The equity and efficiency of incentives to manage ecosystem services for natural resource conservation and rural development

Case studies from Lombok, Indonesia and Alta Floresta, Mato Grosso, Brazil

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Abstract

Incentives to manage ecosystem services have been heralded as important mechanisms to increase efficiency in biodiversity conservation and to facilitate greater equity in the distribution of natural resources. These interventions aim to control the use of natural resources by altering resource users' land-use decisions and environmental behaviours. There is relatively little evidence, however, about the perceived benefits and societal values of incentives, and the institutional effectiveness of incentives to alter land-use behaviours to increase compliance. It is also unclear how incentive-based management institutions align with the local biophysical, social, economic, and political dimensions of the social-ecological systems (SES) in which they are implemented. The thesis examines the ways in which incentives are used to manage ecosystem services and their institutional effectiveness to alter landowner environmental behaviours in the complex reality of the world

It is important to understand the drivers of land-use decisions and environmental behaviours to implement institutions that can address natural resource issues within specific contexts. This thesis contributes to the discourse surrounding the use of incentive-based management that aim to provide motivation for compliant land-use decisions. The research highlights the need to understand the contextual nature of societal values and institutional processes that drive behaviours and determine the 'fit' of natural resource governance mechanisms. The recognition of these values and processes enables sufficient 'incentive effects' to be provided that can motivate pro-environmental behaviours. The thesis also illustrates the reality of how incentive-based institutions can function on the ground makes it difficult to clearly attribute outcomes to theoretical assumptions on which incentive-based institutions are designed.

Case studies from Lombok, Indonesia and Alta Floresta, Mato Grosso, Brazil were used to illustrate the significance of local participation in decision-making, incentive design, and landowner perception of the benefits of behaviours on compliance outcomes, equity in benefit distribution, and efficient conservation management. A mixed methods approach was used to compare different incentives, which included legal sanctions, religious beliefs, social norms, and economic rewards. The thesis examines institutional function, 'fit', and landowner perceptions that can influence compliant pro-environmental behaviours. Spatial analysis, semi-structured questionnaires, key informant interviews, and focus groups were conducted to determine the impact of religious, economic, and customary law incentives on land-use decisions in communities on Lombok. Spatial analysis was used to examine the impact of sanctions in the legal reforms of the Forest Code, Brazil's forest conservation legislation, on farmer land-use decisions in Alta Floresta.

Abstract

This thesis finds that 'incentive effects' are strongly determined by landowner perceptions of the social and economic cost-effectiveness of compliant behaviour, and the 'fit' of incentive-based management to SES's contexts and dynamics. Institutional 'fit' was greater when procedural justice was perceived to be higher. That was driven by stakeholder participation in decision-making, closer links to existing institutions and social norms, and higher community autonomy over incentives. Positive incentives, like religious values and customary laws, were used to generate collective action for pro-environmental behaviours at local levels on Lombok, Indonesia. This generated greater community cooperation when collective action was built on existing social norms, socio-cultural institutions, and ecological dimensions. Incentives for collective action had less impact when they were imposed by external organisations, did not align to the local SES dimensions, and were only focused on increasing efficiency to control natural resource use.

When negative incentives, such as legal sanctions and economic fines, were used to increase compliance with pro-environmental behaviours to protect riparian forests in Alta Floresta, they were found to, in fact, reduce overall compliance. The cost of sanctions and the option to offset illegal deforestation were perceived to be lower than the benefit of non-compliant behaviours like continued deforestation. The 'incentive effects' of these sanctions had limited impact to alter environmental behaviours of landowners.

The findings of this study have implications for policies that use incentives as mechanisms to alter land-use behaviour. These findings also have clear relevance for PES and incentive-based design. They move PES beyond its theoretical application to meet the realities of the 'messy' world in which they are applied. The application of incentives is highly context specific to the SES in which incentives aim to function. This approach includes a need for the understanding of local perceptions of equity and cost-efficiency, and the impact of SES subsystem dynamics. A more integrated SES approach to understand the required incentives of land-use behaviours can enable a greater 'fit' of incentive-based institutions to local contexts, which may address environmental issues that can lead to a more sustainable use and equitable distribution of natural resources.

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"*It always seems impossible until it is done*." Nelson Mandela.

