional arrangements that link local forest users, NGO and local government. Complementary to this, Baynes et al. (2015) develop a causal model of the influences and success factors of community forestry, based on three case studies in Mexico, Nepal and the Philippines. They identify five key success factors, some of which feature in the decision framework: (1) socio-economic status and gender based equality in access to participation in the scheme, (2) secure property and land resource rights, (3) transparent, democratic and effective governance (which relates to question 8 of the framework about the social and political culture of the area in which the PEM scheme is operating), (4) good government support, (5) material benefits to community members (which relates to questions 3 and 10 of the framework about the benefits of PEM to local people).

In two cases studies discussed by Measham and Lumbasi (2013), they highlight the importance of participation and CBNRM projects being genuine community initiatives. Similarly, for those PEM schemes where there is interactive participation, or self-mobilisation of monitoring characterised by a high level of local participation (see Table 2.1), PEM has the potential to be a direct way to link communities with the management of natural resources. The formalised process of collecting and recording data in a regular and relatively systematic way means that there is a 'paper trail' of information. If these reporting procedures are followed, monitors can become a successful link between the local people (often the main natural resource user groups) and local government authorities in the process of resource management. For this reason, PEM has potential to empower local people and change attitudes of local people and authorities, thereby enabling CBNRM. Although empowerment is often cited as benefit to PEM (Danielsen et al. 2005), there are few examples in the literature that demonstrate this is occurring. Constantino et al. (2012) is one of the few studies that explore empowerment in PEM, based on schemes in Brazil and Namibia. They found that the schemes promoted empowerment of individuals, but that wider community empowerment was much rarer and depended on the local context and existing community political organisation. PEM in itself is a means to establish and maintain institutional links between local people and higher levels of government, perhaps with facilitation by external agencies (such as Durrell in the case study). The importance of governance that starts from the ground up and institutional linkages between communities and institutions at district, regional or national levels is recognised in multiple evaluations of conservation and development initiatives (Berkes 2007). Thus, PEM as a foundation to CBNRM has much potential to contribute further directly into conservation and development initiatives where the schemes are carefully planned and can take advantage of existing local governance structures. In that regard, the ability to directly link and empower local people distinguishes it from other forms of community-based conservation (CBC). Here, I refer to CBC as a term that refers to any sort of conservation-related activity that involves a local community within close proximity to the area of interest.

8.4.3 PEM as a type of community-based conservation

Chapter 4 shows that PEM is variable in the goals of schemes and the methods and type of data collected. The commonality to all the different PEM approaches is the involvement of local people in monitoring with the intention of meeting dual conservation and development goals. In many ways, the Durrell case study is typical of a PEM scheme and many community-based conservation projects, by being operated:

- on a relatively small-scale by an NGO,
- with a relatively small budget where the amount of funding may vary from year to year depending on the success of grant applications,
- in poor rural communities often dependent on natural resources,
- at the nexus of conservation and development in complex dynamic situations.

CBC projects employ a range of strategies or activities on the ground including alternative livelihoods, PEM, payments for ecosystem services, ecotourism or human-wildlife conflict mitigation. The similarities between these approaches are that they seek to combine conservation and development, with the shared rationale that long-term conservation success requires engaging with and providing benefits for local communities. However, there are four distinct approaches to integrating conservation and development and a range of CBC project types that fit into one or more of these (Table 8.2). These approaches vary in the level of active engagement and participation of local people, from passive engagement in benefit sharing agreements (for example sharing profits from ecotourism e.g. Archabald & Naughton-Treves 2001) to active engagement such as the involvement of local people in managing natural resources (such as in some PEM schemes e.g. Stuart-Hill et al. 2005).

Table 8.1. Approaches to integrating conservation and development and types of CBC initiatives.

increasing engagement →

Type of CBC Project	Benefit sharing	Alternatives to damaging exploitation	Increasing the value of natural resources	Resource management	Reference
Ecotourism	X	X	X		(Kiss 2004)
Human-wildlife conflict mitigation		X			(Treves et al. 2006)
Agricultural or development support		X			(Campbell & Vainio-Mattila 2003)
Alternative livelihoods (e.g. bee-keeping)		X	X		(Roe et al. 2014)
Community-based enterprise strategy		X	X		(Salafsky et al. 2001)
Payments for Ecosystem Services (PES)		X		X	(Sommerville et al. 2009)
Participatory Environmental Monitoring (PEM)		(x)		X	(Topp-Jørgensen et al. 2005)

Unlike most other strategies, PEM is rarely primarily proposed as an alternative to damaging exploitation, (although ex-hunters or resource users may be trained as monitors e.g. Bachan et al. 2011), but often is uniquely placed as a formal and direct link between local communities and resource management. PES also takes a resource management approach to conservation (Sommerville et al. 2009), although biodiversity PES is often instituted to incentivise desisting from exploitation rather than as a way of promoting active management, and payments are conditional on pro-conservation activities or service provision. For example, PES may encourage communities to cooperate with management plans by providing in-kind payments (such as materials and equipment for schools and agricultural activities) contingent on the state of the forest (Sommerville et al. 2010).

Although widespread, CBC projects and conservation and development initiatives more generally have been the subject of much controversy over many years (Brooks et al. 2013; Roe 2008). Debates stem from whether conservation and development can be truly integrated or whether the reality more resembles conservation projects with development, or development projects with conservation (Brown 2002; Sayer 2009). Historically, there has been a lack of evidence that CBC projects are consistently successful at achieving a win-win (Adams et al. 2004; Tallis et al. 2008). However, CBC remains prevalent in conservation interventions because of its appeal as a means of serving both conservation and developments interests as well as the ethical requirement to incorporate the needs of poor local people into conservation interventions (Makagon et al. 2014; Shoreman-Ouimet & Kopnina 2015). For these reasons, CBC is likely to continue to be promoted both by international treaties (such as the Convention on Biological Diversity) and implementing organisations, whilst researchers continue to advance understanding of the factors affecting conservation and social outcomes of CBC interventions.

8.5 Concluding remarks

This thesis explored the ecological and social dimensions of PEM with a view to providing guidance for practitioners implementing PEM schemes. Conservation and development initiatives and CBC are so commonplace, and such is the importance of this approach, that practitioners and researchers will continue to strive to identify interventions which strengthen synergies between conservation and development. Given the parallels and links between PEM and REDD+, CBNRM, and CBC, there are diverse lessons and opportunities to learn from successes and challenges in implementing all types of conservation projects. PEM is widely practiced and recognised as one means of integrating conservation and development, and integrating both objectives in equal parts is likely to continue posing a big challenge to conservation practitioners in the future. However, as the research and this case study demonstrates, PEM is no silver bullet. Although the case study demonstrates that local people can have a positive attitude towards a PEM scheme and motivation to continue monitoring, this research has also highlighted several challenges that need to be overcome for data to collected to be useful. Firstly, this research has demonstrated how difficult data management in PEM can be and how this prevents the data being available for analysis. Secondly, collecting and analysing data that are statistically powerful may require resources that are unrealistic for detecting trends over time. Although PEM may seem well placed to contribute to community-based conservation and monitoring of biodiversity and natural resources, there are a range of barriers before the Durrell case study, and PEM schemes in general will be able to achieve dual conservation and development goals.

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Appendix A: Chapter 4

A.1. Online survey

We are interested in finding out about monitoring projects involving local people in developing countries. In this context, local people are defined as "non-scientist (people with no formal scientific training beyond secondary education) people living close to the area of interest".

If you are involved in a project/s that collects information for more than one dataset, **please complete one survey for each dataset.**

This survey will take no longer than 10 minutes to answer.

By completing this questionnaire you agree to let this information be used in a systematic review of monitoring projects involving local people, part of PhD research. We would like to keep you updated on the findings of this research, if you agree, please provide your name and email address when asked. The identity of respondents and individual answers is confidential and will not be revealed or passed on to other parties.

Thank you for your time.

Samantha Earle - s.earle13@imperial.ac.uk

1. What is your role? Select one.
    a. Project manager of a monitoring initiative
    b. Project assistant of a monitoring initiative
    c. Independent scientist or adviser
    d. Government staff
    e. Other – please describe_____________________

2. What is the name of the project?

3. Which country does the project operate?

4. What is the habitat type? Select one.
    a. Agricultural land (arable, pasture or plantation)
    b. Desert – hot or cold
    c. Forest - temperate
    d. Forest - tropical or subtropical
    e. Grassland or savannah
    f. Shrubland
    g. Rocky areas (inland cliffs or mountain peaks)
    h. Urban areas (in towns or villages, gardens)
    i. Freshwater wetland (lakes and/or marsh)
    j. Riverine (rivers, streams, creeks)
    k. Marine – inshore (mangroves, sea grass, reef or estuary)
    l. Marine – offshore
    m. Other – please specify ____

5. Who originally designed the monitoring system? Select one.
    a. Professional researchers without involving local people
    b. Professional researchers with assistance from local people
    c. Local people with advice from professional researchers
    d. Local people without involvement from professionals
    e. Other – please describe _______________________________________

6. Which year did the data collection start?

7. Which year did the data collection finish – or is it on-going?

8. What are the main goal/s of the monitoring project? Select as many as required:
    a. Build community capacity, power and engagement with the management of natural resources
    b. Contribute to a REDD+ scheme
    c. Contribute to Protected Area management
    d. Contribute to decisions about control of natural resources, e.g. permit allocation, access rights
    e. Stimulate discussions within the community about natural resource management
    f. Improve livelihoods of local people
    g. Feasibility study for the involvement of local people in monitoring activities
    h. Improve understanding of population ecology or the state of biodiversity, or for general interest
    i. Measure the impact of a conservation intervention
    j. Legal requirements
    k. Ensure compliance with rules
    l. Provide evidence that activities have been implemented
    m. Record changes in land use
    n. Other – please specify:

9. How many sites are involved in the monitoring scheme? ___________

10. What is the total (the sum of all sites, if there is more than one) size, in hectares, of the area monitored? Given 100 hectares = 1km2 and 100 hectares = 247 acres. Select one.
    a. Less than 10 000 hectares
    b. 10 000 – 49 999 hectares
    c. 50 000 – 199 999 hectares
    d. 200 000 – 499 999 hectares
    e. more than 500 000 hectares
    f. unsure

11. How many local people live in your sites? Local people = 'residents that live close to the area of interest'. If your monitoring scheme has multiple sites, please provide a total. Select one.
    a. Less than 500 people
    b. 500 – 999 people
    c. 1000 – 4999 people
    d. 5000 – 19 999 people
    e. 20 000 – 99 999 people
    f. 100 000 people or more
    g. Unsure

12. Who collects the data? Select one.
    a. Professional researchers with assistance from local people
    b. Local people with advice from professional researchers
    c. Local people without involvement from professionals
    d. Other – please describe __________________________

13. How many local people are involved in collecting the data? ________________

14. Apart from materials and equipment required to conduct monitoring, are the local people paid to collect the data? Select one.
    a. Yes – a financial payment
    b. Yes – an in-kind payment (such as food, materials, equipment)
    c. Yes – both financial and in-kind payment
    d. No
    e. Other, please describe: ____________________________________

15. On average, how frequently do local people collect the data? Select one.
    a. daily
    b. 2-6 times a week
    c. once a week
    d. 2-3 times a month
    e. once a month
    f. once every 2 months
    g. 2-6 times a year
    h. once a year
    i. depends on the season/month of the year– please describe ____________
    j. unsure

16. What data are collected? Select all that apply.
    a. Mammals
    b. Birds
    c. Reptiles
    d. Amphibians
    e. Fish
    f. Insects
    g. Plants – trees
    h. Plants – general
    i. Hunting data
    j. Evidence of anthropogenic activities, e.g. traps, snares
    k. Human-wildlife conflict
    l. Socio-economic data
    m. Food security
    n. Human health
    o. Types of landscape use
    p. Landscape characteristics, e.g. soils, climate, biomass
    q. Carbon stocks
    r. Weather
    s. Air quality
    t. Other – please specify ____

17. Is indigenous or traditional knowledge involved in the initiative? (Indigenous/traditional knowledge = 'knowledge, innovations and practices of indigenous local communities, developed from experience gained over centuries and adapted to the local culture and environments transmitted orally from generation to generation' CBD www.cbd.int). Select one.
    a. yes
    b. no
    c. unsure

18. How are the data collected? Select all that apply.
    a. catch data e.g. fishing nets, pitfall traps
    b. pre-determined line transects or patrol routes
    c. patrols – random or non-defined
    d. opportunistic observations of sightings of individual species/resources
    e. point, plot or quadrat counts
    f. tracking – by GPS or radio collared individuals

g. tracking – by sign
h. market surveys
i. photographs – mixed point
j. photographs – random or opportunistic
k. camera trapping using automated cameras
l. log-books or field diaries
m. focus group meetings
n. informal conversations or meetings with people
o. structured or semi-structured interviews with people
p. other – please describe ____

19. How are (or will) the data analysed? Select all that apply.
    a. simple quantitative descriptive summaries, such as graphs and tables
    b. statistics: simple, e.g. t-test, chi-square, regression
    c. statistics: advanced, e.g. mixed modelling, GLMs
    d. occupancy modelling
    e. population abundance and/or density modelling
    f. spatial analyses using GIS software
    g. species accumulation curves
    h. qualitative description or summary
    i. qualitative analyses using software, e.g. NVivo
    j. do not / will not analyse the data, please describe why _______________
    k. other – please specify _____________________
    l. unsure

20. How are / will the data be shared or results disseminated? Select all that apply.
    a. verbal report or discussion within community
    b. verbal report – passed on to local authority
    c. verbal report – passed on to NGO/civil society organisation or other institution
    d. written report – retained by local community
    e. written report – passed onto to local authority
    f. written report – passed onto NGO/civil society organisation or other institution
    g. No intention to share data or results other – please describe ______________
    h. Unsure

21. Who analyses or interprets the data? Select all that apply.
    a. Local people
    b. Local government authorities
    c. Professional researchers
    d. NGO/civil society organisation
    e. Other – please describe __________
    f. Unsure

22. Overall, how effective do you think the monitoring is in meeting conservation or ecological goals of the project (such as contribution to ecological understanding, PA management)? Select one.
    a. Very effective
    b. Effective
    c. A little bit effective
    d. Neither effective nor ineffective
    e. A little bit ineffective
    f. Ineffective
    g. Very ineffective
    h. Unsure

23. Overall, how effective do you think the monitoring is in meeting development or social goals (such as empowerment of local people, capacity and social capital)? Select one.
    a. Very effective

b. Effective
c. A little bit effective
d. Neither effective nor ineffective
e. A little bit ineffective
f. Ineffective
g. Very ineffective
h. Unsure
i. Not a relevant goal

24. Have the data and/or results been published in any format? Select one.
    a. Yes – please go to question 26
    b. No – please go to question 27
    c. Unsure – please go to question 28

25. How has it been published? Select one.
    a. Peer-reviewed paper
    b. Book or book section
    c. Conference proceedings
    d. Report for NGO or other institution
    e. Report for Government or local authority
    f. Non-peer reviewed article (such as magazine, website, blog)
    g. Dissertation or thesis
    h. Other, please describe ____________

26. Do you intend to publish the data and results? Select one.
    a. Yes – please describe where_________
    b. No – please explain why _____________
    c. Unsure

27. Thank you, that is the end of the survey. Do you have any comments or questions?

A.2. List of projects and literature reviewed in Chapter 4

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
lit	Shaffer, L.J.	2014	Journal of Ethnobiology	Making sense of local climate change in rural Tanzania through knowledge co-production	NA	Tanzania	NA
lit	Brofeldt, S., I. Theilade, N. Burgess	2014	Forests	Community Monitoring of Carbon Stocks for REDD+: Does Accuracy and Cost Change over Time?	NA	China	NA
lit	Ortega-Alavarez, R., L.A. Sanchez-Gonzalez, V. Rodriguez-Contreras	2012	Sustainability	Birding for and with People: Integrating Local Participation in Avian Monitoring Programs within High Biodiversity Areas in Southern Mexico	NA	Mexico	NA
lit	Breckwoldt, A., H. Seidel	2012	Current Opinion in Environmental Sustainability	The need to know what to manage - community-based marine resource monitoring in Fiji	NA	Fiji	NA
lit	Stacey, N.E., J. Karam, M.G. Meekan	2012	Conservation and Society	Prospects for Whale Shark Conservation in Eastern Indonesia Through Bajo Traditional Ecological Knowledge and Community-based monitoring	NA	Indonesia	NA
lit	Hamilton, R.J., M. Giningele, S. Aswani	2012	Biological Conservation	Fishing in the dark-local knowledge, night spearfishing and spawning aggregations in the Western Solomon Islands	NA	Solomon Islands	NA
lit	Aldekop, J.A., A.J. Bebbington, F. Berdel	2011	Biodiversity Conservation	Testing the accuracy of non-experts in biodiversity monitoring exercises using fern species richness in the Ecuadorian Amazon	NA	Ecuador	NA
lit	Leopold, M., A. Cakacaka, S. Meo	2009	Biodiversity Conservation	Evaluation of the effectiveness of three underwater reef fish monitoring methods in Fiji	NA	Fiji	NA
lit	Holck, M.H.	2008	Biodiversity Conservation	Participatory forest monitoring: an assessment of the accuracy of simple cost-effective methods	NA	Tanzania	NA

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
lit	Ishihara, S., R.M. Boyles, H. Matsubayashi	2015	Oryx	Long-term community-based monitoring of tamamraw Bubalus mindorensis on Mindoro Island, Philippines	The Tamaraw Population Count	Philippines	NA
lit	Bellfield, H., D. Sabogal, L. Goodman	2015	Forests	Case Study Report: Community-Based Monitoring Systems for REDD+ in Guyana	NA	Guyana	NA
lit	Seak, S., D. Schmidt-Vogt, G.B. Thapa	2012	Environmental Management	Biodiversity Monitoring at the Tonle Sap Lake of Cambodia: A Comparative Assessment of Local Methods	NA	Cambodia	NA
lit	Constantino, P.A.L., H.S.A. Carlos, E.E. Ramalho	2012	Ecology and Society	Empowering Local People through Community-based Resource Monitoring: a Comparison of Brazil and Namibia	Biodiversity and Natural Resources Monitoring Use Program of Amazonas Protected Areas (ProBUC)	Brazil	NA
lit	Van Rijssort, J., Z. Jinfeng	2005	Biodiversity and Conservation	Participatory resource monitoring as a means for promoting social change in Yunnan, China	NA	China	NA
lit	Becker, C.D., A. Agreda, E. Astudillo	2005	Biodiversity and Conservation	Community-based monitoring of fog capture and biodiversity at Loma Alta, Ecuador enhance social capital and institutional cooperation	NA	Ecuador	NA
lit	Aswani, S., P. Weiant	2004	Human Organization	Scienitific Evaluation in Women's Participatory Management: Monitoring Marine Invertebrate Refugia in the Soloman Islands	The Bararulu/Bulelavata Women's Sewing/Shellfish Project	Solomon Islands	NA
lit	Gaidet, N., H. Fritz, C. Nyahuma	2003	Biodiversity and Conservation	A participatory counting method to monitor populations of large mammals in non-protected areas: a case study of bicycle counts in the Zambezi Valley, Zimbabwe	NA	Zimbabwe	NA
lit	Akinsoji, A.	2013	Journal of Environment and Earth Science	Community-based Forest Management in Buru, Taraba State, Nigeria	NA	Nigeria	NA

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
lit	Humber, F., B.J. Godley, V. Ramahery	2011	Animal Conservation	Using community members to assess artisanal fisheries: the marine turtle fishery in Madagascar	NA	Madagascar	NA
lit	Carvalho, A.R., S. Williams, M. january	2009	Fisheries Research	Reliability of community-based monitoring in the Olifants River Estuary (South Africa)	NA	South Africa	NA
lit	Townsend, W.R., R. Borman A., E. Yiyoguaje	2005	Biodiversity and Conservation	Cofan Indians' monitoring of freshwater turtles in Zabalo, Ecuador	NA	Ecuador	NA
lit	Dangles, O., F.C. Carpio, M. Villares	2010	Ambio	Community-Based Participatory Research Helps Farmers and Scientists to Manage Invasive Pests in the Ecuadorian Andes	NA	Ecuador	NA
lit	Poulsen, M.K., K. Luanglath	2005	Biodiversity and Conservation	Projects come, projects go: lessons from participatory monitoring in southern Laos	NA	Laos	NA
lit	Noss, A., I. Oetting, R.L. Cuellar	2005	Biodiversity and Conservation	Hunter self-monitoring by the Isoseno-Guarani in the Bolivian Chaco	NA	Bolivia	NA
lit	Pratihast, A.K., B. DeVries, V. Avitabile	2014	Forests	Combining Satellite Data and Community-Based Observations for Forest Monitoring	NA	Ethiopia	NA
lit	Datta-Roy, A., N. Ved, A.C. Williams	2009	Tropical Ecology	Participatory elephant monitoring in South Garo Hills: efficacy and utility in a human-animal conflict scenario	NA	India	NA
lit	Krause, T., H. Zambonino	2013	International Journal of Biodiversity Science	More than just trees - animal species diversity and participatory forest monitoring in the Ecuadorian Amazon	Programa Socio Bosque	Ecuador	NA
lit	Burton, A.C.	2012	Biodiversity Conservation	Critical evaluation of a long-term, locally-based wildlife monitoring program in West Africa	Ghana Wildlfie Division monitoring programme	Ghana	NA
lit	Rist, J., E.J. MIlner-Gulland, G. Cowlishaw	2009	Conservation Biology	Hunter Reporting of Catch per Unit Effort as a Monitoring Tool in a Bushmeat-Harvesting System	NA	Equatorial Guinea	NA