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Abbreviations

APP	Area of Permanent Preservation (Brazil)
AUSAID	Australian Agency for International Development
BAPPEDA	*Badan Perencana Pembangunan Daerah* - Regional Body for Planning and Development (Lombok)
BUMDES	*Badan Usaha Milik Desa* - Village Owned Enterprises (Lombok)
C	Control village (Chapter 5, Table 5.2)
CRA	*Cota de Reserva Ambiental* - Environmental Reserve Quota (Brazil)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DETER	*Detecção de Desmatamento em Tempo Real* - Real-time System for Detection of Deforestation (Brazil)
FC	*Código Florestal* - Forest Code (Brazil)
FFI	Flora Fauna International
GLMM	General Linear Mixed Model
IB	Incentive-based institution village (Chapter 5, Table 5.2)
IDR – Rp	Indonesian Rupiah
IMP	*Institut Multi Pihak* –Multi-stakeholder group (Lombok)
INGO	International Non-Government Organisation
INPE	*Instituto Nacional de Pesquisas Espaciais* – National Institute for Space Research (Brazil)
HKm	*Hutan Kommunitasi* - Community forest (Lombok)
LR	Legal Reserve (Brazil)
MA	Millennium Ecosystem Assessment
NGO	Non-Government Organisation
NTFP	Non-Timber Forest Products
PES	Payments for Ecosystem Services
PRA	Participatory Rural Appraisal
PRODES	*Programa Despoluição de Bacias Hidrográficas* - Basin Restoration Program (Brazil)
REDD+	Reducing Emissions from Deforestation and Forest Degradation in developing countries and the role of conservation, sustainable management of forests and enhancement of carbon stocks in developing countries
RPA	Riparian Preservation Areas (Brazil)
RRA	Rapid Rural Appraisal
SES	Social Ecological Systems
USD	United States Dollar

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1 Equity and efficiency of incentives to manage ecosystem services

The objective of this thesis is to examine the ways in which incentives to manage ecosystem services can influence the efficiency and equity of natural resource use for both conservation and rural development interventions. It also addresses how the interplay between equity and efficiency affect institutional functions and the motivation of pro-environmental behaviours. It focuses on the provision of water ecosystem services through the conservation of forests. The thesis used two case studies in Lombok, Indonesia and Alta Floresta, Mato Grosso, Brazil to analyse institutions that manage ecosystem services and how this governance affected the conservation efficiency and equity of resource access and distribution.

The thesis centres on the use of a social-ecological systems approach to address conservation and development issues. It is presented in the structure of research papers. Each paper highlights specific characteristics and contexts of the case studies to explore local perspectives on a number of different institutional initiatives. Throughout the research, there is a focus on managing ecosystem services for greater equity and efficiency, and the importance to consider context in governance implementation to match policy approaches with the complex reality of the world. This approach links the overall research study to the broader discourse related to other instances of ecosystem services management.

1.1. Background and context of the study

The United Nations' Millennium Ecosystem Assessment (2005) has driven an 'explosion of interest' in ecosystem services, and how they can be effectively and equitably managed (Perrings 2006). Ecosystem services are used as a conceptual framework to understand the value of the environment and to guide its management (Redford and Adams 2009). The application of this approach aims to reconcile disparities between ecosystem services provision and the needs of individuals' livelihoods. It attempts to promote greater equity in natural capital distribution. It also tries to recognise the trade-offs between natural resources and resource-users (McShane et al. 2010, Wunder 2005a).

Forest ecosystems provide benefits and services at multiple scales. These include social, ecological, and economic benefits such as timber and non-timber forest

products (NTFPs); and, services such as soil, hydrological, and nutrient cycling. These support local livelihoods while playing a role in global biodiversity conservation. Pressure on ecosystem services and the communities that depend on them is increasing with population growth, invasive species, land conversion, and climatic change (MA 2005). The loss of ecosystem services and the resources they provide has global implications. In particular, for the rural poor, who are disproportionately dependent on ecosystem services compared to their urban counterparts, the decline in the provision and availability of these services represents a direct threat to the welfare and livelihoods of rural communities (Daily et al. 2009, Ferraro 2001, Grieg-Gran, Porras, and Wunder 2005, Tallis et al. 2008). Efforts to reduce community poverty levels, and local and global demand for ecological goods can lead to overexploitation of natural resources. Deforestation, for example, is responsible for an estimated 20% of global carbon emissions, and leads to further impacts on the provision of water for both agriculture and human consumption (Trivedi et al. 2009). Consequently, the protection of ecosystem services in developing countries has been identified as a *"*global social objective*"* (Ferraro 2002: 990).

Historical approaches to protect ecosystem services

Historical attempts to meet this objective to protect ecosystems have been made through multiple paradigms and policies aimed at conserving resources for sustainable use. These approaches have been driven by the political arena in which ecosystems are managed, in particular the links and evolution of environmental and development policy (Roe 2008). They have sought to resolve conflict and trade-offs between the needs of local communities and those focused on the broader conversation agenda (Adams and Hulme 2001, Chhatre and Agrawal 2009, McShane et al. 2010). Approaches to conserve and protect ecosystem services aim to provide incentives to establish or change resource use behaviours, which have a harmful effect on biodiversity. These approaches have been conducted through command and control instruments such as protected areas (PAs) and land-use legislation (Keane et al 2008); the facilitation of greater sustainable use through Integrated Conservation and Development Programmes (ICDPs) and community-based natural resource management (CBNRM) (Brandon and Wells 1992); market-based instruments such as tradable permits, subsidies, and taxes (Jack, Kousky, and Sims 2008); and, in the more recent past, direct payments to individuals or communities for the provision of ecosystem services (Ferraro and Kiss 2002, Pagiola et al 2005, Wunder 2005b).