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
lit	Setty, R.S., K. Bawa, T. Ticktin	2008	Ecology and Society	Evaluation of a Participatory Resource Monitoring System for Nontimber Forest Products: the Case of Amla (Phyllanthus spa.) Fruit Harvest by Soligas in South India	NA	India	NA
lit	Andrianadrasana, H.T., J. Randriamahefasoa, J. Durbin	2005	Biodiversity and Conservation	Participatory ecological monitoring of the Alaotra wetlands in Madagascar	NA	Madagascar	NA
lit	Boissiere, M., F. Bastide, I. Basuki	2014	Biodiversity Conservation	Can we make participatory NTFP monitoring work? Lessons learnt from the development of a multi-stakeholder system in Northern Laos	NA	Laos	NA
lit	Brenier, A., J. Ferraris, J. Mahafina	2011	Madagascar Conservation and Development	Participatory assessment of the Toliara Bay reef fishery, southwest Madagascar	NA	Madagascar	NA
lit	Butt, N., K. Epps, H. Overman	2015	Forest Ecology and Management	Assessing carbon stocks using indigenous peoples' field measurements in Amazonian Guyana	Project Fauna	Guyana	NA
lit	Fabricius, C., M. Burger	1997	South African Journal of Science	Comparison between a nature reserve and adjacent communal land in Xeric Succulent Thicket: An Indigenous Plant User's Perspective	NA	South Africa	NA
lit	Gray, M., J. Kalpers	2005	Biodiversity and Conservation	Ranger based monitoring in the Virunga-Bwindi region of East-Central Africa: a simple data collection tool for park management	International Gorilla Conservation Programme	Uganda	NA
lit	Marks, S.	1996	African Journal of Ecology	Local hunters and wildlife surveys: An assessment and comparison of counts for 1989,1990 and 1993	NA	Zambia	NA
lit	Mbata, K.J., E.N. Chidumayo, C.M. Lwatula	2002	Journal of Insect Conservation	Traditional regulation of edible caterpillar exploitation in the Kopa area of Mpika district in northern Zambia	NA	Zambia	NA

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
lit	von Bertrab, A., L. Zambrano	2010	Ecological Restoration	Participatory Monitoring and Evaluation of a Mexico City Wetland Restoration Effort	The Intensive Fishing Project	Mexico	NA
lit	Carter, J (ed) A. Lawerernce, M. Godoy	1996	Book: Recent Approaches to Participatory Forest Resources Assessment	Chapter 3: Awa Sustainable Forest Manamgent Project, Ecuador	The Awa Sustainable Forest Management Project	Ecuador	NA
lit	Carter, J. (ed) J. Gronow, E. Safo	1996	Book: Recent Approaches to Participatory Forest Resources Assessment	Chapter 5: Collaborative Forest Resoure Assessment Surveys for the Management of Community Forest Reserves in Ghana	NA	Ghana	NA
lit	Mahato, N.V., K. Kandel, S. Shakya	2011	Tiger Paper	A long-term community-based monitoring and conservation program for red panda in unprotected forests of eastern Nepal	Red Panda Network	Nepal	NA
lit	Malafaia, P.N., G. Olavo, A.R. Franca, F.S. Seara, M.B.O. Freitas	2014	Desenvolvimento e Meio Ambiente	Participatory Monitoring Experience On-Board Artisinal Fishing Vessels in Territorio de Cidadania do Baixo Sul Bahia, Northeastern Brazil	NA	Brazil	NA
lit	Mortimer, J.A., JC Camille, N. Boniface	2011	Chelonian Conservation and Biology	Seasonality and Status of Nesting Hawksbill (Eretmochelys imbricata) and Green Turtles (Chelonia mydas) at D'Arros Island, Amirantes Group, Seychelles	NA	Seychelles	NA
lit	Oba, G., P. Byakagaba, A. Angassa	2008	Land Degradation & Development	Participatory monitoring of biodiversity in East African grazing lands	NA	Uganda	NA
lit	Takahashi, R. & Y. Todo	2012	Environmental Management	Impact of Community-Based Forest Management on Forest Protection: Evidence from an Aid-Funded Project in Ethiopia	NA	Ethiopia	NA

Type (lit = literature, qu = questionnaire)	Authors	Year Published	Journal	Title of Publication	Name of Project	Country	Organisation or Project
lit	Venter, M., O. Venter, W. Edwards, M.I. Bird	2015	PLOS ONE	Validating Community-Led Forest Biomass Assessments	NA	Papua New Guinea	NA
lit	Wagner, G.	2005	Indian Journal of Marine Science	Participatory monitoring of changes in coastal and marine biodiversity	NA	Tanzania	NA
qu	NA	NA	NA	NA	HerpMapper.org	NA	HerpMapper.org
qu	NA	NA	NA	NA	Conservation of critical habitats for montane birds through community participation in Sainj Valley, Western Himalayas		Biodiversity & Environmental Sustainability (BEST)
qu	NA	NA	NA	NA	Opening doors to Native knowledge	NA	PISUNA
qu	NA	NA	NA	NA	Kayangel Biological Monitoring	Palau	Palau Conservation Society - Kayangel Biological Monitoring
qu	NA	NA	NA	NA	Bijagós islands UNESCO Biosphere Reserve Timneh Parrot monitoring project	Guinea-Bissau	World Parrot Trust
qu	NA	NA	NA	NA	Conservation of the fragmented forests surrounding Ranomafana National Park, Madagascar using Participatory Ecological Monitoring and GIS as a tool for biodiversity and habitat monitoring	Madagascar	Centre ValBio Ranomafana Madagascar
qu	NA	NA	NA	NA	Red de Conservacion - Tortugas Marinas	Peru	ecOceanica
qu	NA	NA	NA	NA	The use of Natural Resources in the Western Border of the Pantanal	Brazil	University College London

Type (lit = literature, qu = questionnaire)	Authors	Year Published	Journal	Title of Publication	Name of Project	Country	Organisation or Project
qu	NA	NA	NA	NA	Our lake Our life, Co-management in the Lake Ossa Wildlife Reserve	Cameroon	ZSL - Our lake Our life, Lake Ossa, Cameroon
qu	NA	NA	NA	NA	PhD Project: Planning for Change: Managing Mangroves in the Face of Climate Change	Philippines	Institute of Zoology (ZSL) and University College London
qu	NA	NA	NA	NA	Ruaha Carnivore Project	Tanzania	NA
qu	NA	NA	NA	NA	Co-producing information for Barbary macaque conservation in northern Morocco	Morocco	Dept of Anthropology, Durham University (Honorary research associate) & Barbary Macaque Awareness & Conservation, Director
qu	NA	NA	NA	NA	The effects of human-wildlife conflict on conservation and development: a case study of Volcanoes National Park, northern Rwanda	Rwanda	Trinity College Dublin / Dublin Zoo
qu	NA	NA	NA	NA	Wildlife Population Estimation in Kerala	India	Retired on superannuation from Kerala Forest Research Institute
qu	NA	NA	NA	NA	Monitoring Persian leopard and its prey in Golestan National Park, Iran	Iran	Georg-August-University Göttingen
qu	NA	NA	NA	NA	Farming with Predators project	Namibia	Stellenbosch University: Farming with Predators project
qu	NA	NA	NA	NA	Calapan City Mariculture Project	Philippines	City Government of Calapan, Oriental Mindoro, Philippines

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
qu	NA	NA	NA	NA	Fresh water Eel fisheries monitoring to include species composition, production and CPUE under ZSL Philippines funded by Darwin Initiative	Philippines	Zoological Society of London; Project Eel Darwin " Eel as a flagship species for freshwater conservation in Northern Luzon"
qu	NA	NA	NA	NA	Philippine Peñablanca Sustainable Reforestation Project	Philippines	NA
qu	NA	NA	NA	NA	Biological and threat monitoring prgrame across 5 landscapes for the Wildlife Conservation Society	Cambodia, Laos, Myanmar	WCS
qu	NA	NA	NA	NA	NetWorks	Philippines and Cameroon	ZSL and NetWorks
qu	NA	NA	NA	NA	Our Sea Our Life	Mozambique	ZSL - OSOL
qu	NA	NA	NA	NA	Programa de Monitoramento Comunitário de Fauna - Instituto Piagaçu (Community Wildlife Monitoring Program/Piagaçu Institute)	Brazil	Instituto Piagaçu - Programa de Monitoramento e Uso de Fauna (Piagaçu Institute - Wildlife Use and Monitoring Program)
qu	NA	NA	NA	NA	Programa de Monitoramento Comunitário de Caça / Self-Monitoring Hunting Program	Brazil	Instituto Piagaçu - Wildlife Use and Monitoring Program
qu	NA	NA	NA	NA	Mobulid fishery in the Bohol Sea	Philippines	NA
qu	NA	NA	NA	NA	FFU-REDD+	Indonesia	NA
qu	NA	NA	NA	NA	Warrior Watch	Kenya	Ewaso Lions

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
qu	NA	NA	NA	NA	KTGAl was the first (see book). We are now doing others for WOTRO (Dutch Scientific Research Council)	KTGAL= Senegal, Mali, Guinea Bissau,Tanzania, India, Nepal, PNG (now terminated), WOTRO=Mexico	NA
qu	NA	NA	NA	NA	Azafady Conservation Programme	Madagascar	NA
qu	NA	NA	NA	NA	Wildlife Conservation Society Indonesian Marine Program	Indonesia	Wildlife Conservation Society - Indonesian Marine Program
qu	NA	NA	NA	NA	A sustainable future for Chinese giant salamanders	China	NA
qu	NA	NA	NA	NA	Okavango Predator monitoring	Botswana	NA
qu	NA	NA	NA	NA	Wildlife and Roads Project	South Africa	NA
qu	NA	NA	NA	NA	Mount Calavite Wildlife Sanctuary - Biodiversity Monitoring System (MCWS-BMS)	Philippines	NA
qu	NA	NA	NA	NA	Wakhan Community Ranger	Afghanistan	WCS Afghanistan Programme
qu	NA	NA	NA	NA	Rede InfoAmazonia	Brazil	InfoAmazonia, Rede InfoAmazonia project
qu	NA	NA	NA	NA	Northern Plains Bird Nest Protection Project	Cambodia	Wildlife Conservation Society
qu	NA	NA	NA	NA	Biodiversity Monitoring Team	Philippines	Biodiversity Monitoring Team of Marinduque Wildlife Sanctuary; Provincial Cave Assessment Team;

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
							Wildlife Enforcement Officers
qu	NA	NA	NA	NA	Forest Compass	Brazil, Guyana	Global Canopy Programme
qu	NA	NA	NA	NA	Biodiversity monitoring in indigenous lands	Brazil	Associação de Defesa Etnoambiental Kanindé
qu	NA	NA	NA	NA	Monitoring of threatened frogs in KwaZulu-Natal, South Africa	South Africa	Endangered Wildlife Trust (Threatened Amphibian Programme) and North-West University
qu	NA	NA	NA	NA	Barefoot ecologists of the Nilgiri Biosphere Reserve	India	keystone foundation
qu	NA	NA	NA	NA	Check out Project Fauna - Publication by Luzar/Fragoso; Also cMRV by the global canopy programme	Guyana	NA
qu	NA	NA	NA	NA	Prek Toal Waterbird	Cambodia	NA
qu	NA	NA	NA	NA	Community Based Monitoring of Revenue Sharing at Bwindi Impenetrable National Park	Uganda	Institute of Tropical Forest Conservation, Mbarara University of Science and Technology-CBM
qu	NA	NA	NA	NA	Coral Reef Monitoring in Chumbe Island Coral Park	Tanzania	Chumbe Island Coral Park
qu	NA	NA	NA	NA	Project Oratsimba	Madagascar	NA
qu	NA	NA	NA	NA	Conservation of the Yellow-shouldered Parrot in Macanao peninsula, Venezuela.	Venezuela	Provita

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
qu	NA	NA	NA	NA	I-redd component Laos	Laos	Nordic Foundation for Development and Ecology
qu	NA	NA	NA	NA	I-redd project component China	China	Nordic Foundation for Development and Ecology
qu	NA	NA	NA	NA	Various	Mexico	CIGA UNAM
qu	NA	NA	NA	NA	Projeto Pé-de-pincha - Manejo Participativo de Quelônios no Médio Rio Amazonas e Juruá	Brazil	Federal University of Amazonas - Laboratory Wild Animals - Project Pé-de-pincha
qu	NA	NA	NA	NA	Design of a CBM system in Santander regiion of Colombia as a tool for linking local and National Information for REDD+	Colombia	University of Goettingen and GIZ
qu	NA	NA	NA	NA	Velondriake Census and ISS	Madagascar	NA
qu	NA	NA	NA	NA	Community-led small scale fisheries monitoring	Madagascar	Blue Ventures; Rebuilding fisheries with the communities
qu	NA	NA	NA	NA	Carbon stock monitoring	Madagascar	Blue Ventures
lit + qu	Bachan, A., R. Kannan, S. Muraleedharan	2011	The Raffles Bulletin of Zoology	Participatory conservation and monitoring of great hornbills and malabar pied hornbills with the involvement of endemic Kadar tribe in the Anamalai Hills of Southern Western Ghats, India	Ecological Monitoring of Hornbills, Hornbill habitat and other engendered resources involving local Kadar tribal communities in the Vazhachal part of Anamalai Landscape in Western Ghats	India	Western Ghats Hornbill Foundation
qu	NA	NA	NA	NA	South Rift Association of Land Owners, ecological monitoring programme. SORALO	Kenya	SORALO (South Rift Association of Land Owners) Ecological Monitoring

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
qu	NA	NA	NA	NA	Event Book System	Namibia	NACSO Natural Resource Working Group
lit + qu	Shrestha, S., B.S. Karky, S. Karki	2014	Forests	Cast Study Report: REDD+ Pilot Project in Community Forests in Three Watersheds in Nepal	REDD+ Himalaaya. We are not monitoring project, but are trying to develop monitoring protocols	Nepal	ICIMOD
lit + qu	Carter, J (ed) R. Dunn and D. Otu	1996	Recent Approaches to Participatory Forest Resources Assessment	Chapter 2: A Community Forest Inventory for Productive Forest Management in Cross River State, Nigeria	Cross River gorilla landscape conservation project	Nigeria	WCS Nigeria Program
lit + qu	Topp-Jordensen, E., M.K. Poulsen, J.F. Lund	2005	Biodiversity and Conservation	Community-based monitoring of natural resource use and forest quality in montane forests and miombo woodlands of Tanzania	Participatory monitoring scheme in Iringa Region	Tanzania	Nordic Foundation for Development and Ecology
lit + qu	Pratihast, A.K., M. Herold, V. Avitabile	2013	Sensors	Mobile Devices for Community-Based REDD+ Monitoring: A Case Study for Central Vietnam	I-redd project component Vietnam	Vietnam	Nordic Foundation for Development and Ecology
lit + qu	NA	NA	NA	NA	Ashaninka Land Monitoring Project	Brazil	Univerisity College London
lit + qu	Constantino, P.A.L., H.S.A. Carlos, E.E. Ramalho	2012	Ecology and Society	Empowering Local People through Community-based Resource Monitoring: a comparison of Brazil and Namibia	Monitoring hunting in indigenous lands (in english)	Brazil	NA
lit + qu	NA	NA	NA	NA	Participatory Biodiversity Monitoring in Amazonian Protected Areas	Brazil	IPE - Instituto de Pesquisas Ecológicas - Conservation and Management in Protected Areas: Participatory Biodiversity Monitoring in Amazonian Protected Areas

Type (lit = literature, qu = questionnaire)	**Authors**	**Year Published**	**Journal**	**Title of Publication**	**Name of Project**	**Country**	**Organisation or Project**
lit + qu	Constantino, P.A.L., H.S.A. Carlos, E.E. Ramalho	2012	Ecology and Society	Empowering Local People through Community-based Resource Monitoring: a Comparison of Brazil and Namibia	Sistema de Monitoramento do Uso de Fauna (SMUF)	Brazil	Instituto de Desenvolvimento Sustentável Mamirauá
lit + qu	Mialhe, F., Y. Gunnell, J. A. Ignacio	2015	International Journal of Applied Earth Observation and Geoinformation	Monitoring land-use change by combining participatory land-use maps with standard remote sensing techniques: Showcase from a remote forest catchment on Mindanao, Philippines	Monitoring of Watershed Development and Management of Key Protected Areas in the Western Mindanao Regions, Philippines	Philippines	Inventory, Assessment and Monitoring of Fauna in the LTER Sites of Mindanao / CONCERNED ADVOCATES SAVING TERRESTRIAL & MARINE ECOSYSTEMS (COASTLINE) Philippines, Inc.
lit + qu	Danielsen, F., A.E. Jensen, P.A. Aliviola | Danielsen, F., D.S. Balete, M.K. Poulsen	2005 | 2000	Biodiversity and Conservation | Biodiversity and Conservation	Does monitoring matter? A quantitative assessment of management decisions from locally-based monitoring of Protected Areas | A simple system for monitoring biodiversity in protected areas of a developing country	The Biodiversity Monitoring System (abbreviated BMS)	Philippines	Nordic Foundation for Development and Ecology

Appendix B: Chapter 5

B.1. Indicators

Appendix B.1. List of the 34 indicators and their conservation status monitored in the programme. Indicators shaded grey (n = 13) were observed in less than 4 villages were not included in the analyses.

Common Name	Latin Name	IUCN Red List Category
Birds		
White-Breasted mesite	*Mesitornis variegatus*	VU
Madagascar crested ibis	*Lophotibis cristata*	NT
Madagascar fish-eagle	*Haliaeetus vociferoides*	CR
Coquerel's coua	*Coua coquereli*	LC
Giant coua	*Coua gigas*	LC
Madagascar teal	*Anas bernieri*	EN
Crested coua	*Coua cristata*	LC
Humbolt's heron	*Ardea humbloti*	EN
Sacred ibis	*Threskiornis aethiopicus*	LC
Mammals		
Red-tailed sportive lemur	*Lepilemur ruficaudatus*	VU
Striped mongoose	*Mungotictis decemlineata*	EN
Fossa	*Cryptoprocta ferox*	VU
Red-fronted brown lemur	*Eulemur rufus*	VU
Giant jumping rat active burrow	*Hypogeomys antimena*	EN
Verreaux's sifaka	*Propithecus verreauxi verreauxi*	EN
Gray mouse lemur	*Microcebus murinus*	LC
Plants or Trees		
Givotia sp. (tree)	*Givotia madagascariensis*	-
Viguieranthus sp. (tree)	*Viguieranthus sp*	-
Cedrelopsis grevei (tree)	*Cedrelopsis grevei*	-
Madagascar rosewood (tree)	*Dalbergia greveana*	-
Masonjoany (plant)	*Coptosperma madagascariense*	-
Reptiles		
Madagascar boa	*Acrantophis madagascariensis*	LC
Flat-tailed tortoise	Pyxis planicauda	CR
Chameleon	*Furcifer sp*	-
Threats		
Animal trap	-	-
Camp	-	-
Canoe	-	-
Car	-	-
Fire	-	-
Hunting	-	-
Logging	-	-
People or dog	-	-
Slash and burn	-	-
Track	-	-

B.2. Power curves for all indicators

B.2. Power curves for all indicators according to occupancy probability and detection probability. In all models alpha = 0.05, K (number of patrols) = 6. Power curves for 54 sites in green, 26 sites in blue, 8 sites (the current number) in black and 9 sites in orange. The horizontal red lines indicate power of 0.8, considered a standard level in ecological studies.

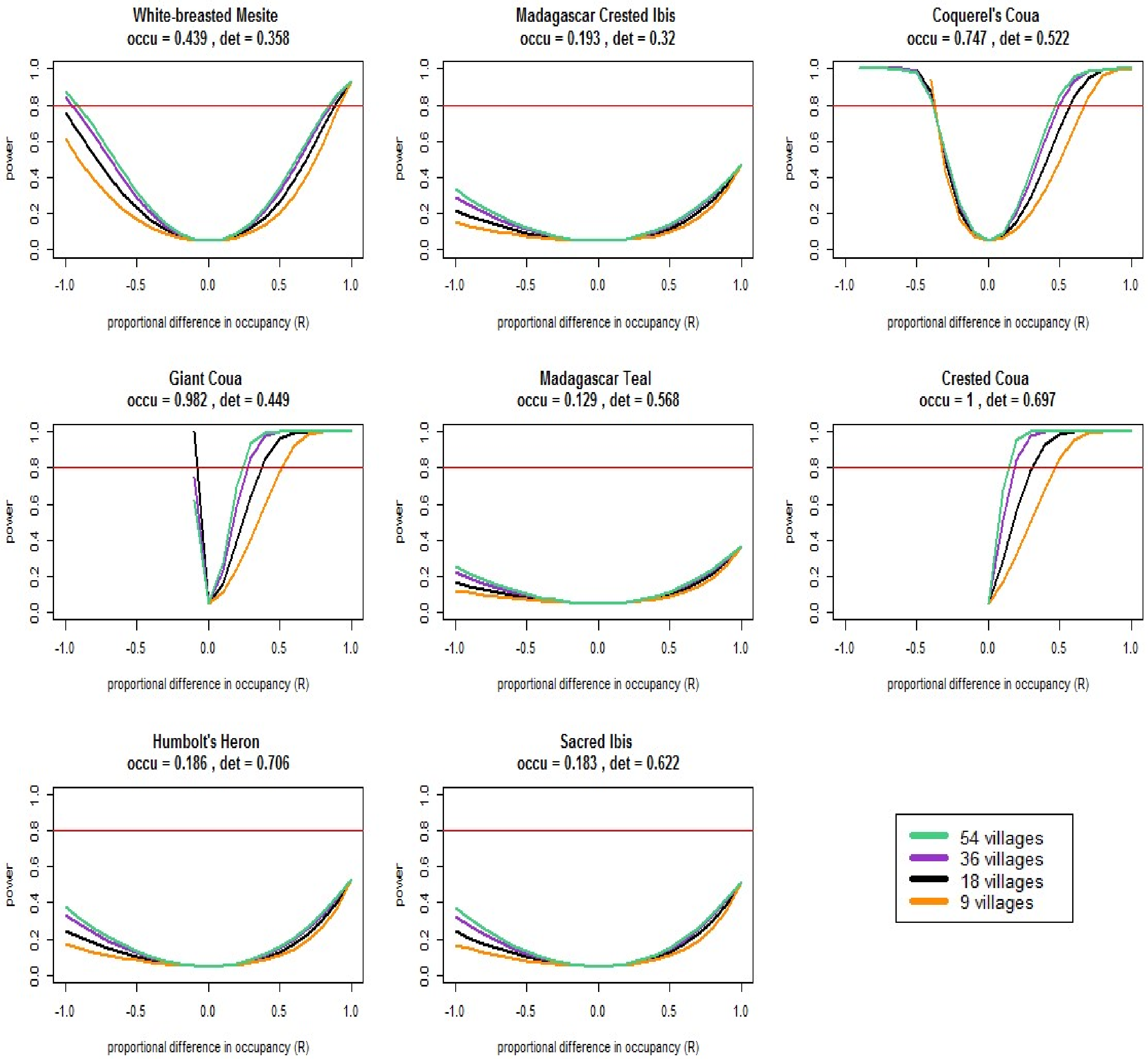

Figure B.2.1. Power curves for bird indicators with varying number of sites.

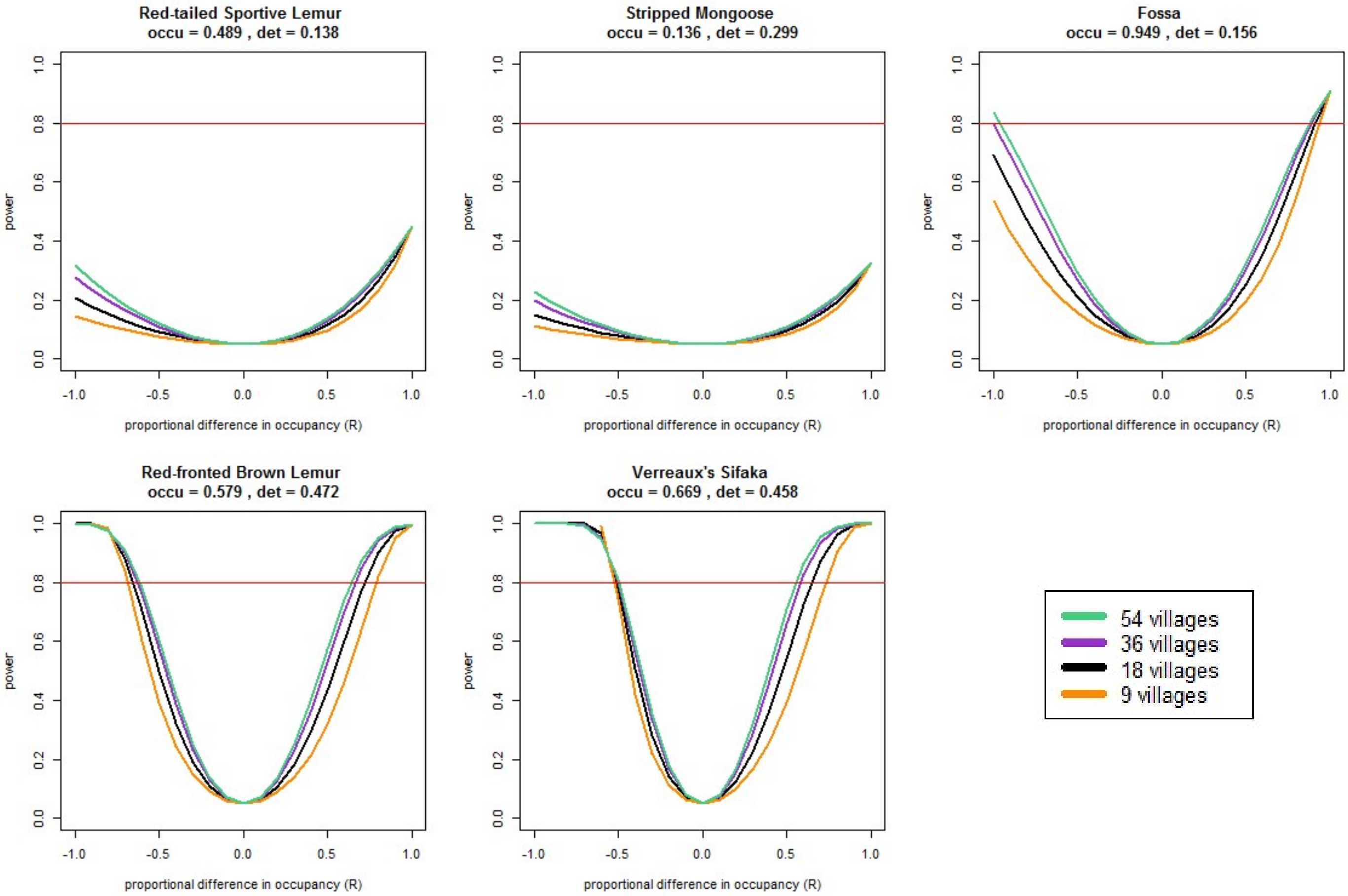

Figure B.2.2. Power curves for mammal indicators with varying number of sites.

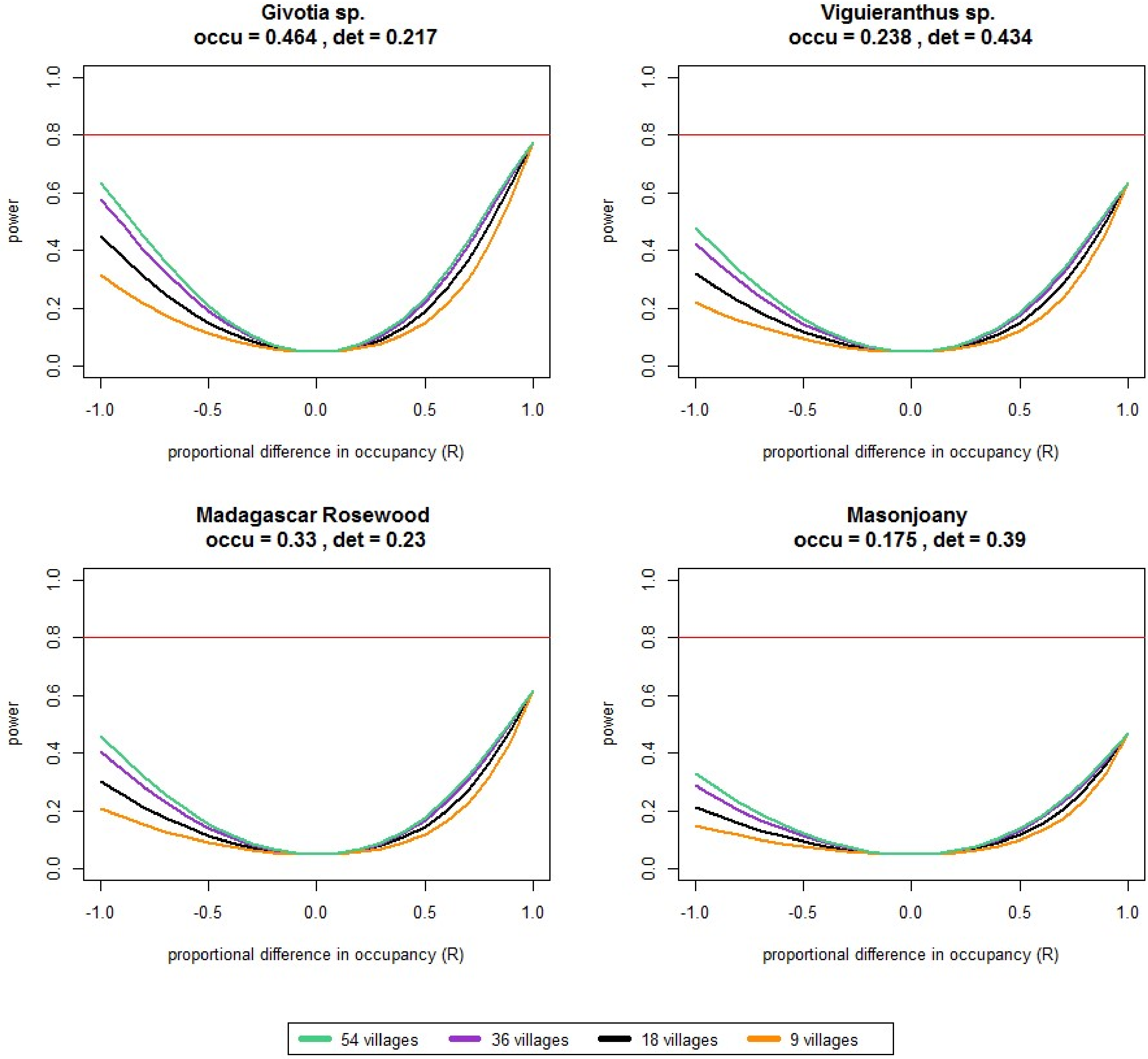

Figure B.2.3. Power curves for plant indicators with varying number of sites.

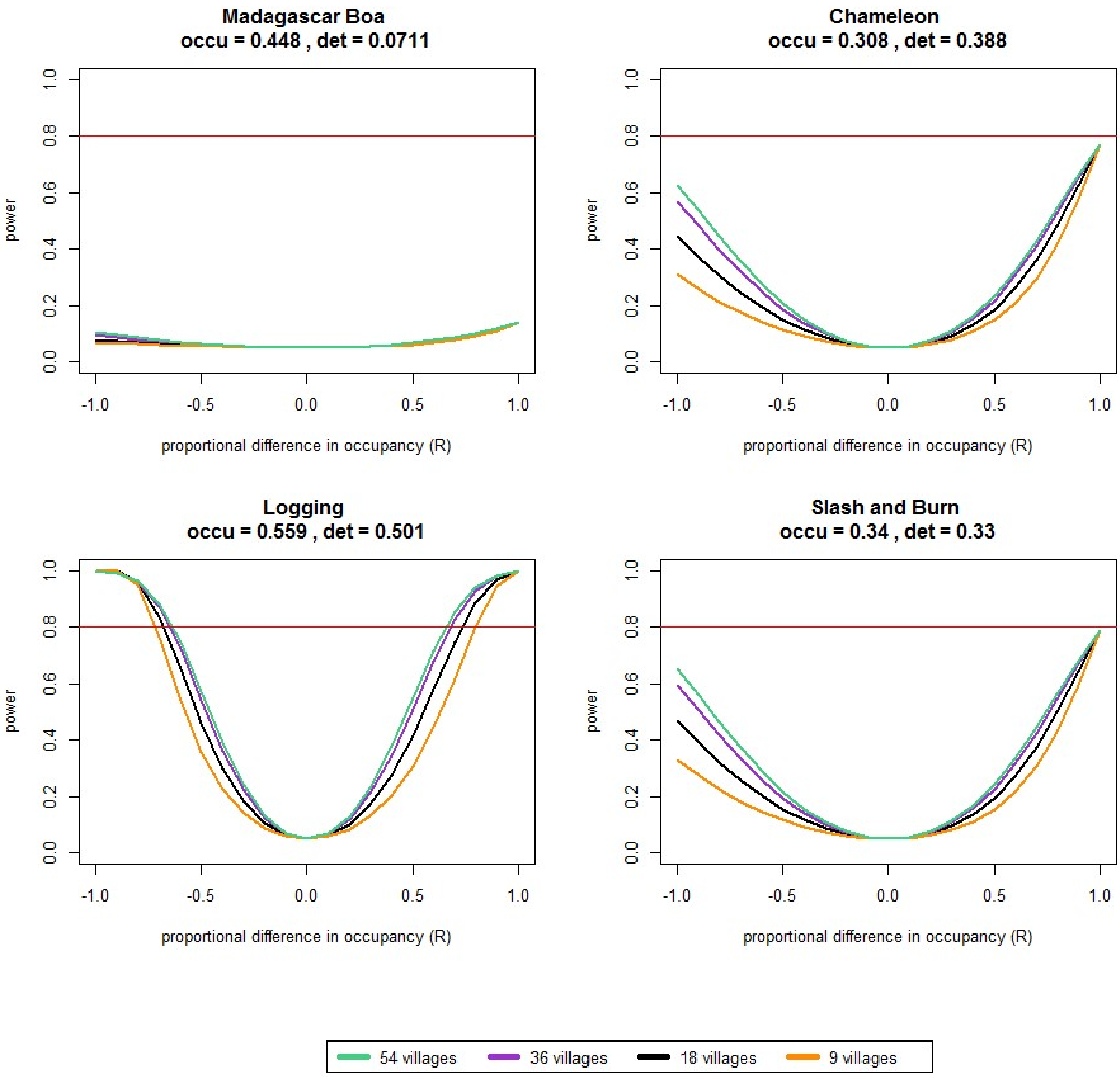

Figure B.2.4. Power curves for reptile (top row) and threat (bottom row) indicators with varying number of sites.

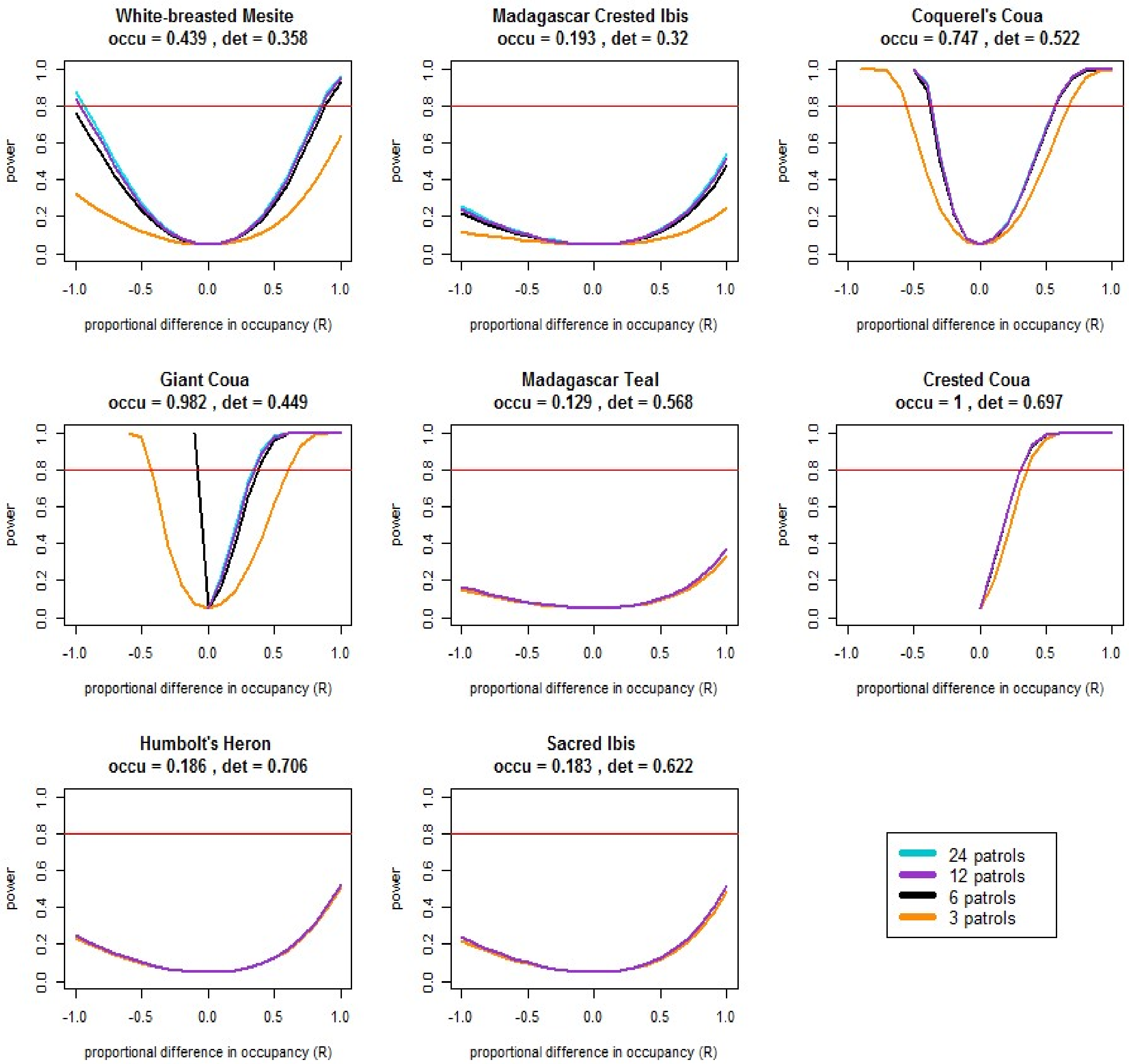

Figure B.2.5. Power curves for bird indicators with varying number of patrols per monitoring season.

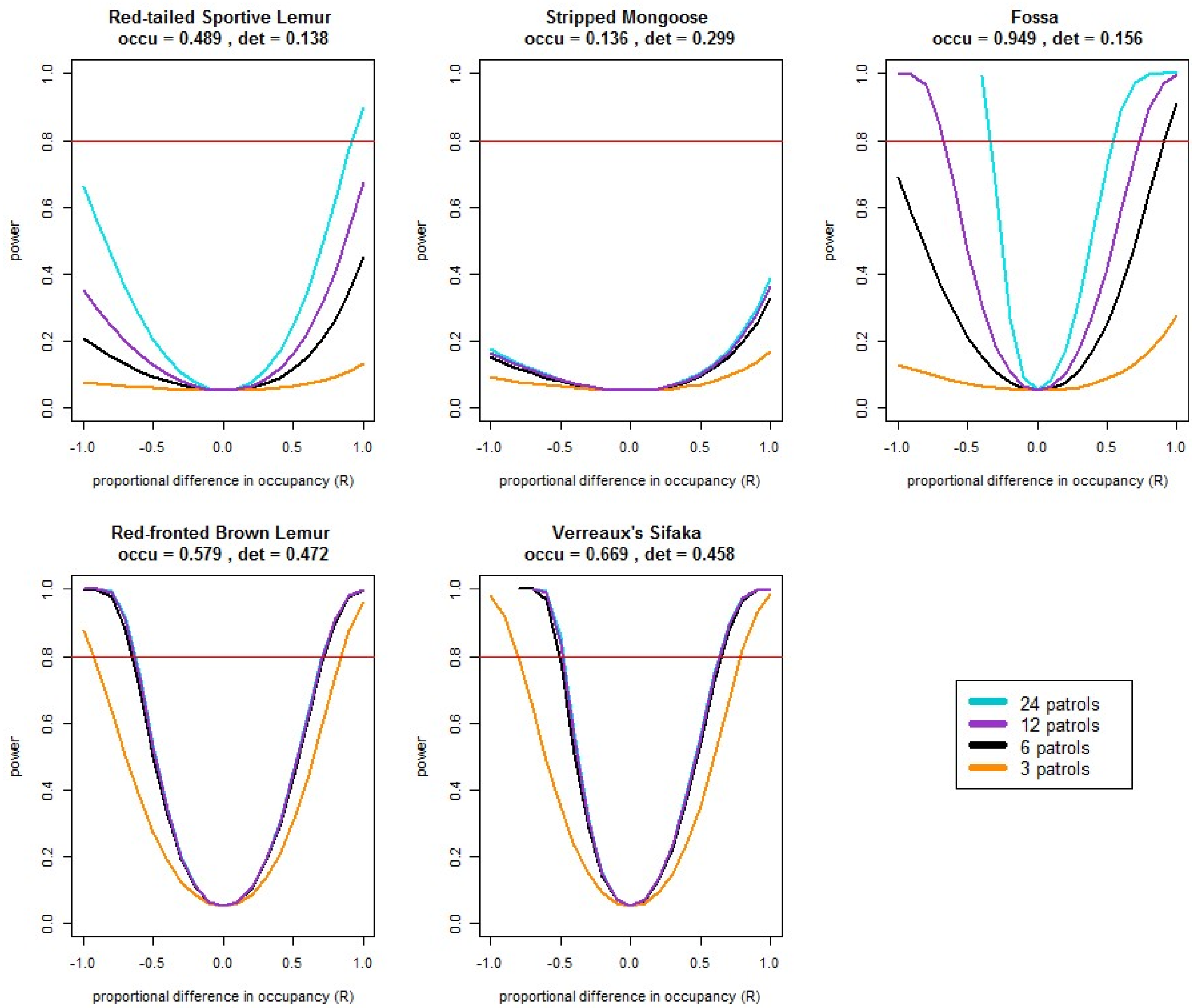

Figure B.2.6. Power curves for mammal indicators with varying number of patrols per monitoring season.