Early conservation programmes often differed from development policy. They viewed human activity as key driver of biodiversity loss and, as such, an obstacle to conservation practice. Central to many of these programmes was Hardin's (1968) 'Tragedy of the Commons' theory. Hardin argued that economic rationale and self-interest would drive individual behaviour for common pool resources. Resources, therefore, that were common property would eventually be overexploited and/or

degraded. Programmes sought to restrict access to resources and establish rules surrounding resource use.

These command-and-control measures to restrict resource use and the creation of PAs, especially in developing countries, were, however, controversial (Adams et al. 2003, Adams and Hutton 2007, Roe 2008). Such top-down governance was costly to implement, the outcomes difficult to predict, and, more often than not, created "paper parks" that lacked social and political legitimacy (Balmford et al. 2002, Wilkie, Carpenter, and Zhang 2001, Clements 2012).

To establish long-term social and political support, programmes must have greater convergence with development policy agendas which seek to increase community participation, decentralise power, and encourage sustainable development (Roe 2008). Programmes, such as CBNRM and ICDPs, introduced in the 1980s, took as assumption that greater community involvement and the development of alternative livelihoods would lead to sustainable incomes and alter how resources were used (Carlsson and Berkes 2005). The shift in priority, though, was viewed by some as inefficient, as it did not lead to significant changes beyond the policy framework (Sandbrook 2003).

To improve environmental effectiveness, and the cost-efficiency and social equity of conservation initiatives, a more direct approach to conservation has been advocated (Ferraro and Kiss 2002, Balmford et al. 2002, Kemkes, Farley, and Koliba 2010). This approach seeks to use incentives that combine both biodiversity protection and sustainable development through mechanisms such as Payments for Ecosystem Services (PES). The success of such mechanisms are, however, difficult to determine (Adams et al. 2003, McShane et al. 2010, Travers 2011). Their outcomes are significantly dependent on social, political, economic and institutional contexts that remain highly uncertain (Adams et al. 2003, McShane et al. 2010, Travers 2011).

Ecological systems are both dynamic and complex. They are interdependent on social systems that create adaptive, multi-scale social-ecological systems (SES). These SES interactions generate complex social, ecological, and economic issues and feedbacks that influence land-use decisions by individual landowners. SES dynamics influence the effectiveness of regulation. For example, the drivers of environmental degradation, poverty, and underdevelopment are often based on established institutions and SES interactions such as property rights, access to natural resources, and mechanisms of governance. This creates a challenge to design policies and institutions that can effect incentive structures needed to promote behaviours to sustainably manage land-use change (Clements et al. 2010, Ostrom 2005).

Motivation alone does not determine human behavioural responses (Steg and Viek 2009). Biophysical, economic, social, and institutional contexts, as well as the interactions between them, also directly and indirectly influence human behavioural

responses. Effective governance of these responses must therefore create incentives that facilitate behavioural responses to meet social objectives (Hanna 2001). For this reason, incentive-based institutions have been advocated as an approach to influence the land-use decisions and behaviours that affect the provision of ecosystem services, while also acting as a mechanism for poverty alleviation (Robbards et al. 2011, Corbera, Kosoy, and Martinez-Tuna 2007, Promberger and Marteau 2013). Incentive-based institutions work on the principle that the strategic use of incentives will influence sustainable resource behaviours (Hanna 2001).

As a basic principle, incentives-based institutions aim to address a more sustainable use of natural resources through greater economic and environmental efficiency. This is considered to also enable a more equitable distribution of benefits (Jack, Kousky, and Sims 2008). The includes, for example, the increased participation of stakeholders in decision-making (procedural justice) and a more just allocation of benefits from ecosystem management (distributive justice) (Corbera, Brown, and Adger 2007, Pascual et al. 2010). Based on an ecosystem services approach, the use of this governance mechanism has been viewed by many to generate a 'win-win' outcome. For example, incentives such as Reducing Emissions from Deforestation and forest Degradation (REDD) use financial payments to compensate the opportunity costs of deforestation. Reducing deforestation also sequesters carbon, and therefore decreases the amount of carbon emissions from deforestation and forest degradation. REDD simultaneously tackles climate change, reduces environmental degradation, and addresses local poverty levels (Kosoy et al 2007). The promotion of ecosystem commodification, which transforms natural resource goods and services into marketable values, is driving the use of incentives in natural resource governance. This is occurring at national, regional, and local levels, as economic, social, or cultural incentives provide an impetus to alter institutions and practices (Corbera 2005). These incentives, however, can either support or hinder environmental conservation. The outcomes of using incentives to manage land-use change decisions also remain inconclusive.

The potential of incentive-based interventions to be applied as a tool to integrate conservation and sustainable goals is, as yet, undetermined (Pirard 2012a). In addition, the efficiency and equity effects of policies that attempt to alter behavioural dynamics to protect ecosystems remains varied and unpredictable (Pascual et al. 2010). As such, there is limited evidence to substantiate how the development of extrinsic incentives can effect collection action to manage communal resources (Kerr, Vardhan, and Jindal 2013). The outcomes of introducing incentives is likely to be complex (Kreps 1997). Messy or not, however, incentives play an important role in conservation and therefore the understanding of their function in conservation outcomes and social interactions is important.