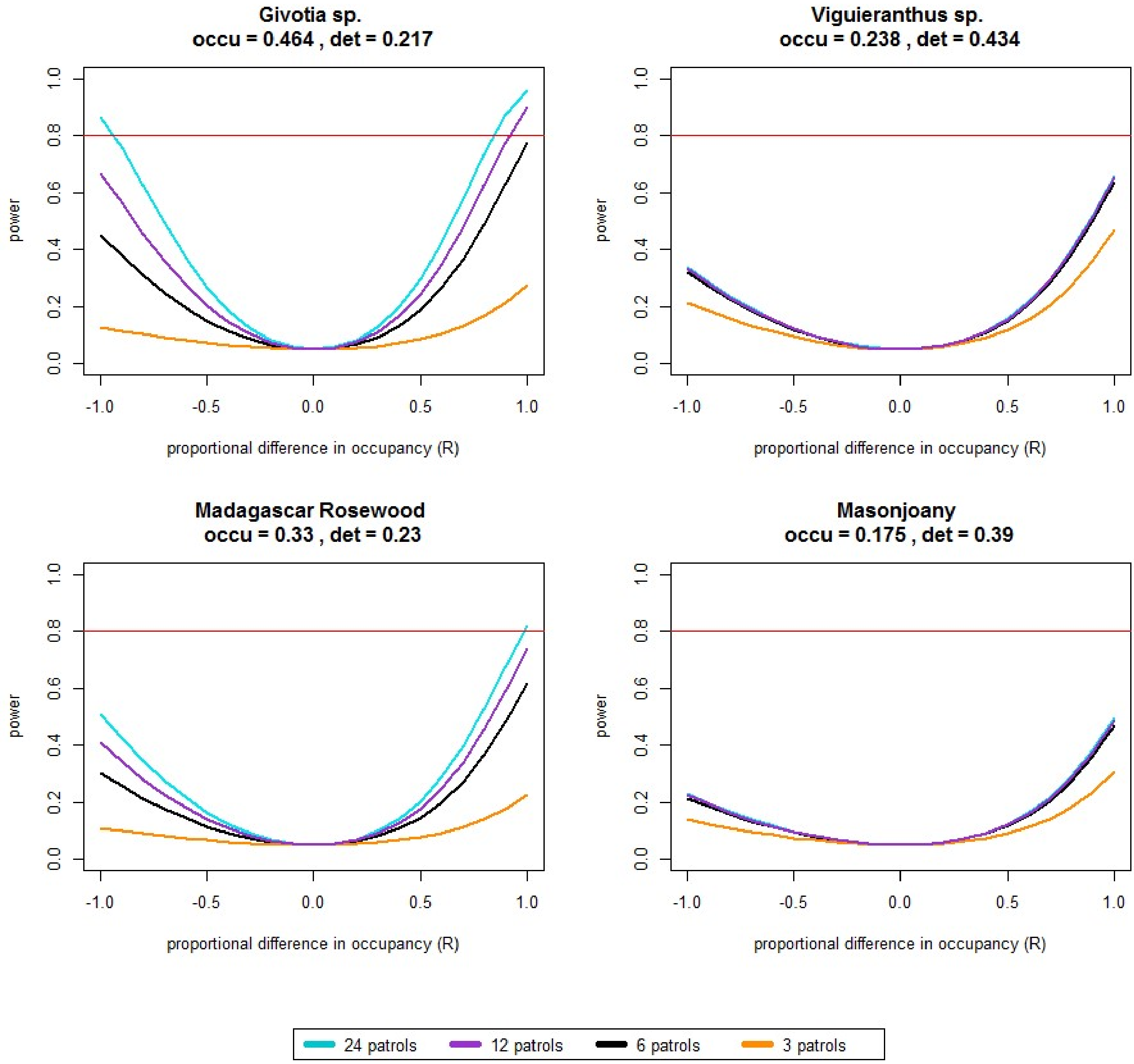

Figure B.2.7. Power curves for plant species for varying number of patrols per monitoring season.

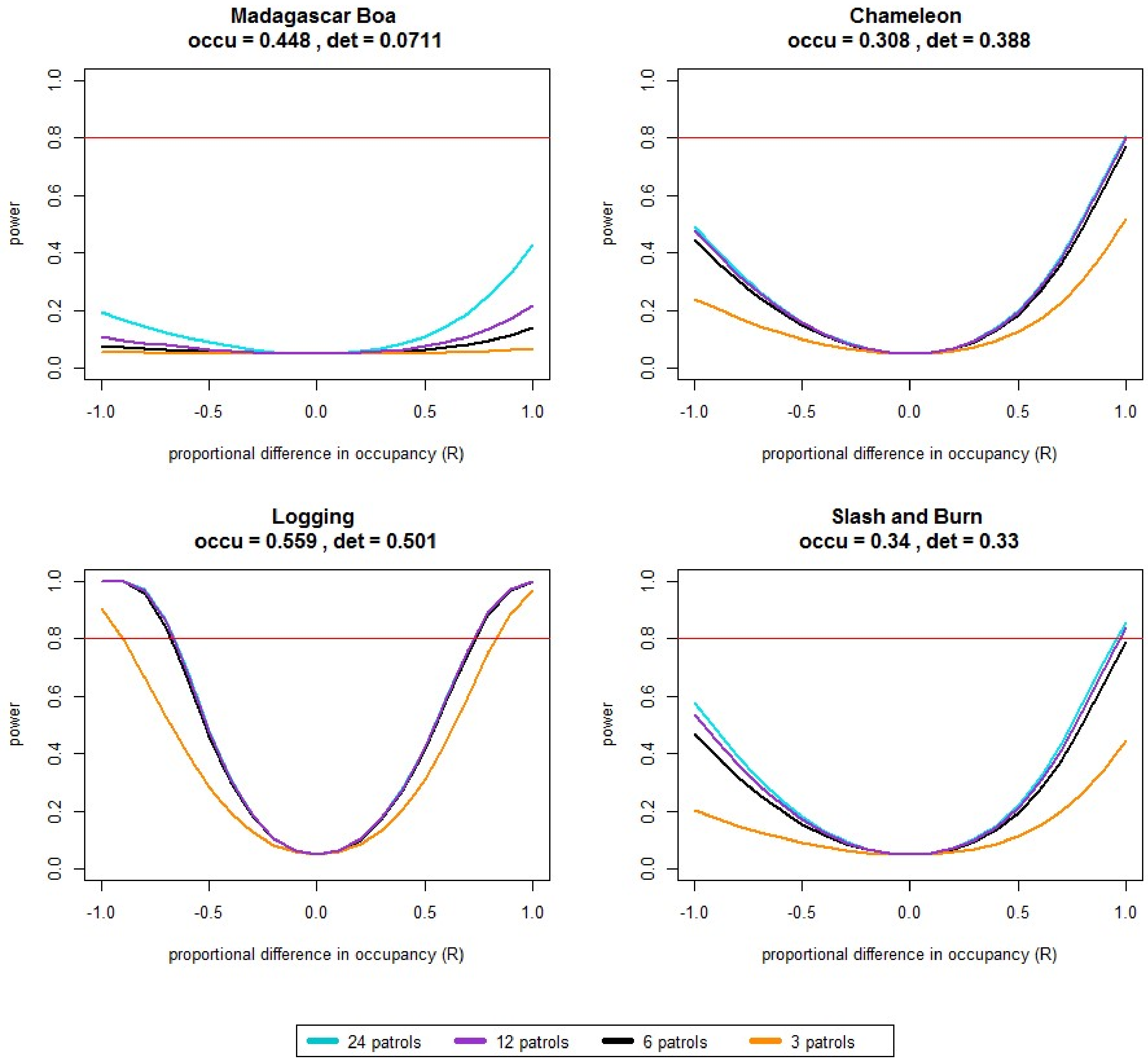

Figure B.2.8. Power curves for reptile (top row) and threats (bottom row) for varying number of patrols per monitoring season.

Appendix B.3. Number of sites and patrols needed to detect decline (solid lines) and growth (dashed lines) of 10% (purple), 30% (pink), 50% (blue), 80% (green) for each indicator.

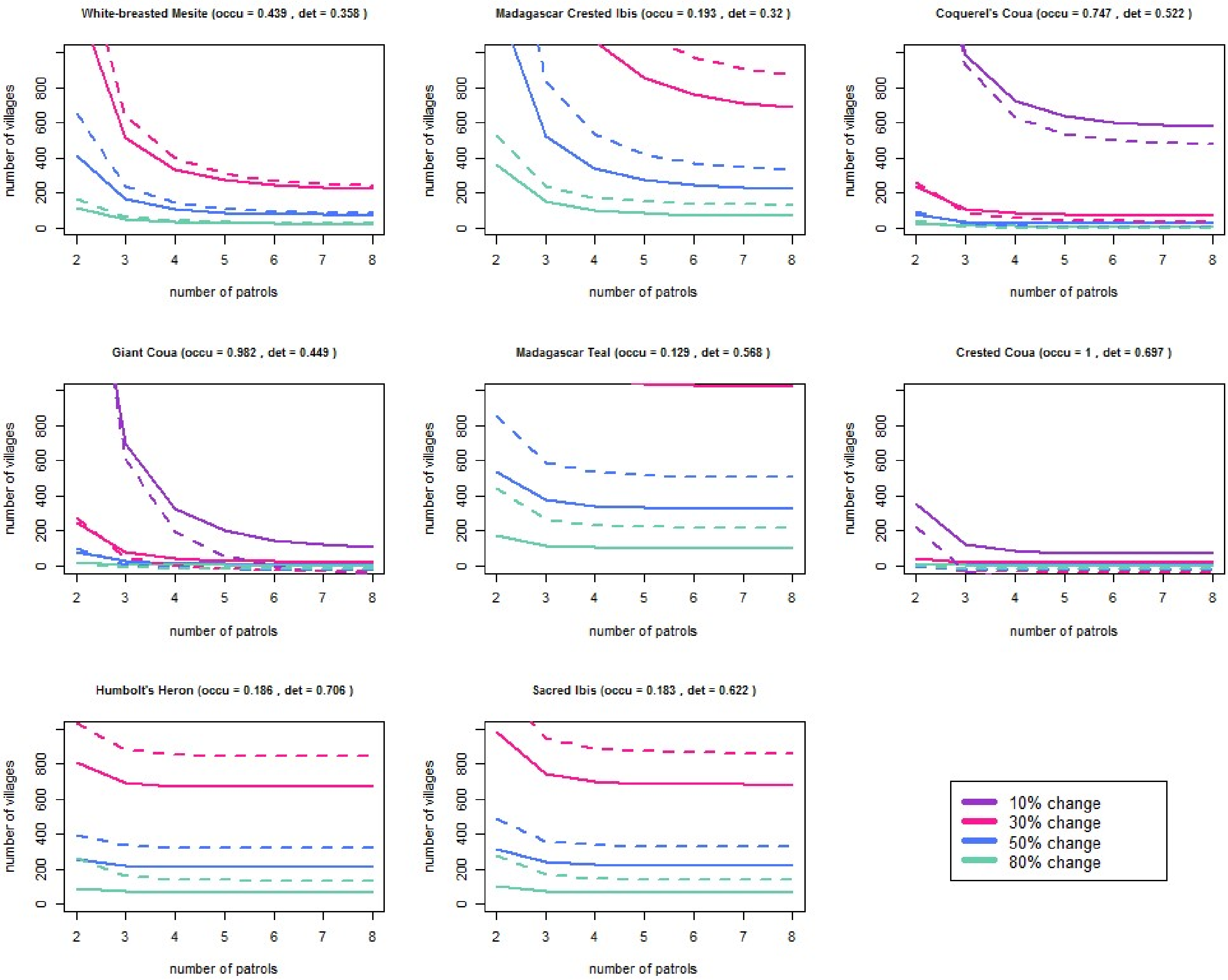

Figure B.3.1. Number of sites and patrols needed to detect decline (solid lines) and growth (dashed lines) for each bird indicator. For some species, detection of growth or decline of 10% required more than 1000 sites and are not plotted on these graphs.

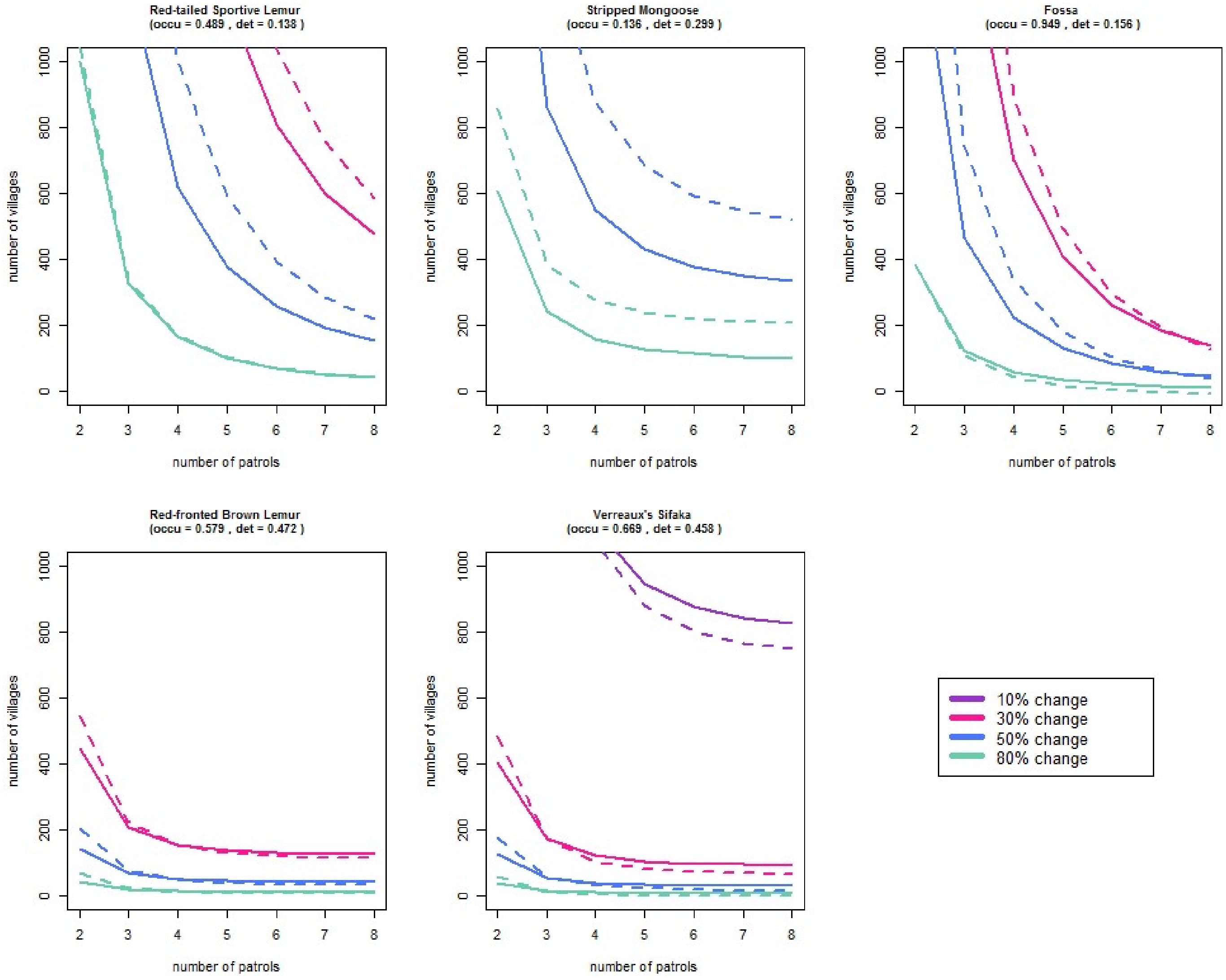

Figure B.3.2. Number of sites and patrols needed to detect decline (solid lines) and growth (dashed lines) of each mammal indicator. For some species, detection of growth or decline of 10% required more than 1000 sites and are not plotted on these graphs.

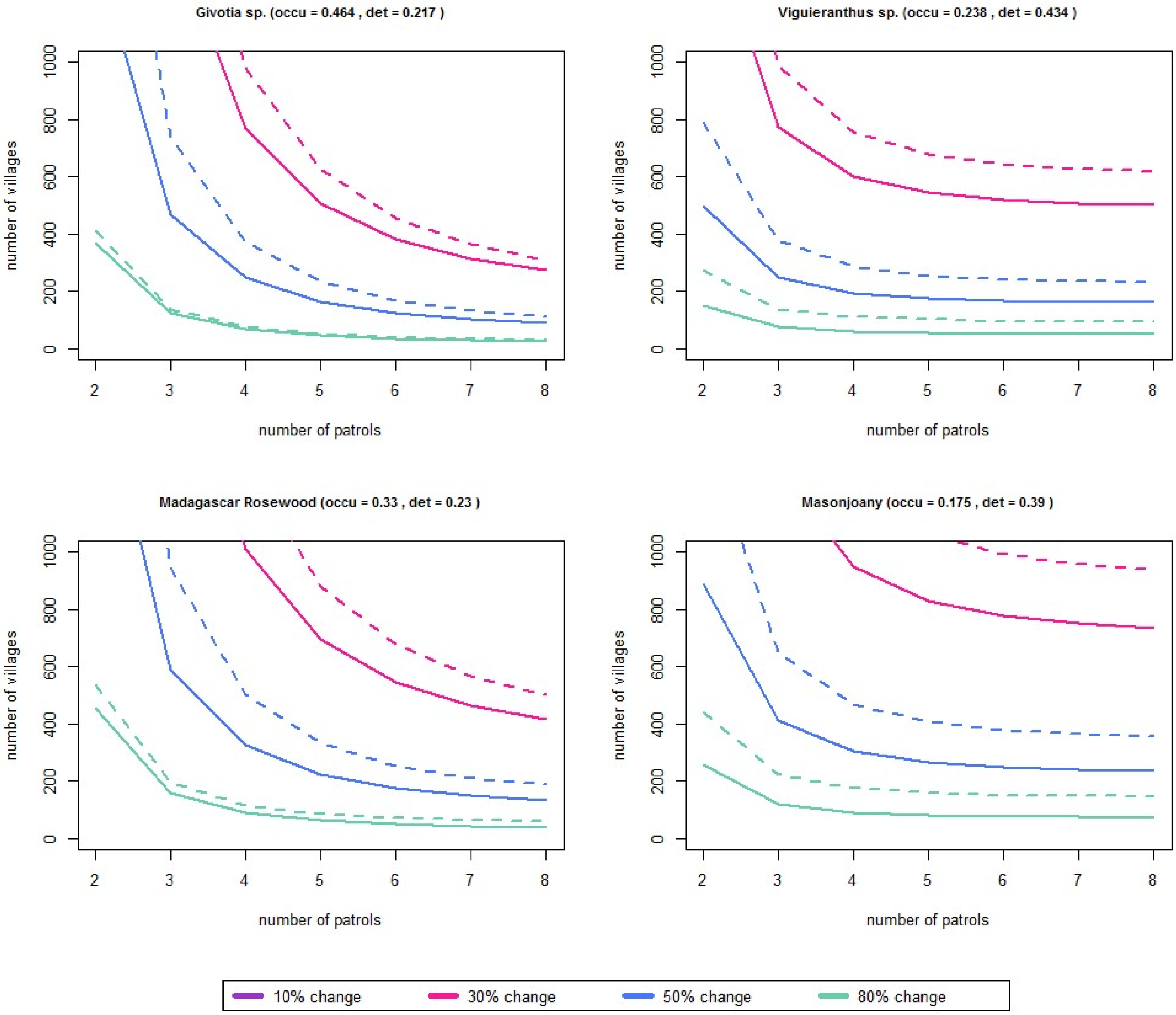

Figure B.3.3. Number of sites and patrols needed to detect decline (solid lines) and growth (dashed lines) of each plant indicator. The number of sites required to detect growth or decline of 10% required more than 1000 sites, and therefore are not plotted on these graphs.