This thesis provides opportunities to explore such messy realities within a real-world setting. It seeks to examine how these policies emerge and function within their SES

context to understand how institutional incentives influence resource-use decisions that provide water and forest ecosystem services through the alteration of environmental behaviours.

This thesis considers case studies from Lombok, Indonesia and Alta Floresta, Mato Grosso, Brazil to investigate how the use of incentives in forest and water resource governance affects the equity and efficiency of ecosystem services provision and their livelihood benefits. In Lombok, voluntary incentives included positive financial, religious, and traditional cultural motivations. In Alta Floresta, negative incentives were applied through the regulation of land-use behaviours and the punishment for non-compliance.

While these two case studies nevertheless stand alone, both are relevant to the study of incentives. Together, they provide a context in which to examine the impact of different incentive mechanisms to alter land-use behaviours, and their application as an intervention to control natural resource use. The research focuses on social, biophysical, cultural, and economic factors that influence compliance behaviours. These factors have been examined using data on land cover and land-use, combined with socio-economic surveys and interviews collected over nine months in Lombok, Indonesia; and, using spatial analysis of land use and deforestation under policy reforms in Alta Floresta.

In the subsequent section, an introduction to the current literature surrounding ecosystem services and policy implementation is provided. A conceptual framing of social-ecological systems and how this will be applied in the research papers is also outlined. This is then followed by the specific objectives, research questions, and outline of the thesis.

1.2. The concept of ecosystem services

Ecosystem services are the functions and services provided from ecosystems that directly and indirectly benefit human wellbeing (Kemkes, Farley, and Koliba 2010, Nelson et al. 2009, MA 2005). Natural processes and services provide direct and indirect benefits that are essential to sustain life. They also support important parts of the economy (MA 2005, Nelson et al. 2009). The short-term economic benefits of many of the human activities that degrade ecosystems are often eclipsed by the long-term economic, ecological, and social values that the services provide (Wunder, Engel, and Pagiola 2008).

There are four main categories of ecosystem services: provisioning, regulating, supporting, and cultural. Provisioning services such as food, water, fuel, and fibre often have clear values that can be quantified (Kumar and Muradian 2008, Tallis and

Kareiva 2005). Regulating services such as flood control, soil erosion prevention; supporting services such as nutrient cycling and soil formation; and, cultural services such as recreation and spiritual activities are linked to greater uncertainty in regards to biophysical production functions. They are therefore more difficult to value economically (Kumar and Kumar 2008).

The ecosystem services concept, as originally described by the MA (2005), is built on the rationale that the true value of ecosystem services in current environmental management is often excluded or underestimated. The usefulness and application of the concept to understand human-environmental relationships has, however, generated widespread debate and criticism (Lele et al. 2013). The simplification of ecosystem services into goods and processes to be valued (economically or otherwise) has been criticised as potentially damaging when used for environmental policy. Some studies have suggested that valuation is in itself anthropogenic (Farber, Costanza, and Wilson 2002). Others have argued that a clearer definition of ecosystem services is needed to prevent double counting of goods and services, in particular with respect to supporting services such as nutrient cycling (Fisher, Turner, and Morling 2009); that the concept may not address the true complexities and interactions within ecosystems (Mace, Norris, and Fitter 2012); and, that negative relationships within ecosystems, which deliver 'bads' and dis-services such as pests, diseases, and floods, are not always recognised or accounted for (Zhang et al. 2007).

This thesis will investigate the governance of provisioning and regulating ecosystem services, and focuses on forest conservation and its implications for water resources. Water ecosystem services are important for rural development and provide multiple benefits for livelihoods, other ecosystem services, and wellbeing (MA 2005). Land-use change to meet demands for growing agriculture, expanding settlements, biofuel, timber, and NTFPs are significantly affecting water resources and the quality of watershed systems. Competition for water supplies between agriculture, industry, irrigation, hydroelectricity, consumption, and the ecosystem itself may have long-term environmental effects (Brauman et al. 2007). This includes, for example, hydrological functions related to water quantity (e.g. precipitation, seasonal flows, floods, annual water yields) and water quality (e.g. run-off and pollutants, sedimentation, erosion), which can be affected when soil properties and vegetation cover are altered (Aylward, Hartwell, and Zapata 2010). Greater afforestation also does not equate to greater water provision (Calder 2005). An understanding of the function of forests relative to the sustainable management of, and interactions between, land and water resources is therefore required to manage watersheds, and the ecosystem services they provide (Calder 2007).

1.3. Framing human behaviour and the environment

For the purpose of this study, however, it was important to understand the social dynamics of the use and value of ecosystem services. Human activities dominate ecosystem services are (Peterson 2000). Interactions between ecological and social systems are complex and multi-layered. Political ecology and social-ecological systems have been developed as approaches with which to understand social and environmental dynamics and relationships by conceptualising human behaviour over natural resources. They are trans-disciplinary in nature and are developed from different values, epistemological, and *cultural settings,* through which environments are perceived and used (Blaikie 2008, 1995, Walker 2006).