Appendix C: Chapter 6

C.1. Questionnaires

Please note in the following questionnaires the PEM scheme is referred to as the 'CFL' or 'KMMFA' project, as it is known by the villagers and local government authorities.

C.1.1. Focus Group Questions – English Translation

Consent statement to be read to each participant prior to interview:

The purpose of this survey is to find out about how you feel about the CFL monitoring project and identify the good bits and where the project could improve. This survey has been designed by Samantha Earle of Imperial College London, UK, and your answers will be used in her doctoral research about participatory ecological monitoring. By taking part in this survey you give consent for your answers to be used in this way. This is an independent survey - – Samantha's boss is a Professor and I am assisting her to collect the information. None of us work for or are paid by an NGO or other organisation. Your identity is anonymous, we will not write your name on the answer sheet and individual responses will not be reported back to anyone, therefore your involvement in this survey will not affect your relationship, position or future job prospects with any organisation. You are free to halt the interview at any time. Is this OK and are you willing to answer these questions? ***YES/NO***

Do you have any questions about this before we start?

1. Can you tell me which associations there are in this village and what sort of decisions they make?
2. Can you explain to me about the role the forest plays in your lives?
3. Please tell me about any changes you have seen or heard about in the forest in the last five years.
4. Please describe any projects or activities that are intended to improve the state of the forest.
5. Do you think that these have performed; successfully or not successfully? Why?
6. Please tell me about other projects or activities that have been intended to improve your lives over the past five years.
7. Do you think these have performed; successfully or not successfully? Why?
8. Tell me, what do you know about the CFL/KMMFA monitoring project?
9. On the whole would you say the CFL/KMMFA project is good or bad for you and your household?
10. On the whole would you say the project is good or bad for the village?
11. If you could change any aspect of the project, what would you change?
12. Do you think the forest laws are respected by people in your village? Why or why not?
13. Which laws are more or less respected?

End of Questions

C.1.2. Household Survey Questions – English Translation

Consent statement to be read to each participant prior to interview:

The purpose of this survey is to find out about how you feel about the CFL monitoring project and identify the good bits and where the monitoring can improve. This survey has been designed by Samantha Earle of Imperial College London, UK, and your answers will be used in her doctoral research about participatory ecological monitoring. By taking part in this survey you give consent for your answers to be used in this way. This is an independent survey – Samantha's boss is a Professor and I am assisting her to collect information. None of us work for or are paid by an NGO or other organisation. Your identity is anonymous, we will not write your name on the answer sheet and individual responses will not be reported back to anyone, therefore your involvement in this survey will not affect your relationship, position or future job prospects with any organisation. You are free to halt the interview at any time. Is this OK and are you willing to answer these questions? ***YES/NO***

Do you have any questions about this before we start?

Record the following information on the participant information sheet:

- What is your name?
- [record gender]
- Which year were you born?
- What is your highest level of education?
- [House category: A, B or C]

Record the start time and these answers on the Household Survey Answer Sheet:

This first section is about you and your household.

Are you native to this village?

Yes / no

If no, when did you move here?

(integer)

1. **Are you the head of the household?**
   Yes / no – *if no skip to question 3*

2. **How are you related to the household head?**
   (text)

3. **How many people are in your household?**
(integer)

4. **How many zebu do you own?**
(integer)

5. **Do you own any land?**
Yes / no

6. **What livelihood activities do you do?**
rice, peanuts, maize, cassava, zebu farming, honey, handicrafts (please specify), other: _____

7. **Do you have a paid job? (such as in a school, shop)**
Yes / no – *if no skip to question 9*

8. **What is the job?**
(text)

9. **How has life been over the past year?**
good / so-so / hard / unsure

10. **Can you explain why?**
(text)

11. **Has the households food production and income over the past 12 months been sufficient to cover the needs of the household?**
Yes / just about sufficient / no / unsure

12. **Can you explain why?**
(text)

13. **Compared with other households in the village, how well-off is your household?**
Worse / about average / better / unsure

14. **If someone in your household is sick, can you get help (either money or assistance) from someone in your village?**
No / sometimes / yes / unsure

15. **Does someone in your household go to village meetings/member of a committee or association now?**
Yes / no – *if no skip to question 18*

16. **If so, who and which ones?**
(text)

17. **How often does this person go to meetings or work with the association?** More than once a week / once a week / every 2 weeks / 2 – 3 times a month/ every 2 – 3 months / rarely / other (specify)

This section is about visits into the forest made by members of your household.

18. **How many people from your household have been into the forest in the past month?**
(integer)

19. **How frequently have people from your household visited the forest in the past month?**
    Daily / 2-3 times a week / once a week / 2-3 times a month / once / unsure

20. **What is the main reason for someone in your household to go into the forest?**
    (text)

This is about organisations and projects in your village.

21. **Have you heard of Durrell?**
    Yes / no

22. **Have you heard of Fanamby?**
    Yes / no

23. **Do you know about the KMMFA / CFL project?**
    Yes/no - If yes go to question 25

24. **Do you know [give the names of the CFL monitors]?**
    Yes / no – *if no skip to question 34*

25. **What do you understand is the goal of the KMMFA / CFL project or what they do in the forest?**
    (text)

26. **Does the CFL/KMMFA project make life easier or harder for your household?**
    Much easier / a little easier / no difference / a little harder / a lot harder / unsure

27. **Can you explain why?**
    (text)

28. **In general throughout the village, do you think there is a positive, neutral or negative feeling towards the project?**
    Positive / neutral / negative / no-one cares / unsure

29. **Can you explain why?**
    (text)

30. **Does anyone else IN YOUR VILLAGE benefit from the KMMFA / CFL project? This can be any good thing, such as social things, experiences, networks, access**
    yes / no / unsure – *if no or unsure, skip to question 31*

31. **Who and how do they benefit from the KMMFA /CFL project?**
    (text)

32. **Does anyone IN YOUR VILLAGE lose out from the KMMFA / CFL project?**
    Yes / no/ unsure – if no or unsure, *skip to question 34*

33. **Who and how do they lose-out from the KMMFA / CFL project?**
    (text)

34. **Do you have any comments you would like to make about the KMMFA / CFL project?**
    (text)

<u>This is the final section, about other projects in your village.</u>

35. **Apart from Durrell and Fanamby, are there any projects or organisations operating in your village?**
    Yes / no / unsure

36. **If so, who are they and what do they do?**
    (text)

37. ***That is the end of the questionnaire. Do you have any questions?***

Finish time_______

<u>RESEARCHER ASSESSMENT OF THE INTERVIEW</u>

38. ***During the interview, did the respondent laugh and/or smile?***
    Yes / a little / no

39. ***Based on what you have seen (house/assets) how well off do you think this household is compared to other households in the village?***
    worse-off / about average / better-off

40. ***How well did the person understand the questions?***
    very / moderately / not at all / unsure

41. ***Was the respondent willing to answer your questions?***
    Very / moderately / not at all / unsure

42. ***How honest were the answers given?***
    Very / moderately / not at all / unsure

43. ***How reliable is the information generally provided by this household?***
    Very reliable / reasonably reliable / not reliable / unsure

44. ***If the information isn't reliable, why?***
    _____ (free text)

45. ***Did the respondent refuse to answer the questionnaire?***
    Yes / no

46. ***If yes why:***
    a. *Too busy*
    b. *Doesn't want to reveal household information/personal details*
    c. *Tired of answering questionnaires*
    d. *Illness*
    e. *Other – please specify: _____ (free text)*

End of Questions

C.1.3. Monitor survey questions – English Translation

Consent statement to be read to each participant prior to interview:

The purpose of this survey is to find out about how you feel about the CFL monitoring project and identify the good bits and where the monitoring can improve. This survey has been designed by Samantha Earle of Imperial College London, UK, and your answers will be used in her doctoral research about participatory ecological monitoring. By taking part in this survey you give consent for your answers to be used in this way. This is an independent survey – Samantha's boss is a Professor and I am assisting her to collect information. None of us work for or are paid by an NGO or other organisation. Your identity is anonymous, we will not write your name on the answer sheet and individual responses will not be reported back to Durrell, Fanamby or DREF, therefore your involvement in this survey will not affect your relationship, position or future job prospects with Durrell, Fanamby or DREF. You are free to halt the interview at any time. Is this OK and are you willing to answer these questions? ***YES/NO***

Do you have any questions about this before we start?

Record the following information on the participant information sheet:

- What is your name?
- [record gender]
- Which year were you born?
- What is your highest level of education?
- [House category: A, B or C]
- Which year did you become a CFL monitor?
- Did you attend the CFL workshop in Antananarivo in May 2014?

Record the start time and these answers on the Monitor Survey Answer Sheet:

<u>This first section is about you and your household.</u>

Are you native to this village?

Yes / no

If no, when did you move here?

(integer)

1. **Are you the head of the household?**
Yes / no – *if yes skip to question 3*

2. **How are you related to the household head?**
(text)

3. **How many people are in your household?**
(integer)

4. **How many zebu do you own?**
(integer)

5. **Do you own any land?**
Yes / no

6. **What livelihood activities do you do (e.g. agriculture)?**
rice, peanuts, maize, cassava, zebu farming, handicraft, other: _____

7. **Apart from the KMMFA / CFL project, do you have a regular paid job?**
Yes / no – *if no skip to question 9*

8. **What is the job?**
(text)

9. **How is life been over the past year?**
good / so-so / hard / unsure

10. **Can you explain why?**
(text)

11. **Has the households food production and income over the past 12 months been sufficient to cover the needs of the household?**
Yes / just about sufficient / no / unsure

12. **Can you explain why?**
(text)

13. **Compared with other households in the village, how well-off is your household?**
Worse / about average / better / unsure

14. **If someone in your household is sick, can you get help (either money or assistance) from someone in your village?**
No / sometimes / yes / unsure

<u>This section is about your involvement in village committees and associations.</u>

15. **Are you a member of any village committees or associations at the moment?**
Yes / no – *if no skip to question 18*

16. **If so, which ones?**
(text)

17. **How often do you go to meetings or work with the association?**
More than once a week / once a week / every 2 weeks / 2 – 3 times a month/ every 2 – 3 months / rarely / other (specify)

18. **Does anyone else in your household go to village meetings/member of a committee or association at the moment?**
    Yes / no – *if no skip to question 21*

19. **If so, who and which ones?**
    (text)

20. **How often does this person go to meetings or work with the association?**
    More than once a week / once a week / every 2 weeks / 2 – 3 times a month/ every 2 – 3 months / rarely / other (specify)

<u>This section is about visits into the forest made by members of your household.</u>

21. **Apart from your work as KMMFA / CFL monitor, how many people from your household have gone into the forest in the past month?**
    (integer) if none – *skip to question 24*

22. **How frequently has someone from your household visited the forest?**
    Daily / 2-3 times a week / once a week / 2-3 times a month / once month / unsure

23. **What is the main reason for someone from your household to go into the forest?**
    (text)

<u>This section is about the CFL project.</u>

24. **How did you get onto the KMMFA / CFL project?**
    Volunteered / asked by someone else / elected / other:______

25. **What were your reasons for joining the KMMFA / CFL monitoring project?**
    (text)

26. **What do you understand is the goal of this project?**
    (text)

27. **Do you think this has been achieved?**
    Yes / partly /no / unsure

28. **Can you explain why?**
    (text)

29. **Does the project make life easier or harder for you and your household?**
    Much easier / a little easier / no difference / a little harder / a lot harder / unsure

30. **Can you explain why?**
    (text)

31. **Overall, throughout the village, do you think there is a positive, neutral or negative feeling towards the KMMFA/CFL project?**
    Positive / neutral / negative / unsure

32. **Why?**
    (text)

33. **Does anyone IN YOUR VILLAGE benefit from the KMMFA / CFL project?**
    yes / no / unsure – *if no or unsure, skip to question 35*

34. **Who and how do they benefit from the KMMFA /CFL project?**
    (text)

35. **Does anyone IN YOUR VILLAGE lose out from the KMMFA / CFL project?**
    Yes / no/ unsure – *if no or unsure, skip to question 37*

36. **Who and how do they lose-out from the KMMFA / CFL project?**
    (text)

37. **If you could change one thing about the KMMFA/CFL project, what would it be?**
    (text)

<u>**This section is about the state of the forest and forest laws.**</u>

38. **Are there any species that you see more of in the forest now compared to 5 years ago?**
    yes / no – *if no skip to question 49*

39. **Can you tell me which species?**
    (text)

40. **Are there any species that you see less of in the forest now compared to 5 years ago?**
    Yes / no – *if no skip to question 51*

41. **Can you tell me which species?**
    (text)

42. **Are there any threats that you have seen more of in the forest now compared to 5 years ago?**
    yes / no – *if no skip to question 53*

43. **Can you tell me which threats?**
    (text)

44. **Are there any threats that you see less of in the forest now compared to 5 years ago?**
    Yes / no – *if no skip to question 55*

45. **Can you tell me which threats?**
    (text)

46. **Can you explain why any of these changes have happened?**
    (text)

47. **Do you think forest laws are generally respected by the villagers?**
    Yes / sometimes / no / unsure

48. **Do you think forest laws are respected by those people outside of your village?**
    Yes / sometimes / no / unsure

49. **Do you think the forest laws are enforced?**
    Yes / sometimes / no / unsure - *if no skip to question 60*

50. **Who enforces the forest laws?**
(text)

<u>This is the final section, about other projects working in your village.</u>

51. **Apart from Durrell and Fanamby projects, are there any projects or organisations in your village?**
Yes / no / unsure – *if no skip to question 62*

52. **If so, who are they and what do they do?**
(text)

Finish time_______

<u>RESEARCHER ASSESSMENT OF THE INTERVIEW</u>

53. ***During the interview, did the respondent laugh and/or smile?***
Yes / a little / no

54. ***Based on what you have seen (house/assets) how well off do you think this household is compared to other households in the village?***
Better than average / average / worse than average

55. ***How well did the person understand the questions?***
Very / moderately / not at all / unsure

56. ***Was the respondent willing to answer your questions?***
Very / moderately / not at all / unsure

57. ***How honest were the answers given?***
Very / moderately / not at all / unsure

58. ***How reliable is the information generally provided by this household?***
Very reliable / reasonably reliable / not reliable / unsure

59. ***If the information isn't reliable, why?***
_____ *(free text)*

60. ***Did the respondent refuse to answer the questionnaire?***

61. ***If yes why:***
    f. *Too busy*
    g. *Doesn't want to reveal household information/personal details*
    h. *Tired of answering questionnaires*
    i. *Illness*
    j. *Other – please specify: _____ (free text)*

End of Questions

C.1.4. Focus Group Questions – Malagasy

Votoatin'ny Fanontaniana Mitambatra

Isakin'ny mpandray anjara dia mamaky ity lohahevitra ity fa ametrahana fanontaniana:

Ny antony ity fanadiadiana ity dia mba ahafantarana fa ahoana ny fahatsapanao tetik'asa CFL sy fanamarinana ny vokatra tsara ary koa ahafahana manatsara izany.Ity fanadiadiana ity dia notontosain'I Samantha Earle of Imperial college London, UK, (Mpianatra avy any Angletera),ny valinteninao dia ho ampiasaina amin'ny fikarohana ambony mombany fandraisana anjara amin'ny fanadihadiana ara-ekologika.Fandraisanao anjara amin'ity fanadihadiana ity dia midika fa nekenao fa azo ampiasaina amin'ity fikarohana ity ny valin-teninao. Ity tetik'asa ity dia tsy miankina amin'ny tetik'asa hafa fa mahaleon-tena tanteraka an'i Samantha ihany.Ny lehiben'i Samantha dia mpampianatra fa izaho kosa dia mpanangona ny antontan-kevitra.Izahay dia tsy miara-miasa amin'ny tetik'asa tsy miankina (ONG).Ny mombamomba anao dia raisina ho tsiambaratelo, ny anaranao sy ny valin-teninao dia tsy ho lazaina na amin'iza na amin'iza.Ny fandraisanao anjara amin'ity fanadihadihana ity dia tsy manimba ny fifandraisanao amin'ny asanao sy ny ho avinao amin'ny tetik'asa tsy miankina (ONG).Malalaka ianao fa tsy terena amin'ny fanontaniana.Vonona tsara ve ianao hamaly ireto fanontaniana ireto? **ENY SA TSIA**

Manana fanontaniana ve ianao alohan'ny

Mba azonao lazaina ve inona avy ny fikambanana misy eto amin'ity Tanàna ity dia inona no fototra ijoroany sy ny fanapahan-keviny?

1. Azonao hazavaina amiko ve ny mahazavadehibe ny ala amin'ny fiananananao, midika inona ny ala aminao ?
2. Azafady, mba azonao azavaina amiko ve ny anjara asan'ny ala amin'ny fiainanao?.
3. Azafady mba lazalazao ny Zavatra nihitanao na henonao fotsiny momba ny fiovan'ny ala nandritra ny dimy taona lasa?
4. Inona no tetik'asa efa nandraisanao anjara momba ny ala amin'ny asa?
5. Nahomby ve sa Tsia izany tetik'asa izany, Nahoana ?
6. Azonao lazaina ahy ve ny momba ny tetik'asa hafa izay efa nampiova amin'ny fiainanao tanatin'ny dimy taona farany?
7. Noheverinao fa nahomby ve izany na tsia , Nahoana
8. Azonao lazaina amiko ,ahoana ny fahafantaranao ny CFL/KMMF; CFL = KMMFA = (Komity Miaro sy Manaramaso ny Faritra Arovana)
9. Amin'ny ankapobeny dia afaka miteny ve ianao fa ratsy na tsara ho anao sy ny ankohonanao ity tetik'asa ity?
10. Amin'ny ankapobeny dia afaka miteny ve ianao fa ratsy na tsara ho an'i tanàna ity tetik'asa ity?
11. Raha ianao no afaka manova ny tetik'asa, dia inona no ovainao?
12. Arakin'ny fahafantaranao azy ve fa hajain'olona eto aminy Tanana ny lalanala?
13. Nahoana ary inona izay lalàna izay?

Tapitra ny fanontaniana

C.1.5. Household Survey Questions – Malagasy

Fanontaniana ao amin'ny Ankohonana

Isakin'ny mpandray anjara dia mamaky ity lohahevitra ity fa ametrahana fanontaniana :

Ny antony ity fanadiadiana ity dia mba ahafantarana fa ahoana ny fahatsapanao tetik'asa CFL sy fanamarinana ny vokatra tsara ary koa ahafahana manatsara izany. Ity fanadiadiana ity dia notontosain'I Samantha Earle of Imperial college London, UK, (Mpianatra avy any Angletera), ny valinteninao dia ho ampiasaina amin'ny fikarohana ambony mombany fandraisana anjara amin'ny fanadihadiana ara-ekologika.Fandraisanao anjara amin'ity fanadihadiana ity dia midika fa nekenao fa azo ampiasaina amin'ity fikarohana ity ny valin-teninao. Ity tetik'asa ity dia tsy miankina amin'ny tetik'asa hafa fa mahaleon-tena tanteraka an'i Samantha ihany.Ny lehiben'i Samantha dia mpampianatra fa izaho kosa dia mpanangona antontan-kevitra. Izahay dia tsy miara-miasa amin'ny tetik'asa tsy miankina (ONG) .Ny mombamomba anao dia raisina ho tsiambaratelo, ny anaranao sy ny valin-teninao dia tsy ho lazaina na amin'iza na amin'iza. Ny fandraisanao anjara amin'ity fanadihadihana ity dia tsy manimba ny fifandraisanao amin'ny asanao sy ny ho avinao amin'ny tetik'asa hafa. Malalaka ianao fa tsy terena amin'ny fanontaniana.Vonona tsara ve ianao hamaly ireto fanontaniana ireto ? **ENY SA TSIA**

Manana fanontaniana ve ianao alohan'ny hanomboatsika?