The world is, however, chaotic, unpredictable, and not clearly understood. Individual and group behaviours in reality do not always match theoretical or institutional frameworks. Outcomes are almost impossible to forecast. Different perceptions, cultural backgrounds, social norms, and ecological dynamics will determine, control, or influence human behaviour and conflict over natural resources (Peterson 2000). Nonetheless, theoretical approaches such as political ecology and SES are useful to guide our understanding of human behaviours in relation to natural resources. They help to develop more applicable policy measures with which to govern the environment.

1.3.1. Political ecology

Political ecology aims to examine human-ecological systems within the context of local, regional, and global political economies (Blaikie 1985, 1995, 2008, Bryant 1998). By using a more political approach, this theory provides a 'chain of explanation' (Blaikie 1985) that enables an understanding of the dynamics of natural resource use. Their is a focus on how decision-making is influenced by institutional arrangements, multiple interests, and actors (Agrawal and Gibson 1999). Central to political ecology is the examination of power relations surrounding the environment. That includes examining the role of political and economic systems on individual and community access to resources, material conflict, and governance institutions that influence behaviours.

Political ecology is a powerful framework with which to analyse social-ecological relationships. But the focus on human systems in much of the current political ecology theory and frameworks, however, can be viewed as one-dimensional: It often overlooks the dynamics and the feedback systems between and within ecological systems (Peterson 2000, Rocheleau et al. 1996). It is these dynamics that alter the types of social conflict over natural resources. Some studies have gone so far as to suggest that political ecology would be more appropriately viewed as 'environmental politics' (Peterson 2000, Walker 2005).

1.3.2. Social-ecological systems

1: Introduction

The relationship between ecological and social systems is highly integrated and exists between multiple sub-systems, which operate across various landscapes and scales (Anderies, Janssen, and Ostrom 2004, Brunckhorst 2002, Holling 2001). This thesis advocates the use of concepts such as adaptive feedback cycles and cross-scale interaction to explain the connections between humans and the winder ecosystem within these sub-systems. This approach, in the context of this thesis, is best illustrated through an SES framework. An SES framework allows for the examination of how ecosystem processes interact and co-evolve with social systems through human responses, while also taking the approach beyond political power relationships (Ostrom 2007, Carpenter et al. 2009). An understanding of the complexities of SES – including, for example, interactions such as local use and cultural value of resources – is key to maximizing the efficacy of natural resource management and determining SES' sustainability (Ostrom 2009). That includes, for example, how land management affects the provision of water ecosystem services.

Change in a SES is inevitable. Shocks, uncertainty, and change at global and local scales are inherent to SESs. Walker et al. (2006) and Folke et al. (2005) suggest that attributes of resilience, adaptability, and transformability are key to defining SES. The capacity for a SES to adapt to change (while maintaining defined functions and structures) is dependent on the links between natural resources in ecological systems and resource users within social systems (Berkes, Colding, and Folke 2000, Olsson, Folke, and Berkes 2004, Berkes and Folke 1998, Holling 1973, Ostrom 2009, Walker et al. 2006, Folke 2006). SES interactions, such as fires or increased migration to an area, can induce rapid change, which has both social and ecological impacts. Slower change, which is driven by variables such as wealth growth, soil degradation, or alterations in resource-use rights, can also impact a SES' ability to adapt and transform. Sufficient resources and appropriate institutional structures are necessary to allow for adaptive capacity within societies. In contrast, an inadequate capacity to adapt to sudden shocks can worsen a community's vulnerability to extreme changes within a SES. Those changes include uniformed institutional policies, global market fluctuations, or long-term climatic shocks (Walker et al. 2006, Janssen, Anderies, and Ostrom 2007)

The relationships between the natural capital provided by ecosystem services and resource users link the livelihoods of those living within a SES to the resources on which they rely (Anderies, Janssen, and Ostrom 2004). The nature of these social and ecological conditions and interactions enables particular institutional arrangements for effective governance. The complex connections between resource users, governance systems, and natural resources require institutions that provide incentives for sustainable resource-use behaviours (Travers 2009). Drivers of environmental degradation and agents of poverty, such as deforestation and land conversion for agricultural expansion in the case of Alta Floresta, influence these institutions. They also feedback into the ecosystems that they aim to govern (Folke 2006). Improvements in the efficiency of land-use practices, particularly in agriculture, can

contribute to both poverty alleviation and provide incentives for the conservation of forest and water resources.

Studies (Berkes and Folke 1998, Janssen et al. 2010) suggest a SES approach can help with the governance of common pool natural resources such as water and forest resources. Levin (2006) furthers this theory. He states that a SES approach may be crucial to create links between environmental protection and economic growth, and to account for SES interactions. Natural resource management is driven by interactions between ecosystems and socio-economic and political dimensions. These drive stakeholders' decision-making, and the dynamics between and within these systems (Bunnefeld, Hoshino, and Milner-Gulland 2011). Subtleties in market forces, social or economic incentives, and weak institutions, for example, may determine compliant human behavioural responses.

For both Alta Floresta and Lombok, it is apparent that compliant behavioural responses are influenced by internal and external subtleties. Effective and equitable governance should therefore be able to address the social, economic, cultural, political, and ecological dynamics that affect resource-use decisions (Knight, Cowling, and Campbell 2006, Fulton et al. 2011). Governance of natural resources exists in both case studies. However, each focuses on different drivers and influences of landowner behaviours. In Lombok, communities are faced with internal subtleties such as social incentives, weak institutions, and cultural norms. Governance within this case study builds on these internal influences, social values, and community cultural norms to drive cooperative compliant behaviours. In Alta Floresta, external subtleties such as market forces, economic incentives, and weak institutions influence compliant behaviours. Reform of forest governance has aimed to address these factors, and therefore increase the incentive for higher compliance. However, the outcomes of this incentive change have been difficult to predict.

A SES approach based on Ostrom (2009) was used to provide a conceptual framework in which to understand the multidisciplinary and multifaceted roles and implications of institutional governance on resource users and ecosystems in the case studies (Figure 1.1). Causal relationships can be difficult to determine within a SES due to the complexities and dynamics of SES interactions. The use of a SES conceptual framework is, however, useful to identify concepts, which contribute to institutional function, and which provide incentives for pro-environmental behaviours (De Caro and Stokes 2013, 2008).

Key concepts identified in this approach emphasise the specific contexts in which resource users live, the types of resources available, and the institutions that constrain access to resources (Ostrom 2009). The conceptual framework used in this study simplified interactions between natural resources, resource system, governance system, and resource user subsystems that were managed in the social-ecological systems of the case studies Alta Floresta and Lombok. The framework conceptualised

the following as: Natural resource units as timber, water, NTFPs, and agricultural products; Resource systems as forest, agricultural, and riparian habitat; Governance systems as incentive-based mechanisms and public policies; and, Resource users as farmers and downstream users. The interactions between these subsystems lead to specific outcomes. All outcomes feedback into related ecosystem services and the core subsystems within the context of social, economic, and political settings.

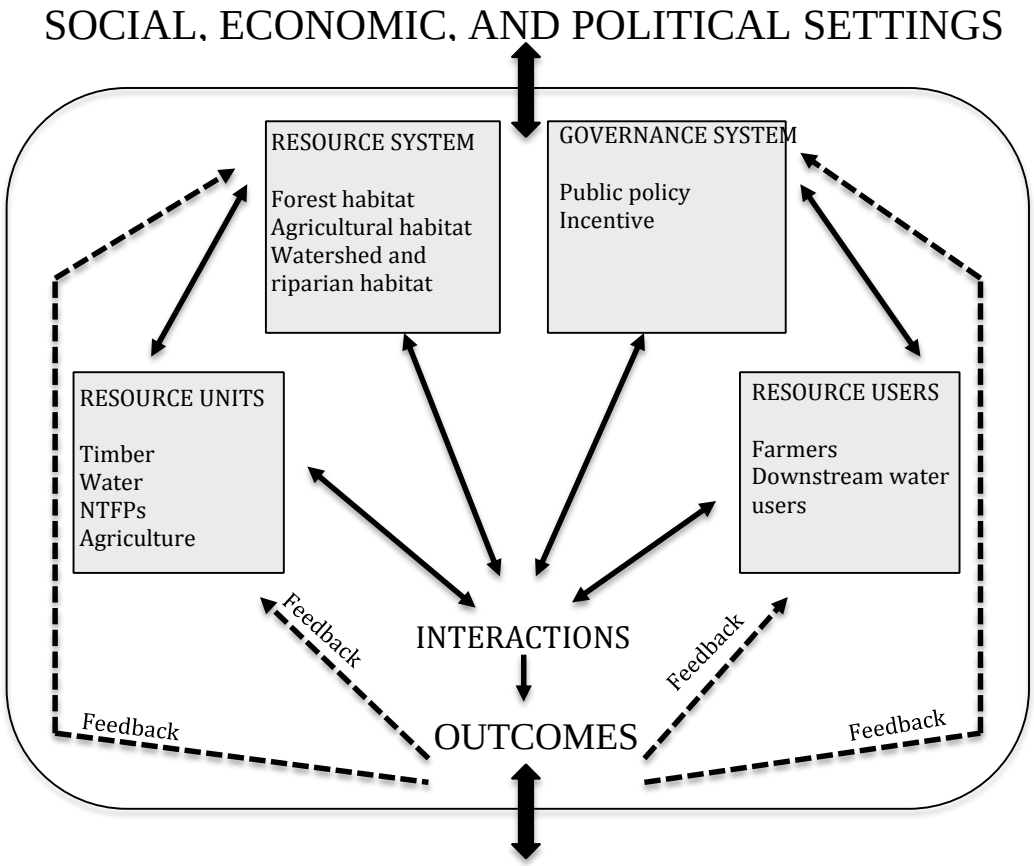

Figure 1.1. Diagram illustrating the conceptual framework for the research based on a social-ecological system approach, as proposed by Ostrom (2009).