Fandraisana an-tsoratra ny hevitra avy amin'ny mpandray anjara :

- Iza no anaranao?
- [lahy sa Vavy]
- Oviana ianao no teraka
- kilasy fahafiry no nianaranao farany?
- [Sokajin'ny trano: A,B na C]

Fandraisana an-tsoratra ny fanombohana sy ny famalian-tenin'ny Lehiben'ny mpanadina:

Ity no sampana voalohany momba anao sy ny ankohonanao

1. **Ianao ve no lohan'ankohonanao?**
   Eny / Tsia - raha eny dia dingano 3
2. **Inona no fifandraisanao amin'ny lohan'ankohonana**
   (Lahantsoratra)
3. **Firy ny olona ao amin'ny ankohonanao?**
   (Isany)
4. **Firy ny omby anananao?**
   (Isany)
5. **Manana tany ve ianao?**
   Eny / Tsia
6. **Inona ny raharaham-pivelomana ataonao (ohatra. Fambolena)?**
   Vary, Voanjo, Katsaka, Mangahazo,Tantely, Omby, Asatanana, zavatra hafa
7. **Manana asa fidiram-bola hafa ve ianao (@ sekoly na varotra sns ...)**
   Eny / Tsia- raha tsia dia dingano 9

8. **Asa inona ary izany?**
(Lahantsoratra)
9. **Ahoana ny fiainanao Arakin'ny fahitanao azy tamin'ny taona lasa?**
Tsara/ eo ho eo / Mafy / tsy azo antoka
10. **Azonao azavainao ve nahoana?**
(Lahantsoratra)
11. **Ny sakafo vokarin'ity ankohonana ity tao anatiny iray taona lasa ve ampy aminy filan'ankohonana sa mbola misy ambiny?**
Eny / Antonony / Tsia / Tsy azo antoka
12. **Azonao hazavaina ve nahoana?**
(Lahantsoratra)
13. **Raha ampitahaina amin'ny ankohonana hafa eto an-tanàna, ahoana ny farimpiainanao?**
Ratsy /e oho eo /Tsara / Tsy fantatra
14. **Raha misy marary ato amin'ny ankohonanao, Ianao ve mba mahazo fanampiana (vola na fanotronana) avy amin'olona eto an-tanànareo ?**
Tsia / Indraindray / Eny / Tsy azo antoka
15. **Misy olona avy amin'ankohonanao ve manatrika fivoriana na komity na fikambanana eto antanana amin'izao fotoana izao**
Eny / Tsia –Raha tsia dia dingano 18
16. **Raha eny dia iza?**
(Lahantsoratra)
17. **Impiry izay olona izay no manatrika fivoriana na manao asan'ny fikambanana?**
Mihoatra indray isan-kerin'andro / in-1 isan-kerin'andro / isaky ny 2 herinandro / 2-3 isam-bolana / isaky ny 2-3 volana / Mahalana / Hafa Farito

<u>Ity sampana ity dia momba ny fitsidihana anaty ala ataony mambran'I ankohonanao.</u>

18. **Firy ny olona avy ao an-tokatranonao nandeha tany anaty ala tao anatin'ny volana lasa?**
(Isany)
19. **Impiry no nitsidihan' olona avy ao amin'ny ankohonanao ny ala nandritra ny iray volana lasa izay?**
Isan'andro / in-2-3 anatin'ny Herin'andro / indray mandeha anatiny herin'andro / in-2-3 anatiny iray volana / indray mandeha / Tsy azo antoka
20. **Inona no tena antony andehanan'olona avy ao amin'ny ankohonanao any anaty ala?**
(lahantsoratra – Nontanisainy ny an-kapobeny)

<u>Ity dia momba ny tetik'asa tsy miankina (ONG) eto an-tananareo .</u>

21. **Efa naheno momba ny Durrell ve ianao?**
Eny / Tsia
22. **Efa nahaheno momba ny FANAMBY ve ianao?**
Eny / Tsia
23. **Mahafantatra mombamomba ny tetik'asan'i KMMFA na CFL ve ianao?**
Eny / Tsia
24. **Ahoana ny fahazahoanao ny tanjona ny KMMFA / CFL ?**
(text)
26. **Mahasarotra sa manamora ny fiainanareo ao amin'ny ankohonanao ve io tetik'asa io?**
Mora kokoa / Moramora kely / Tsy misy fahasamihafany / Mafimafy kely / Mafy loatra / Tsy fantatra
27. **Azonao hazavaina ve nahoana?**
(Lahantsoratra)
28. **Amin'ny ankapobeny eto antanàna, ahoana ny eritreritrao, mba misy fahombiazana ve sa tsy mahomby na eo ho eo ny fandrosoan 'ity tetik'asa ity?**
Mahomby / Eo ho eo / Tsy Mahomby / Tsy misy miraharaha / Tsy fantatra
29. **Azonao hazavaina ve nahoana?**
(Lahantsoratra)
30. **Misy olon-kafa ato amin'ny tanànanareo ve efa nahazo tombotsoa avy amin'ny KMMFA na CFL?**
Eny / Tsia / Tsy fantatra - raha tsia na tsy fantatra dia dingano 31
31. **Iza ary nanao ahoana no nahazahoandreo tombotsoa avy amin'ny KMMFA sy CFL?**
(Lahantsoratra)
32. **Iza no tsy nahazo tombontsoa amin'io tetik'asa io?**
Eny / Tsia / Tsy fantatra - raha tsia dia dingano 34

33. **Iza ary nahoana?**
(Lahantsoratra)
34. **Misy zavatra tianao ho resahina ve momba ny KMMFA na CFL?**
(Lahantsoratra)

<u>**Ity no sampana farany mikasika ny tetik'asa hafa eto amin'ny tanànanareo**</u>

35. **Ankoatran'ny DURRELL sy FANAMBY dia misy tetik'asa hafa ve miasa eto amin'ny tanànanareo ?**
Eny / Tsia / Tsy fantatra .
36. **Raha eny dia Iza zareo ary inona no ataony?**
(Lahantsoratra)
37. ***Izay no fanontaniana farany apetraka.Manana fanontaniana ve ianao?***

TAPITRA NY ORA ________

FAMARITAN'I MPIKAROKA NY FANADIHADIANA

38. **Nandritra ny fanadihadiana,nihomehy ve izy ireo sa nitsiky?**
Eny / Kelikely / Tsia
39. **Inona no hitanao ifotony (Trano,fananana)ahoana ny fari-pianan'ity ankohonana ity raha ampitahaina amin'ny ankohonana hafa eto antanàna?**
Tena ratsy / Eo ho eo / Tena tsara
40. **Ahoana tsara ny fahazahoan'olona ny fanontaniana?**
Tena azony / Eo ho eo / Tsy izy rehetra / Tsy azo antoka
41. **Vonona namaly ny fanontanianao ve izy ireo tamin'izay?**
Tena vonona / Eo ho eo / tsy vonona loatra / Tsy azo antonka
42. **Ahoana ny fahamarinan'ny valinteny nomeny?**
Tena marina / eo ho eo / Tsy izy rehetra / Tsy azo antoka
43. **Ahoana ny fahazahoana antoka ny ankapoben'ny atontan-kevitra zay nomen'ity ankohonana ity?**
Tena azo antoka / azo inoana / Tsy marina / eo ho eo
44. **Raha tsy azo antoka ny valinteny omeny,dia nahoana?**
_____ (Lahantsoratra mivelatra)
45. **Nandà tsy namaly ny fanontaniana ve izy ireo?**
46. **Raha eny,dia nahoana:**

- Tena raikitra
- Tsy tian'izy ireo ny hanambara ny antsipirian'ny tokatranony
- Reraka amin'ny famaliana ireo fanontaniana
- Aretina
- Zavatra hafa voafaritra:______ (Lahatsoratra mivelatra)

C.1.6. Monitor Questions – Malagasy

Fanontaniana Apetraka amin'ny Fanadihadiana

Fanekena ho an'i mpandray anjara tsirairay amin'ny fanontaniana:

Ny antony ity fanadiadiana ity dia mba ahafantarana fa ahoana ny fahatsapanao tetik'asa CFL sy fanamarinana ny vokatra tsara ary koa ahafahana manatsara izany.Ity fanadiadiana ity dia notontosain'I Samantha Earle of Imperial college London, UK, (Mpianatra avy any Angletera),ny valinteninao dia ho ampiasaina amin'ny fikarohana ambony mombany fandraisana anjara amin'ny fanadihadiana ara-ekologika.Fandraisanao anjara amin'ity fanadihadiana ity dia midika fa nekenao fa azo ampiasaina amin'ity fikarohana ity ny valin-teninao. Ity tetik'asa ity dia tsy miankina amin'ny tetik'asa hafa fa mahaleon-tena tanteraka an'i Samantbha ihany.Ny lehiben'i Samantha dia mpampianatra fa izaho kosa dia mpanangona antontan-kevitra antontan-kevitra. Izahay dia tsy miara-miasa amin'ny tetik'asa tsy miankina (ONG). Ny mombamomba anao dia raisina ho tsiambaratelo,ny anaranao sy ny valin-teninao dia tsy ho lazaina amin'ny tetik'asa DURRELL , FANAMBY na DREF.Ny fandraisanao anjara amin'ity fanadihadihana ity dia tsy manimba ny fifandraisanao sy ny asanao miaraka amin'ny DURRELL , FANAMBY na DREF Ny vokatrin'ny asa fikarohana ity dia ampahafantarina anao amin'ny alalan'ny ekipan'ny CFL, Malalaka ianao fa tsy terena amin'ny fanontaniana.Vonona tsara ve ianao hamaly ireto fanontaniana ireto ? **ENY SA TSIA**

Manana fanontaniana ve ianao alohan'ny hanomboatsika?

Fandraisana an-tsoratra ny valinteny aran-kevitra avy amin'ny mpandray anjara:

- Iza no anaranao?
- [Lahy sa Vavy]
- Oviana ianao no teraka?
- Kilasy fahafiry ianao no nijanonana nianatra?
- [Sokajin'ny ankohonana : A, B na C]
- Tamin'ny taona firy no nahalehiben'ny KMMFA anao?
- Efa nanatrika fivoriana mitambatra tany Antananarivo tamin'ny volana May 2014 ve ianao?

Fandraisana an-tsoratra ny fanombohana sy ny famalian-tenin'ny Lehiben'ny mpanadina
Ity no sampana voalohany momba anao sy ny ankohonanao.

1. **Ianao ve no lohan'ankohonanao?**
   Eny / Tsia - Raha eny dia dingano 3
2. **Inona no fifandraisanao amin'ny lohan'ankohonana**
   (Lahantsoratra)
3. **Firy ianareo no ankohonana iray?**
   Eny / Tsia
4. **Firy ny omby anananao?**
   (Isany)
5. **Manana tany ve ianao?**
   Eny / Tsia
6. **Inona ny raharaham-pivelomana ataonao (ohatra. Fambolena)?**

Vary, Voanjo, Katsaka, Omby, Asatanana, Zavatra hafa:_______

7. **Manana asa fidiram-bola hafa ve ianao ankoatran'ny maha KMMFA anao?**
   Eny / Tsia- raha tsia dia dingano 9
8. **Asa inona ary izany?**
   (Lahantsoratra)
9. **Ahoana ny fiainanao Arakin'ny fahitanao azy tamin'ny taona lasa?**
   Tsara/ eo ho eo / Mafy / tsy azo antoka
10. **Azonao azavainao ve nahoana?**
    (Lahantsoratra)
11. **Ny sakafo vokarin'ity ankohonana ity tao anatiny iray taona lasa ve ampy aminy filan'ankohonana sa mbola misy ambiny?**
    Eny / Antonontonony / Tsia / Tsy azo antoka
12. **Azonao azavaina ve nahoana?**
    (Lahantsoratra)
13. **Raha ampitahaina amin'ny ankohonana hafa eto an-tanàna, ahoana ny fahampian-tokatranonao?**
    Ratsy / Eo ho eo / Tsara / tsy fantatra
14. **Raha misy marary ao amin'ny ankohonanao, ianao ve mba mahazo fanampiana (ara-bola na fanotronana) avy amin'olona eto an-tanàna?**
    Tsia / Indraindray / Eny / Tsy azo antoka

<u>**Ity no sampana momba ny fandraisanao anjara amin'ny komity sy ny fikambanana eto an-tanàna.**</u>

15. **Ianao ve anatin'ny mambra ny komity na fikambanana eto an-tanàna amin'izao fotoana izao?**
    Eny / Tsia - Raha tsia dia dingano 18
16. **Raha eny, Iza amin'ireo?**
    (Lahantsoratra)
17. **Impiry ianao no manatrika fivoriana na manao asa amin'ny fikambanana?**
    Mihoatra ny 1- isan-kerin'andro / in-1 isan-kerin'andro / Isakin'ny 2 herin'andro/ in-2 na 3 isam-bolana / Isakin'ny 2 na 3 volana/ Mahalana / Hafa (farito)
18. **Misy olon-kafa amin'ny ankohonanao manatrika fivoriana na mambran'I komity na fikambanana eto antanana amin'izao fotoana izao?**
    Eny / Tsia - Raha tsia dia dingano 21
19. **Raha eny, Iza amin'ireo?**
    (Lahantsoratra)
20. **Impiry izay olona izay no mivory na manao asan'ny fikambanana?**
    Mihoatra ny 1- isan-kerin'andro / in-1 isan-kerin'andro / Isakin'ny 2 herin'andro/ in-2 na 3 isam-bolana / Isakin'ny 2 na 3 volana/ Mahalana / Hafa (farito)

<u>**Ity sampan ity dia momba ny fitsidihana anaty ala ataony mambran'ny ankohonanao.**</u>

21. **Ankoatran'ny asa maha- KMMFA anao, firy ny olona avy ao amin'ny ankohonanao no nandeha tanaty ala tamin'ny volana lasa iny?**
    (isany) Raha tsy misy dia dingano 24
22. **Impiry no nitsidihan' olona avy ao amin'ny ankohonanao ny ala?**
    Isan'andro / in-2-3 anatin'ny Herin'andro / indray mandeha anatiny herin'andro / in-2-3 anatiny iray volana / indray mandeha / Tsy voafaritra
23. **Inona no tena antony andehanan'olona avy ao amin'ny ankohonanao any anaty ala?**
    (Lahantsoratra – Nontanisainy ny an-kapobeny)

<u>**Ity sampana ity dia momba ny tetik'asa KMMFA.**</u>

24. **Ahoana no nahatafiditra anao amin'ny tetik'asa KMMFA na CFL?**
    Fahavononana / Niangavian'olona / Nofidina / antony hafa
25. **Inona no hevitrao no nahatonga anao niditra amin'ity tetik'asa CFL ity?**
    (Lahantsoratra)
26. **Inona no fahazahoanao ny tanjon'ity tetik'asa ity?**
    (Lahantsoratra)
27. **Mieritreritra ve ianao fa Tratra ny tanjona?**
    Eny / sasantsasany / Tsia / Tsy fantatra
28. **Azonao hazavaina ve, nahoana?**

(Lahantsoratra)

29. **Mahasarotra sa manamora ny fiainanao sy ny ankohonanao ve Ity tetik'asa ity?**
   Mora kokoa / Moramora kely / Tsy misy fahasamihafany / Mafimafy kely / Mafy loatra / Tsy fantatra
30. **Azonao hazavaina ve, nahoana?**
   (Lahantsoratra)
31. **Amin'ny ankapobeny manerana ny Tanàna, mieritreritra ve ianao fa mahomby sa tsy mahomby ny fivoaran'io tetik'asa io?**
   Mahomby / Eo ho eo / Tsy mahomby / Tsy azo antoka
32. **Nahoana?**
   (Lahantsoratra)
33. **Misy olona avy eto amin'ny tanananareo ve no efa nahazo tombotsoa avy amin'ny tetik'asa KMMFA /CFL?**
   Eny / Tsia / Tsy fantatra Raha tsiana tsy fantantra dia dingano 35
34. **Iza no efa nahazo tombotsoa tamin'ny tetik'asa KMMFA /CFL? Amin'ny fomba ahoana?**
   (Lahantsoratra)
35. **Misy olona avy ao amin'ny tanananareo koa ve no tsy nahazo tombotsoa avy tetik'asa KMMFA / CFL?**
   Eny / Tsia / Tsy fantatra Raha tsiana tsy fantantra dia dingano 37
36. **Iza no tsy nahazo tombontsoa Tamin'io tetik'asa io, ary nahoana?**
   (Lahantsoratra)
37. **Raha mba afaka manova zavatra ianao amin'ity tetik'asa KMMFA/ CFL ity dia mety ho inona izany?** Lahantsoratra malalaka

<u>Ity sampana ity dia mombamomba ny ala sy ny lalàna mifehy azy</u>

38. **Misy karazana biby fahitanao matetika ve ao anaty ala amin'izao raha ampitahaina tamin'ny dimy taona lasa?**
   Eny / Tsia – Raha tsia dia dingano 49
39. **Azonao lazaina ve, inona avy izany karazana biby izany?**
   (Lahantsoratra)
40. **Misy karazana biby tsy fahitanao matetika ve ao anaty ala amin'izao raha ampitahaina tamin'ny dimy taona lasa?**
   Eny / Tsia – Raha tsia dia dingano 51
41. **Azonao lazaina ve, inona avy izany karazana biby izany?**
   (Lahantsoratra)
42. **Betsaka ve ny fahasimbana hitanao ao anaty ala amin'izao, raha ampitahaina tamin'izay dimy taona lasa izay?**
   Eny / Tsia – Raha tsia dia dingano 53
43. **Inona no fahasimbana?**
   (Lahantsoratra)
44. **Kely ve ny fahasimbana hitanao ao anaty ala amin'izao, raha ampitahaina tamin'izay dimy taona lasa izay?**
   Eny / Tsia - Raha tsia dia dingano 55
45. **Inona no fahasimbana?**
   (Lahantsoratra)
46. **Azonao hazavaina ve ny antony nahatonga izay fiovana izay?**
   (Lahantsoratra)
47. **Mieritreritra ve ianao fa hajain'olona eto antanana ny lalana mifehy ny ala amin'ny ankapobeny?**
   Eny / indraindray/ Tsia / Tsy fantatra
48. **Mieritreritra ve ianao fa hajain'olona ivelan'ny tanananareo ny lalana mifehy ny ala?**
   Eny / indraindray / Tsia / Tsy fantatra
49. **Mieritreritra ve ianao fa nohamafisina ny lalana mifehy ny ala?**
   Eny / indraindray / Tsia / Tsy fantatra—Raha tsia dia dingano 60
50. **Iza no nanamafy izany lalana izany?**
   (Lahantsoratra)

<u>Ity no sampana farany,momba ny tetik'asa hafa ao amin'ny tanànanareo.</u>

51. **Ankoatran'ny FANAMBY sy DURRELL dia misy tetik'asa hafa ve eto amin'ny tanananareo?**
   Eny / Tsia / Tsy fantatra -- Raha tsia dia dingano 62
52. **Raha eny dia iza izy ireo ary inona no ataony?**

(Lahantsoratra)

Izay no fanontaniana farany. Manana fanontaniana ve ianao?

TAPITRA NY ORA ________

FAMARITAN'I MPIKAROKA NY FANADIHADIANA

53. **Nandritra ny fanadihadiana, nihomehy ve izy ireo sa nitsiky?**
    Eny / Kelikely / Tsia
54. **Amin'ny ankapobeny Inona no hitanao ifotony (Trano, fananana)ahoana ny faripianan'ity ankohonana ity raha ampitahaina amin'ny ankohonana hafa eto antanàna?**
    Tsara kokoa / Antonony / Ratsy kokoa
55. **Ahoana tsara ny fahazahoan'olona ny fanontaniana?**
    Tena azony / Eo ho eo / Tsy izy rehetra / Tsy azo antoka
56. **Vonona namaly ny fanontanianao ve izy ireo?**
    Tena vonona / Eo ho eo / Tsy izy rehetra no vonona / Tsy voafaritra
57. **Ahoana ny fahamarinan'ny valinteny nomeny?**
    Tena marina / Eo ho eo / Tsy izy rehetra no marina / Tsy azo antoka
58. **Ahoana ny fahazahoana antoka ny ankapoben'ny information izay nomen'ity ankohonana ity?**
    Tena azo antoka / azo inoana / Tsy marina / eo ho eo
59. **Raha tsy azo antoka ny information, Nahoana?**
    _____ (Lahantsoratra mivelatra)
60. **Nandà tsy namaly ny fanontaniana ve izy ireo?**

61. **Raha eny,dia nahoana:**
    a. Tena raikitra
    b. Tsy tian'izy ireo ny hanambara ny antsipirian'ny tokatranony
    c. Reraka amin'ny famaliana ireo fanontaniana
    d. Aretina
    e. Zavatra hafa voafaritra

C.2. Wealth index

A factorial analysis on mixed data was used in R to create a wealth index based on four variables:

- Total number of zebu (cattle) owned by people in the household
- Whether land was owned by anyone in the household
- Whether anyone in the household had a paid job
- Each respondent perceived wealth of the household relative to other households in the village.

Six dimensions explained the variance, see Table C.1. and Figure C.1 below:

Table C.1. Percentage of variation and cumulative variation of the six dimensions of the wealth index created using a factorial analysis on mixed data.

dimension	percentage of variance	cumulative percentage of variance
1	25.54	25.54
2	21.13	46.67
3	16.17	62.84
4	14.23	77.07
5	12.38	89.45
6	10.55	100.00

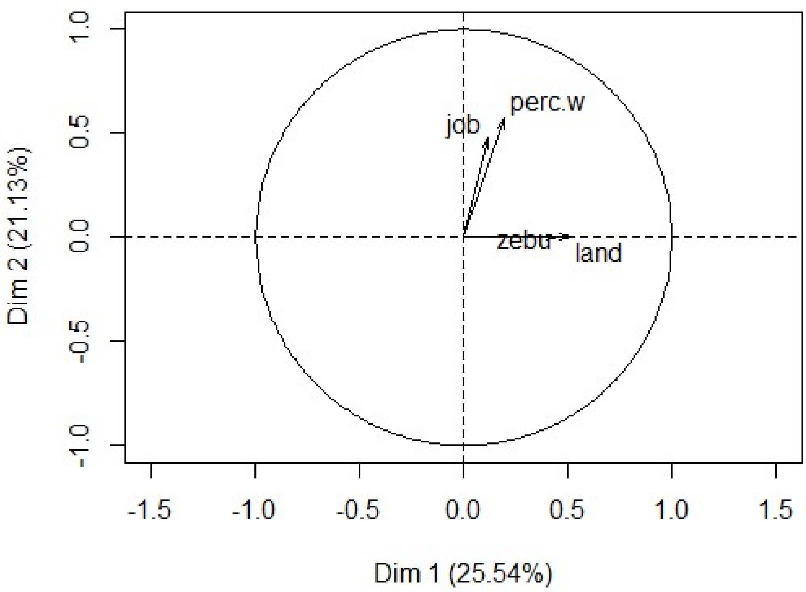

Figure C.1. Graph of variables represented in dimension 1 and dimension 2 of the factorial analysis on mixed data to create a wealth index for households. The percentage values in the axis labels indicate the percentage variance explained by that dimension. Perc.w= perceived relative wealth.