1.4. Valuation of ecosystem services

The benefits provided by ecosystem services hold multiple values for multiple actors. These include direct (e.g. timber, NTFPs) and indirect market values (water provision), intrinsic use and non-use values, and option and existence values (Kumar and Kumar 2008, Fisher and Turner 2008). They infer economic, social, or cultural importance, and contribution of ecosystem services to specific goals. Some scientists and policy makers have advocated the economic valuation of ecosystem services as a way to integrate natural capital into decision-making (Goulder and Kennedy 2011, Daily et al. 2009). The communication of biodiversity value within the political and economic realms of decision makers may therefore increase the implementation of

more pragmatic solutions (Gomez-Baggethun and Ruiz-Perez 2011). If nature's value is recognized, investment in, and compliance to, conservation should, theoretically, increase (Daily et al. 2009).

Commodification of natural capital requires an understanding of the ecological context and how this relates to wider SESs through economic efficiency, ecological sustainability, and economic systems (Wilson and Howarth 2002). Sweeney et al. (2004) argue that acknowledging the true value of ecosystems through the services they provide may alter economic behaviour. If the values of ecosystem services are considered within management approaches, Sweeney et al. (2004) argue that the conversion of forest or natural habitats for agricultural profit will be reduced, and the habitat's perceived economic value by landowners can be increased. Combining effective and sufficient incentives for landowners is therefore important to encourage management, rather than exhaustion, of ecosystems (Walker et al. 2013).

The economic value of ecosystem services is, however, often external to the market system. Because of this, failures of institutions, policy, or markets to address these values can lead to externalities. Externalities are negative environmental outcomes that impose social costs to society (Ferraro and Kiss 2002, Rudel 2005, Wunder, Engel, and Pagiola 2008, Landell-Mills and Porras 2002). Short-term economic benefits from land conversion such as timber, livestock, and crop production are often outweighed by these non-marketed externalities (Sweeney et al. 2004). Where benefits or costs of ecosystem services are undervalued, do not have a market value (such as clean water and wildlife populations), or are non-excludable, these environmental externalities may lead to inefficient resource allocation, and therefore market failure. Negative externalities, such as pollution, are more widely recognised and addressed than positive externalities, such as the provision of wildlife habitat or hydrological resources (Krutilla 1991).

Externalities can be address through regulation, taxation, subsidies, and internalizing the external cost of ecosystem benefits. This can be conducted through a 'Coasean approach,' where market failures are corrected through markets that trade ecosystem services through transactions such as PES. 'Pigovian solutions' can also be used to correct market failures through public policy interventions such as taxes (Gomez-Baggethun and Ruiz-Perez 2011).

The case studies used in this thesis use both Coasean and Pigovian approaches to address externalities: In Lombok, one case study using positive financial incentives aimed to address deforestation through a Coaesean approach. Pigovian approaches were used in Alta Floresta, where public policy imposed regulations and negative incentives to enforce forest conservation. This Pigovian approach was also used indirectly in two case studies in Lombok where local socio-cultural incentives imposed community-wide informal policies.

While there is a need to understand ecosystem services in an economic context, the varying temporal and spatial scales, and socio-cultural perspectives that characterize ecosystem services, processes, and values, must also be recognised (Hein et al. 2006). The concept of economic valuation of the environment is fundamentally a human construct. Individual perception and value of ecosystems are therefore highly variable. They are often linked to socio-cultural backgrounds and specific natural resource use (Oteros-Rozas et al. 2013). In determining ecosystem services values, incorporating socio-cultural values, such as equity, and local perceptions of the environment, are important (de Groot, Wilson, and Bourmans 2002). Social values attributed to ecosystems are themselves also highly contextual. Methods of valuation are not 'ideologically neutral,' but instead are cultural constructs (Gómez-Baggethun et al. 2010). Culturally constructed values can act as an institution that feeds into the decision-making processes over how the environment and related human behaviours are managed (Vatn 2010a, Martin-Lopez et al. 2014, Oteros-Rozas et al. 2013).

The valuation of ecosystem services, however, has been criticised. Kosoy and Corbera (2010) argue that the trade of single services oversimplifies complex ecological processes. They also suggest that the political nature of commodification may in fact emphasise existing power inequalities in people's access to resources. Others advocate a bio-centric approach that argues a price cannot be placed on nature, and it therefore should be valued for intrinsic reasons (Goulder and Kennedy 1997).

For the governance of ecosystem services, however, valuation can be a useful tool to guide decisions towards managing ecosystem services. In particular, placing values on environmental benefits can be used to highlight economic inefficiencies and address the asymmetric distribution of natural resources (Wilson and Howarth 2002). Valuations can estimate the opportunity cost incurred by ecosystem services providers, and, therefore, the amount for which these users must be compensated. Governance such as public policy to regulate land-use, market-based instruments such as PES, and institutions such as defined property rights, can be used to compensate for externalities that drive market failure and environment degradation. The case studies examined in this thesis are examples of ecosystem services management that used economic and culturally constructed values to influence human behaviours towards the environment.