C.3. Summary of the results of the household survey by village

Table C.3. Summary of the results of the household by village

	Ampataka	Beroboka	Kiboy	Kirindy	Lambokeley	Marofandilia	Tsianloka
total # respondents	54	54	53	53	54	50	50
# respondents	26	26	23	25	23	27	25
# female respondents	28	28	30	28	31	23	25
average age of respondents	34.7	37.7	42.3	34.1	36.8	36.2	34.3
average education grade	3.8	4.8	6.0	3.1	2.7	4.1	5.2
# respondents native to village	45	45	42	41	43	37	41
# house category A	15	11	10	8	8	15	12
# house category B	21	20	16	22	18	21	24
# house category C	17	23	21	20	28	13	13
house category unsure	1	0	6	3	0	1	1
# respondents that were the household head	30	29	32	28	30	33	31
average number of people in household	5.8	5.8	6.4	6.0	5.2	4.9	5.7
average number of zebu in each household	3.4	1.4	1.8	1.7	1.9	1.2	5.2
# households that owned land	51	48	44	45	38	47	37
average dimension 1 value	0.19	-0.08	-0.04	-0.05	-0.36	0.17	0.18
average dimension 2 value	-0.03	0.13	-0.16	-0.15	-0.19	0.18	-0.04
What are your livelihood activities?							
rice	6	51	37	0	1	1	49
maize	22	24	12	51	40	42	35
peanuts	31	40	40	52	48	45	41
cassava	42	2	12	5	22	5	12
tsesisa (small bean)	0	0	4	0	0	0	46
sweet potatoes	1	0	0	0	5	0	7
Do you have a paid job?							
no	23	25	31	37	32	27	24
yes	31	29	22	16	22	23	26
What is the paid job?							
livestock breeder or seller	0	0	0	0	0	1	0
production or the sale of charcoal	0	1	0	0	0	2	0
works in the fields	0	1	1	2	2	1	2
catches and/or sells fish	12	1	2	0	0	0	3
sells food, clothes or tobacco	5	11	12	7	0	7	8
teacher	0	0	0	1	2	1	0
salt factory	9	1	0	0	0	0	0
sale or rental of zebu carts	0	0	0	1	0	0	0
whatever is available, no regular job	7	14	8	5	19	1	13
How has life been over the past year?							
good	3	2	2	2	3	5	2
so-so / average	22	21	13	24	21	28	19
hard	29	31	38	27	30	17	29

Why is life hard / average / good?							
Life is average or hard: I have no family	7	1	4	0	2	3	8
Life is hard: worried for the future	3	3	3	3	4	1	5
Life is average / hard: I do not have sufficient harvests	23	26	25	19	19	10	19
Life is average / hard: I have recently lost a family member	2	0	1	1	0	4	1
Life is average / hard: I am old	2	0	2	0	2	1	0
Life is average / hard: a lack of food	7	7	5	3	3	2	9
Life is average / hard:a lack of money	5	6	7	4	3	8	8
Life is average / hard: sickness or poor health	0	0	0	0	0	3	0
Life is average / hard: zebu theft	0	2	1	1	0	0	0
Life is average / hard: I have no job	2	4	6	0	7	0	5
Life is average / hard: I have no land	3	0	1	0	1	0	0
Life is hard: no access to the market	0	0	3	0	0	0	1
Life is good / average: I have no worries	1	3	0	6	4	8	3
Life is good: I have access to market	0	0	0	3	0	1	1
Life is good / average: I have some money	1	0	1	0	0	1	1
Life is good: I have had some education	0	1	0	0	1	0	0
Life is good: I have family	0	0	0	0	2	0	0
Life is good / average: I have sufficient harvests	12	7	12	3	8	10	11
Life is average: I have sufficient food	1	10	0	11	11	5	1
Life is average: I have a job	2	1	2	2	0	1	1
Life is average: I am healthy	0	0	0	0	0	2	0
Has the household food production and income over the past 12 months been sufficient to cover the needs of the household?							
no	46	35	40	29	36	23	26
just about sufficient	4	17	9	17	14	14	11
yes	4	2	3	7	3	13	10
unsure	0	0	1	0	1	0	3
Compared with other households in the village, how well off is your household?							
worst than most	34	26	26	25	32	15	25
average	16	26	20	27	15	33	21
better than most	4	2	7	1	7	2	4
If someone in your house is sick, can you get help from someone else in your village?							
no	37	37	19	34	33	40	25
sometimes	10	10	24	11	9	6	12
yes	7	7	10	8	11	4	12
unsure	0	0	0	0	1	0	1
Does anyone in your household go to village meetings or is a member of a committee or association now?							
no	34	36	30	15	32	15	30
yes	20	18	23	38	21	35	20
unsure	0	0	0	0	1	0	0

How often does this person go to meetings or work with the association?							
more than once a week	0	0	0	0	0	0	0
once a week	0	0	1	0	0	3	0
every 2 weeks	0	0	0	0	0	1	0
2 - 3 times a month	4	0	8	8	0	7	5
every 2 - 3 months	2	9	2	7	14	4	3
rarely	10	8	5	21	7	17	9
other (specify next question)	2	0	1	1	0	3	0
unsure	2	1	6	1	0	0	3
How many people from your household have been into the forest in the past month?							
0	30	10	11	13	24	5	3
1	3	14	3	10	10	20	15
2	10	14	14	13	8	16	8
3	2	10	5	11	7	6	3
4	1	4	8	3	1	2	8
5	4	1	6	3	1	0	5
6	2	0	2	0	1	0	2
7	0	0	1	0	0	0	1
8	1	1	1	0	1	1	3
10	1	0	1	0	0	0	2
11	0	0	0	0	1	0	0
16	0	0	1	0	0	0	0
How frequently have people from your household visited the forest in the past month?							
once a month	0	1	1	1	1	0	1
2 or 3 times a month	0	0	0	1	1	7	0
once a week	2	5	6	14	5	1	5
2 or 3 times a week	17	32	33	18	21	19	34
daily	4	4	3	4	2	18	6
unsure	1	2	0	2	0	0	1
no-one goes into the forest	30	10	10	13	24	5	3
What is the reason why someone in hour household goes into the forest?							
collect firewood	11	30	8	34	21	18	24
collect tubers	17	39	34	30	21	38	41
gather timber	1	0	4	2	1	1	5
collect honey	0	1	0	1	2	4	3
collect food	3	0	8	1	1	0	4
to trap animals	2	0	0	0	0	1	0
collect mushrooms	1	0	0	0	0	0	0
go to the toilet	0	0	0	0	0	0	0
for charcoal production	0	0	0	0	0	1	0
Have you heard of Durrell?							
no	15	3	2	1	7	4	4
yes	39	51	51	52	47	46	46
Have you heard of Fanamby?							
no	24	9	11	10	24	1	18
yes	30	45	42	43	30	49	32
Do you know about the patrol/monitoring project?							
no	40	7	19	2	21	13	27
yes	14	47	34	51	33	37	23

Does the patrol/monitoring project make life easier or harder for your household?							
harder	0	3	0	2	0	0	0
no difference	6	6	7	5	3	2	6
easier	6	3	2	8	5	10	3
much easier	34	36	35	34	40	25	34
unsure	0	1	1	2	0	0	0
NA	8	5	8	2	6	13	7
In general, throughout the village, do you think there is a positive, neutral or negative feeling towards the patrol/monitoring project?							
negative	0	5	3	2	5	0	4
neutral	5	12	4	22	7	12	5
positive	34	30	34	22	33	24	29
unsure	7	2	4	5	3	1	5
NA	8	5	8	2	6	13	7
Does anyone in your village benefit from the patrol/monitoring project?							
no	6	4	6	1	11	1	3
yes	39	38	35	49	34	35	37
unsure	1	7	4	1	3	1	3
NA	8	5	8	2	6	13	7
Does anyone in your village lose out because of the patrol/monitoring project?							
no	20	23	26	25	37	19	23
yes	18	22	9	23	9	15	14
unsure	8	4	10	3	2	3	6
NA	8	5	8	2	6	13	7

C.4. Project Success Score and Village Level Variables

Durrell staff gave a score of 0, 0.5 or 1 for overall level of enthusiasm for the project by the villagers and monitors and a second score of 0, 0.5 or 1 for the operational performance of the project in each village. The sum of the Durrell scores were compared with the rank from the Research Assistants (RAs) ranks to validate the opinions of the RAs and Durrell staff (Figure C.2.). The RAs agreed that each village was sufficiently different and did not assign joint ranks to two or more villages. There is a strong linear relationship between the RA rankings and the Durrell staff scores (Kendall, tau -0.744, p-value <0.001). Although the success measure is subjective and rather coarse, agreement between the two types of experts indicate that the final summed scores are a reasonable measure of 'project success' in study villages. Therefore, the ranks were scaled 0 to 2 to give equal weighting to the views of both sets of assessors and summing the scores. See Table C.2. for the final scores for each village.

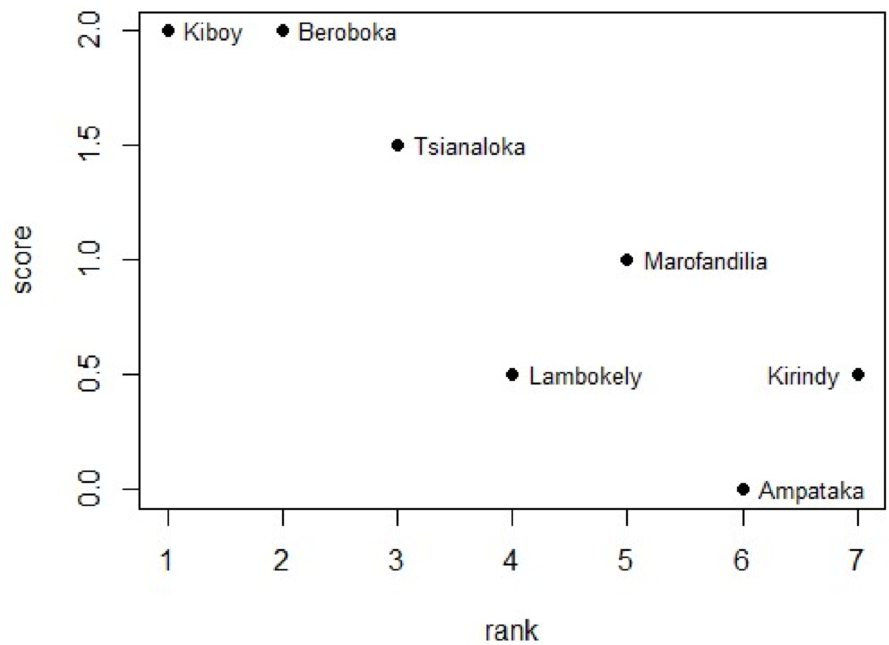

Figure C.2. Graph of the Durrell scores (vertical axis) and the Research Assistants ranks (horizontal axis). The project is most successful in those villages that appear in the upper left corner of the box.

Table C.3. Summary of the village level variables used in the models.

Village	Success score	Number of associations	Proportion of forest cover	Population size	Number of Days since last Durrell visit
Ampataka	0.3	3	0.377	1089	54
Beroboka	3.7	2	0.429	1616	41
Kiboy	4.0	3	0.679	740	148
Kirindy	0.5	3	0.730	416	129
Lambokely	1.5	8	0.777	626	78
Marofandilia	1.7	3	0.695	785	18
Tsianloka	2.8	5	0.472	1057	0

C.5. Variables

Table C.4. Description, justification and expectations of all variables included in the modelling.

Variable		Description	Type	Range	source	justification for including variables
Response variable	heard	Answer to the question: have they heard of the monitoring project and/or know who the monitors are?	binary	0 = no, 1 = yes	Household or monitor survey.	Response variable.
	ease of life	Does the project make life easier? Collapsed variable from does the project make life easier or harder for your household (5 scales)	binary	0 = no (much harder, harder or no difference), 1 = yes (easier or much easier)	Household or monitor survey.	Response variable.
	benefits	Answer to the question: does anyone benefit from the project?	binary	0 = no, 1 = yes	Household or monitor survey.	Response variable.
	losses	Answer to the question: does anyone lose out from the monitoring project?	binary	0 = no, 1 = yes	Household or monitor survey.	Response variable.

Variable		Description	Type	Range	source	justification for including variables
Random effect	village	village	categorical	7 villages: Ampataka, Beroboka, Kiboy, Kirindy, Lambokeley, Marofandilia, Tsianaloka	Household or monitor survey.	Village is a random effect due to the design of the data collection.
Individual/household level variable	involveme nt	involvement of the respondent in relation to the project	categorical	"monitor", "VOI member", "other villager"	Household or monitor survey.	Indicates different level of involvement with the forest and the project, therefore different knowledge about the project.
	forest use frequency	forest use: frequency of visits to the forest (for anything other than patrolling)	categorical	"never", "low", "high"	Household or monitor survey.	Indicates those that spend more time in the forest, and rely on natural resources in the forest, may have more knowledge and be more impacted by the project, for example by being more or less affected by increased enforcement of forest laws.
	wealth 1 (assets)	wealth PCA dimension 1 (mostly land and zebu = assets)	continuous	-2.35 to 5.14	Factorial analysis on mixed data from household or monitor survey.	Indicates the level of material assets. This might affect their perspectives on the benefits of the project, for example, households that are already well off may rely less on the forest or materials benefits provided by the forest.
	wealth 2 (income)	wealth PCA dimension 2 (mostly job, smaller amount perceived wealth = income)	continuous	-2.76 to 2.73	Factorial analysis on mixed data from household or monitor survey.	Indicates the level of income. This might affect their perspectives on the benefits of the project, for example, households that are already well off may rely less on the forest or materials benefits provided by the forest.
	household size	number of people in living in the household (definition of household = group of	continuous	1 to 17	Household or monitor survey.	Household size might affect the level of forest use and perceived benefits and losses of the project, as larger households may be more reliant on forest resources.

	Variable	Description	Type	Range	source	justification for including variables
		people that frequently eat together)				
	gender	gender of the respondent	binary	male, female	Household or monitor survey.	Men and women have different roles within the household which may be reflected in their knowledge, understanding and perception of the project. Men tend to ne the household head and the decision-maker and also responsible for getting timber to build houses and hunt. Women collect non-timber forest products, firewood, honey, tubers and medicinal products from the forest.
	age	age of respondent	continuous	18 to 90	Household or monitor survey.	Different generations may have different understanding and/or perception of the project of the project if there are generational differences in the importance, reliance of the forest and/or involvement in decision-making in relation to forest management.
	native	whether the respondent was native to the village	binary	0 = no, 1 = yes	Household or monitor survey.	Native people might have different experience and knowledge of the project (having seen the project start up in 2011) than those non-natives, who may not have been in the village for very long or be at the periphery of activities or decision-making within the village.
village level variable	population size	number of people in the village	continuous	416 to 1089	Collected during meeting with each village president.	Population size might affect the utilisation of the forest and demand for natural resources.
	success	score of successfulness of the project in the village	continuous	0 to 2	Expert judgement from Durrell staff and Research Assistants.	The operational performance and enthusiasm for the project within the community might affect the overall perception of the project.
	village associations	number of associations in the village	continuous	0 to 2	Collected from focus groups and informal meetings with the village president and/or committee.	Indicates the degree of organisation and management within the community, which may affect the operational performance of the project, the success of the project in that village and therefore knowledge and perceptions of the project.

Variable		Description	Type	Range	source	justification for including variables
	surrounding forest cover	proportion of forest cover in 5km buffer from the centre of each village	continuous	0 to 1	National Geomatics Center of China (2014) 30-meter Global Land Cover Dataset (GlobeLand30). www.globallandcover.com, DOI:10.11769/GlobeLand30.2010.db	Indicates availability of natural resources to the community and the level of reliance there might be on forest resources for livelihoods.
	days since last Durrell visit	number of days since Durrell's last visit to the village	continuous	0 to 148	Date of village visits provided by Durrell.	Villages that have had a recent visit (with the possibility of salary payments, new uniforms or other materials and/or equipment) from Durrell may the current perception of the project.

C.6. Variance inflation factors

To explore the variables, variance inflation factors (VIF) were calculated using one explanatory variable as a response variable and all others as an explanatory variable set within linear regression. VIF values > 10 indicates serious collinearity and requires correction, VIF values > 4 warrant further investigation, whilst VIF values of > 2 indicates that there is no evidence for collinearity and that all variables should stay in the model.

Binomial linear regression of the 'ease of life' response variable and all explanatory variables were used to calculate VIF values =

Project makes life easier ~ involvement + wealth 1 + wealth 2 + household size + age + forest use + gender + success score + native + number of associations + days since Durrell visit + population size

All VIF values were < 10 all variables were used, but population size and proportion of forest cover were > 4 (see column 'a' of Table C.4). Therefore, these variables were removed in a stepwise fashion and the VIF values recalculated (Table C.4.b and c). Without either population size or forest cover all VIF values were <2 (Table C.4.d).

Table C.5. Variance inflation factor values for explanatory variables

Variable	(a) VIF values - all	(b) VIF values without population size	(c) VIF values without forest cover	(d) VIF without population size or forest cover
population size	8.019	NA	4.372	NA
proportion forest cover	6.211	3.415	NA	NA
days since Durrell visit	3.099	2.539	2.757	1.098
success score	2.412	1.129	1.817	1.122
number of associations	2.265	2.209	1.858	1.090
involvement	1.689	1.668	1.682	1.570
forest use	1.463	1.436	1.424	1.339
gender	1.318	1.318	1.320	1.322
age	1.187	1.175	1.182	1.174
wealth 1	1.156	1.156	1.153	1.510
household size	1.141	1.140	1.139	1.131
native	1.092	1.087	1.090	1.081
wealth 2	1.076	1.055	1.061	1.059

C.7. Model Selection

In cases where no model stood out as being the best model, all models within 4 delta-AICc of the lowest AICc value were considered as candidate models. In adherence to the principal of parsimony, selection of the final model was based on the AICc value, the number of degrees of freedom and a model that was meaningful and logical.

C.7.1. Heard of the project

Table C.7.1. 30 top candidate models within <4 AICc values of the top performing binomial mixed effect model for whether a respondent had heard of the monitoring project, the logLink, AICc values, the delta AICc and the weight of each model. The grey row indicates the model that was selected.

intercept	age	number of associations	days since Durrell visit	forest cover	forest use	household size	involvement	native	village population	success score	gender	wealth 1	wealth 2	forest cover + population	degrees of freedom	logLik	AICc	Delta AICc	weight
-0.496	NA	NA	NA	0.387	+	NA	NA	+	0.245	0.368	+	0.452	NA	-0.164	11.000	-102.668	228.121	0.000	0.013
-0.902	NA	0.145	NA	0.340	+	NA	NA	+	0.241	0.391	+	0.507	NA	-0.157	12.000	-101.904	228.740	0.619	0.009
-0.993	0.018	NA	NA	0.370	+	NA	NA	+	0.225	0.351	+	0.445	NA	-0.161	12.000	-101.974	228.879	0.758	0.009
-1.536	NA	0.216	0.141	0.234	+	NA	NA	+	0.328	NA	+	0.470	NA	-0.094	12.000	-102.047	229.025	0.903	0.008
-1.551	0.021	0.169	NA	0.314	+	NA	NA	+	0.217	0.379	+	0.520	NA	-0.153	13.000	-100.990	229.070	0.949	0.008
-2.134	0.020	0.233	0.134	0.216	+	NA	NA	+	0.302	NA	+	0.478	NA	-0.093	13.000	-101.200	229.491	1.370	0.006
-0.554	NA	NA	NA	0.385	+	NA	NA	+	0.330	NA	+	0.394	NA	-0.129	10.000	-104.445	229.543	1.422	0.006
-0.932	NA	NA	NA	0.406	+	NA	NA	+	0.246	0.417	+	0.405	NA	-0.177	13.000	-101.305	229.700	1.579	0.006
-0.933	NA	NA	NA	0.334	NA	NA	NA	+	0.211	0.403	+	0.490	NA	-0.147	9.000	-105.597	229.727	1.606	0.006
-1.553	0.022	NA	NA	0.318	NA	NA	NA	+	0.193	0.375	+	0.479	NA	-0.144	10.000	-104.589	229.830	1.709	0.005
-1.126	0.020	NA	NA	0.366	+	NA	NA	+	0.305	NA	+	0.386	NA	-0.128	11.000	-103.560	229.906	1.785	0.005
-0.725	NA	NA	0.086	0.321	+	NA	NA	+	0.320	NA	+	0.397	NA	-0.111	11.000	-103.573	229.932	1.811	0.005
-0.566	NA	NA	NA	0.401	+	NA	NA	+	0.256	0.366	+	0.468	0.088	-0.168	12.000	-102.543	230.018	1.897	0.005
-0.375	NA	NA	NA	0.395	+	-0.028	NA	+	0.249	0.379	+	0.467	NA	-0.167	12.000	-102.599	230.129	2.008	0.005
-2.226	NA	0.237	0.169	0.226	+	NA	NA	+	0.340	NA	+	0.417	NA	-0.095	14.000	-100.445	230.151	2.030	0.005
-0.460	NA	NA	-0.013	0.397	+	NA	NA	+	0.240	0.396	+	0.456	NA	-0.169	12.000	-102.660	230.250	2.129	0.004
-0.485	NA	NA	NA	0.387	+	NA	+	+	0.245	0.364	+	0.455	NA	-0.163	12.000	-102.665	230.260	2.139	0.004
-1.359	NA	0.150	NA	0.355	+	NA	NA	+	0.241	0.443	+	0.459	NA	-0.169	14.000	-100.505	230.271	2.150	0.004
-1.356	0.019	NA	NA	0.385	+	NA	NA	+	0.220	0.403	+	0.393	NA	-0.174	14.000	-100.534	230.329	2.208	0.004
-1.914	0.022	0.175	NA	0.326	+	NA	NA	+	0.212	0.433	+	0.466	NA	-0.166	15.000	-99.508	230.461	2.340	0.004

intercept	age	number of associations	days since Durrell visit	forest cover	forest use	household size	involvement	native	village population	success score	gender	wealth 1	wealth 2	forest cover + population	degrees of freedom	logLik	AICc	Delta AICc	weight
-2.734	0.022	0.256	0.164	0.204	+	NA	NA	+	0.309	NA	+	0.420	NA	-0.094	15.000	-99.522	230.490	2.369	0.004
-0.854	0.021	NA	NA	0.382	+	-0.056	NA	+	0.230	0.373	+	0.474	NA	-0.167	13.000	-101.723	230.535	2.414	0.004
-1.213	NA	0.182	0.069	0.285	+	NA	NA	+	0.271	0.247	+	0.497	NA	-0.129	13.000	-101.737	230.564	2.443	0.004
-1.120	0.019	NA	NA	0.385	+	NA	NA	+	0.235	0.351	+	0.463	0.114	-0.166	13.000	-101.770	230.629	2.508	0.004
-0.971	NA	0.146	NA	0.353	+	NA	NA	+	0.251	0.389	+	0.522	0.092	-0.161	13.000	-101.774	230.637	2.516	0.004
-2.044	0.024	0.131	NA	0.284	NA	NA	NA	+	0.192	0.395	+	0.538	NA	-0.139	11.000	-103.931	230.648	2.527	0.004
-1.634	0.022	0.137	NA	0.332	+	NA	NA	+	0.310	NA	+	0.437	NA	-0.122	12.000	-102.867	230.665	2.543	0.004
-0.914	NA	0.113	NA	0.357	+	NA	NA	+	0.336	NA	+	0.430	NA	-0.125	11.000	-103.951	230.687	2.566	0.004
-1.198	0.018	NA	0.076	0.310	+	NA	NA	+	0.297	NA	+	0.388	NA	-0.112	12.000	-102.906	230.742	2.621	0.003

C.7.2. Does the project make life easier?

Table C.7.2. 30 closest top models within <4 AICc values of the top performing binomial mixed effect model for whether a respondent thinks the project makes life easier for them, the logLink, AICc values, the delta AICc and the weight of each model. The grey row indicates the model that was selected.

intercept	age	number of associations	Days since Durrell visit	forest cover	forest use	household size	involvement	native	village population size	success score	gender	wealth 1	wealth 2	forest cover + population size	df	logLik	AICc	delta	weight
2.06	NA	NA	NA	NA	+	NA	+	NA	NA	NA	NA	NA	NA	NA	6.00	-132.64	277.54	0.00	0.01
1.81	NA	NA	NA	0.06	+	NA	+	NA	NA	NA	NA	NA	NA	NA	7.00	-131.70	277.75	0.20	0.01
1.41	0.02	NA	NA	NA	+	NA	+	NA	NA	NA	NA	NA	NA	NA	7.00	-131.83	278.01	0.47	0.00
1.70	NA	0.10	NA	NA	+	NA	+	NA	NA	NA	NA	NA	NA	NA	7.00	-131.92	278.17	0.63	0.00
1.18	0.02	NA	NA	0.06	+	NA	+	NA	NA	NA	NA	NA	NA	NA	8.00	-130.92	278.29	0.74	0.00
2.34	NA	NA	NA	NA	+	NA	+	NA	-0.06	NA	NA	NA	NA	NA	7.00	-132.01	278.35	0.81	0.00
1.95	NA	NA	-0.07	0.09	+	NA	+	NA	NA	NA	NA	NA	NA	NA	8.00	-130.96	278.36	0.82	0.00
2.05	NA	NA	NA	NA	+	NA	+	NA	NA	NA	NA	NA	-0.15	NA	7.00	-132.09	278.51	0.97	0.00
1.69	0.02	NA	NA	NA	+	NA	+	NA	-0.06	NA	NA	NA	NA	NA	8.00	-131.13	278.69	1.15	0.00
1.06	0.02	0.10	NA	NA	+	NA	+	NA	NA	NA	NA	NA	NA	NA	8.00	-131.13	278.70	1.16	0.00
1.30	0.02	NA	-0.08	0.09	+	NA	+	NA	NA	NA	NA	NA	NA	NA	9.00	-130.12	278.78	1.24	0.00
2.45	NA	NA	NA	NA	+	NA	+	+	NA	NA	NA	NA	NA	NA	7.00	-132.26	278.86	1.32	0.00
1.81	NA	NA	NA	0.05	+	NA	+	NA	NA	NA	NA	NA	-0.14	NA	8.00	-131.23	278.90	1.36	0.00
1.40	0.02	NA	NA	NA	+	NA	+	NA	NA	NA	NA	NA	-0.15	NA	8.00	-131.29	279.01	1.47	0.00
0.92	0.02	NA	-0.10	0.10	NA	NA	+	NA	NA	NA	NA	NA	NA	NA	7.00	-132.36	279.05	1.51	0.00
2.26	NA	NA	NA	NA	+	NA	+	NA	NA	-0.09	NA	NA	NA	NA	7.00	-132.38	279.11	1.57	0.00

intercept	age	number of associations	Days since Durrell visit	forest cover	forest use	household size	involvement	native	village population size	success score	gender	wealth 1	wealth 2	forest cover + population size	df	logLik	AICc	delta	weight
1.81	NA	NA	NA	0.06	+	NA	+	NA	NA	NA	NA	0.11	NA	NA	8.00	-131.44	279.31	1.77	0.00
2.07	NA	NA	NA	NA	+	NA	+	NA	NA	NA	NA	0.08	NA	NA	7.00	-132.49	279.32	1.78	0.00
2.79	NA	NA	-0.06	NA	+	NA	+	NA	-0.09	NA	NA	NA	NA	NA	8.00	-131.45	279.33	1.79	0.00
2.14	NA	NA	NA	0.05	+	NA	+	+	NA	NA	NA	NA	NA	NA	8.00	-131.45	279.33	1.79	0.00
1.71	NA	0.09	NA	NA	+	NA	+	NA	NA	NA	NA	NA	-0.14	NA	8.00	-131.47	279.39	1.84	0.00
1.96	NA	NA	-0.08	0.09	+	NA	+	NA	NA	NA	NA	NA	-0.15	NA	9.00	-130.42	279.39	1.85	0.00
2.13	0.02	NA	-0.07	NA	+	NA	+	NA	-0.10	NA	NA	NA	NA	NA	9.00	-130.43	279.42	1.87	0.00
2.22	NA	NA	NA	NA	+	-0.03	+	NA	NA	NA	NA	NA	NA	NA	7.00	-132.55	279.43	1.89	0.00
1.61	0.02	NA	NA	NA	+	NA	+	NA	NA	-0.10	NA	NA	NA	NA	8.00	-131.50	279.43	1.89	0.00
1.99	NA	NA	NA	0.05	+	NA	+	NA	NA	-0.07	NA	NA	NA	NA	8.00	-131.52	279.47	1.93	0.00
1.19	0.02	NA	NA	0.05	+	NA	+	NA	NA	NA	NA	NA	-0.14	NA	9.00	-130.47	279.49	1.95	0.00
2.00	NA	NA	NA	NA	+	NA	+	NA	NA	NA	+	NA	NA	NA	7.00	-132.58	279.49	1.95	0.00
0.97	0.02	NA	NA	NA	NA	NA	+	NA	NA	NA	NA	NA	NA	NA	5.00	-134.66	279.50	1.96	0.00

C.7.3. Benefits

Table C.7.3. 30 top candidate models within <4 AICc values of the top performing binomial mixed effect model for whether a respondent thinks that someone benefits from the monitoring project, the logLink, AICc values, the delta AICc and the weight of each model. The grey row indicates the model that was selected.

intercept	age	number of associations	days since Durrell visit	forest cover	forest use	household size	involvement	native	village population size	success score	gender	wealth 1	wealth 2	forest cover + population size	df	logLik	AICc	delta	weight
3.173	0.030	NA	NA	NA	+	-0.137	+	NA	NA	NA	NA	NA	NA	NA	10.000	-121.745	264.161	0.000	0.009
3.052	0.028	NA	NA	NA	+	-0.138	+	NA	NA	-0.426	+	NA	NA	NA	11.000	-120.881	264.570	0.409	0.007
3.751	0.030	NA	NA	NA	+	-0.138	+	NA	-0.089	-0.370	NA	NA	NA	NA	11.000	-120.895	264.597	0.436	0.007
3.677	0.028	NA	NA	NA	+	-0.141	+	NA	-0.099	-0.363	+	NA	NA	NA	12.000	-119.845	264.647	0.486	0.007
4.608	0.033	NA	-0.177	0.163	+	-0.137	+	NA	-0.169	NA	NA	NA	NA	-0.084	13.000	-118.981	265.081	0.920	0.005
4.697	0.032	NA	-0.109	NA	+	-0.131	+	NA	-0.200	-0.267	NA	NA	NA	NA	12.000	-120.118	265.193	1.032	0.005
4.461	0.031	NA	-0.168	0.162	+	-0.140	+	NA	-0.170	NA	+	NA	NA	-0.084	14.000	-118.012	265.321	1.160	0.005
4.559	0.030	NA	-0.101	NA	+	-0.135	+	NA	-0.202	-0.268	+	NA	NA	NA	13.000	-119.187	265.493	1.333	0.004
3.236	0.029	NA	NA	0.045	+	-0.137	+	NA	NA	-0.439	NA	NA	NA	NA	11.000	-121.413	265.634	1.473	0.004
5.022	0.031	NA	-0.184	NA	+	-0.127	+	NA	-0.304	NA	NA	NA	NA	NA	11.000	-121.416	265.639	1.478	0.004
2.778	0.032	NA	NA	NA	+	-0.141	+	+	NA	-0.414	NA	NA	NA	NA	11.000	-121.437	265.681	1.520	0.004
3.117	0.027	NA	NA	0.052	+	-0.139	+	NA	NA	-0.441	+	NA	NA	NA	12.000	-120.442	265.841	1.680	0.004
3.323	0.033	NA	NA	NA	+	-0.143	+	+	-0.097	-0.349	NA	NA	NA	NA	12.000	-120.463	265.883	1.722	0.004
4.886	0.029	NA	-0.176	NA	+	-0.130	+	NA	-0.306	NA	+	NA	NA	NA	12.000	-120.474	265.906	1.745	0.004
3.245	0.031	NA	NA	NA	+	-0.146	+	+	-0.106	-0.344	+	NA	NA	NA	13.000	-119.399	265.918	1.757	0.004
2.656	0.030	NA	NA	NA	+	-0.142	+	+	NA	-0.414	+	NA	NA	NA	12.000	-120.565	266.088	1.927	0.003
2.363	0.028	NA	NA	NA	+	-0.133	+	NA	NA	-0.350	NA	NA	NA	NA	9.000	-123.781	266.109	1.949	0.003
3.196	0.030	-0.165	NA	NA	+	-0.142	+	NA	NA	-0.423	NA	0.052	NA	NA	11.000	-121.679	266.165	2.004	0.003
3.427	0.030	-0.168	NA	NA	+	-0.138	+	NA	NA	-0.423	NA	NA	NA	NA	11.000	-121.680	266.167	2.006	0.003
3.149	0.030	-0.166	0.013	NA	+	-0.138	+	NA	NA	-0.431	NA	NA	NA	NA	11.000	-121.711	266.229	2.069	0.003

intercept	age	number of associations	days since Durrell visit	forest cover	forest use	household size	involvement	native	village population size	success score	gender	wealth 1	wealth 2	forest cover + population size	df	logLik	AICc	delta	weight
4.483	0.034	NA	-0.181	NA	+	-0.133	+	+	-0.308	NA	NA	NA	NA	NA	12.000	-120.641	266.239	2.078	0.003
4.173	0.036	-0.347	-0.182	0.165	+	-0.141	+	+	-0.174	NA	NA	NA	NA	-0.080	14.000	-118.483	266.261	2.101	0.003
3.177	0.030	-0.169	NA	NA	+	-0.137	+	NA	NA	-0.425	NA	NA	-0.024	NA	11.000	-121.732	266.272	2.111	0.003
4.277	0.035	-0.321	-0.114	NA	+	-0.136	+	+	-0.213	-0.241	NA	NA	NA	NA	13.000	-119.602	266.324	2.163	0.003
3.756	NA	-0.152	NA	NA	+	-0.115	+	NA	NA	-0.391	+	NA	NA	NA	10.000	-122.865	266.400	2.239	0.003
2.229	0.027	NA	NA	NA	+	-0.134	+	NA	NA	-0.352	+	NA	NA	NA	10.000	-122.884	266.439	2.278	0.003
4.034	0.034	-0.343	-0.173	0.163	+	-0.145	+	+	-0.177	NA	+	NA	NA	-0.080	15.000	-117.496	266.477	2.317	0.003
4.367	NA	-0.220	NA	NA	+	-0.114	+	NA	-0.097	-0.331	+	NA	NA	NA	11.000	-121.840	266.488	2.327	0.003
4.363	0.033	-0.359	-0.175	NA	+	-0.137	+	+	-0.311	NA	+	NA	NA	NA	13.000	-119.685	266.491	2.330	0.003
3.976	0.031	-0.209	NA	-0.045	+	-0.138	+	NA	-0.135	-0.326	NA	NA	NA	NA	12.000	-120.788	266.533	2.372	0.003

C.7.4. Losing out

Table C.7.4. 30 closest top models within <4 AICc values of the top performing binomial mixed effect model for whether a respondent thinks that someone loses out because of the monitoring project, the logLink, AICc values, the delta AICc and the weight of each model. The grey row indicates the model that was selected.

intercept	age	number of associations	days since Durrell visit	forest cover	forest use	household size	involvement	native	village population size	success score	gender	wealth 1	wealth 2	forest cover + population size	df	logLik	AICc	delta	weight
0.654	NA	NA	NA	NA	+	-0.095	+	NA	0.083	-0.277	NA	NA	NA	NA	10.000	-207.756	436.182	0.000	0.009
0.516	NA	NA	NA	NA	NA	-0.084	+	NA	0.072	-0.237	NA	NA	NA	NA	8.000	-210.046	436.529	0.347	0.008
0.848	NA	NA	NA	NA	NA	-0.080	+	NA	NA	-0.167	NA	NA	NA	NA	7.000	-211.210	436.758	0.576	0.007
1.080	NA	NA	-0.047	NA	NA	-0.078	+	NA	NA	-0.175	NA	NA	NA	NA	8.000	-210.318	437.071	0.889	0.006
1.032	NA	NA	NA	NA	+	-0.091	+	NA	NA	-0.193	NA	NA	NA	NA	9.000	-209.264	437.076	0.894	0.006
0.003	NA	NA	NA	NA	+	-0.091	+	NA	0.119	-0.292	NA	NA	NA	NA	9.000	-209.366	437.280	1.098	0.005
-0.005	NA	-0.154	NA	0.074	NA	-0.081	+	NA	0.157	-0.315	NA	NA	NA	NA	9.000	-209.510	437.568	1.386	0.004
0.238	NA	-0.140	NA	0.057	+	-0.092	+	NA	0.149	-0.337	NA	NA	NA	NA	11.000	-207.436	437.680	1.498	0.004
1.209	NA	-0.181	-0.044	NA	+	-0.087	+	NA	NA	-0.198	NA	NA	NA	NA	10.000	-208.522	437.714	1.532	0.004
0.665	NA	NA	NA	NA	+	-0.098	+	NA	0.086	-0.279	NA	NA	-0.083	NA	11.000	-207.487	437.781	1.599	0.004
0.688	NA	-0.126	NA	NA	+	-0.100	+	NA	0.082	-0.275	NA	0.069	NA	NA	11.000	-207.550	437.907	1.725	0.004
0.586	NA	-0.127	NA	NA	+	-0.095	+	NA	0.082	-0.275	+	NA	NA	NA	11.000	-207.586	437.979	1.797	0.004
1.113	NA	-0.139	NA	-0.039	+	-0.095	+	NA	NA	-0.199	NA	NA	NA	NA	10.000	-208.656	437.983	1.801	0.004
0.534	NA	NA	NA	NA	NA	-0.087	+	NA	0.074	-0.239	NA	NA	-0.089	NA	9.000	-209.729	438.005	1.823	0.004
0.482	0.006	-0.127	NA	NA	+	-0.099	+	NA	0.084	-0.283	NA	NA	NA	NA	11.000	-207.603	438.014	1.831	0.004
0.550	NA	-0.134	NA	NA	NA	-0.089	+	NA	0.070	-0.235	NA	0.080	NA	NA	9.000	-209.764	438.075	1.893	0.003
0.067	NA	-0.129	NA	NA	NA	NA	+	NA	0.068	-0.243	NA	NA	NA	NA	7.000	-211.878	438.094	1.911	0.003
0.397	NA	-0.168	NA	NA	NA	NA	+	NA	NA	-0.177	NA	NA	NA	NA	6.000	-212.925	438.103	1.921	0.003
0.658	NA	-0.175	-0.049	NA	NA	NA	+	NA	NA	-0.186	NA	NA	NA	NA	7.000	-211.920	438.179	1.997	0.003
0.877	NA	-0.175	NA	NA	NA	-0.086	+	NA	NA	-0.166	NA	0.087	NA	NA	8.000	-210.871	438.179	1.997	0.003

intercept	age	number of associations	days since Durrell visit	forest cover	forest use	household size	involvement	native	village population size	success score	gender	wealth 1	wealth 2	forest cover + population size	df	logLik	AICc	delta	weight
0.898	NA	-0.151	NA	-0.028	NA	-0.083	+	NA	NA	-0.169	NA	NA	NA	NA	8.000	-210.883	438.203	2.021	0.003
-0.191	NA	NA	NA	NA	NA	-0.080	+	NA	0.110	-0.249	NA	NA	NA	NA	7.000	-211.936	438.211	2.029	0.003
0.447	NA	-0.135	NA	NA	NA	-0.083	+	NA	0.070	-0.236	+	NA	NA	NA	9.000	-209.854	438.255	2.073	0.003
0.626	NA	-0.124	0.003	NA	+	-0.095	+	NA	0.086	-0.280	NA	NA	NA	NA	11.000	-207.754	438.315	2.133	0.003
0.643	NA	-0.127	NA	NA	+	-0.095	+	+	0.083	-0.277	NA	NA	NA	NA	11.000	-207.755	438.317	2.135	0.003
0.430	NA	-0.155	NA	NA	NA	-0.085	+	NA	NA	NA	NA	NA	NA	NA	6.000	-213.045	438.344	2.162	0.003
0.762	NA	-0.176	NA	NA	NA	-0.080	+	NA	NA	-0.167	+	NA	NA	NA	8.000	-210.965	438.366	2.184	0.003
0.873	NA	-0.182	NA	NA	NA	-0.083	+	NA	NA	-0.167	NA	NA	-0.075	NA	8.000	-210.977	438.390	2.208	0.003
0.387	0.005	-0.136	NA	NA	NA	-0.087	+	NA	0.072	-0.242	NA	NA	NA	NA	9.000	-209.944	438.434	2.252	0.003
1.130	NA	-0.190	-0.050	NA	NA	-0.081	+	NA	NA	-0.176	NA	NA	-0.094	NA	9.000	-209.964	438.476	2.294	0.003

END