1.5. Institutions to govern ecosystem services

Institutions define the ways in which humans interact with the surrounding environment (Corbera, Brown, and Adger 2007, Dietz, Ostrom, and Stern 2003, Young, King, and Schroeder 2008, Young 2003). Institutions are defined as a system of regulations and decision-making structures that lead to social norms connected to

the environment (Ostrom, Gardner, and Walker 1994, Young 2002). They provide guidance to individuals and regulate interactions between groups of people (Corbera, Brown, and Adger 2007, Young 2003). Institutions are dynamic. They are reshaped through social, political and biophysical change, and human action (Corbera 2005).

Institutions can be formal and are implemented through legal systems, policy regimes, and land tenure. They also can be informal in nature, and structured around cultural traditions, social norms, and customary laws. Institutions operate at different levels to influence who makes specific decisions, and how these choices are either enforced or limited (Corbera 2005). Institutions provide capacity to communities to manage SES interactions, address environmental externalities, and may offer solutions to community problems (Vatn 2010a).

To control the use of natural resources, governance institutions must alter the incentives that drive resource users' land-use decisions and behaviours (Milner-Gulland 2011). These environmentally-linked human behaviours are shaped by multiple and complex factors. 'Pro-environmental behaviours' can be considered as behaviours that seek reduce negative impacts on ecosystems, and promote the sustainable use of resources (Kollmuss and Agyeman 2002).

Human motivation, incentives and collective action

"Incentives matter" (Gneezy, Meier, and Rey-Biel 2011). They can be economic or social, and can act on intrinsic motivation to alter individual and collective behaviours (Pascual-Ezama, Prelec, and Dunfield 2013). Resource users' perceived incentives are often based on the considerations of the costs and benefits of different behaviours. These considerations are influenced by the constraints of the institutional and contextual setting, and the dynamics of resources and their users. These include factors and circumstances, such as: Existing institutions, i.e. that can aid or be used to promote pro-environmental behaviours; Economic, i.e. the financial cost and benefits of certain actions; Social and cultural, such as social norms and traditional customs; Personal capabilities, such as capital, time, social status, and power; and, Internal motivations, such as environmental awareness, and underlying values and attitudes (Stern 2000, Kollmuss and Agyeman 2002). Various incentives will have different effects on these factors and contexts, and, therefore, incentives must be highly context specific.

Two over-arching views towards individuals' desire to cooperate are described in the existing literature: (1) Individual rational utility maximisation – i.e. economic gain (e.g. Hardin 1968); and, (2) Social utility maximisation – i.e. social acceptance (Vatn 2009). An individual rational utility maximisation viewpoint suggests human behaviour is motivated through extrinsic incentives, such as rewards or sanctions (e.g. command and control, payments). It is based on individual cost-benefit analysis for self-interest (REF). Conversely, social utility maximisation incorporates social

institutions, such as social norms, traditions, and customs, that guide pro-social cooperative behaviour (Ostrom 1998, Deci 1971, Gachter and Fehr 1999).

Economic theory has often been solely used to design incentives. This rationale has, however, been criticised for excluding social interactions and the influence of social acceptance as an extrinsic incentive on individual behaviour (Harsanyi, 1969, Granovetter 1992, Kreps 1997, Falk, Gachter, and Kovacs 1999, Fehr and Falk 2002). Economic rationale is, in itself, dependent on already-established incentives and intrinsic motivation which provides a basis for societal actions and alter social norms (Kreps 1997, Gneezy, Meier, and Rey-Biel 2011). The assumption that economic incentives are complementary to existing altruistic motivation may therefore have significant implications and affect existing pro-social behaviours (Deci 1971, Pagiola and Platais 2002).

Fehr and Falk (2002) argue that economic theory alone constrains our understanding of the influence of incentives on human behaviour. The use of social, anthropological, and psychological theory to understand other factors and foundations of behavioural motivation, such as reciprocity, social (dis-)approval, and intrinsic enjoyment, should also be taken into account when introducing extrinsic incentives (Gachter and Fehr 1999). These social interactions themselves — how behaviours are formed and evolve — mean that the reality of introducing extrinsic incentives in practice is likely to be difficult to determine.

Policy changes and the implementation of incentive-based institutions to govern ecosystem services aim to alter these motivations, and the behaviours of resource users. This can be either through positive means, such as social or financial rewards, as was observed in Lombok, or negative means, such as fines and punishments for non-compliance, as was observed in Alta Floresta. Should land users' incentives for non-compliance, such as continued deforestation, be stronger than those for compliance, sustainable governance of ecosystem services is likely to be compromised (Rudd 2004). In Alta Floresta, non-compliant deforestation behaviours are the result of ineffectual incentives to alter land-use decisions. In the case study, non-compliant behaviours are perceived by landowners to be more cost efficient than pro-environmental behaviours. Consequently, ecosystem governance and function are severely compromised. Reformed policy approaches in Alta Floresta aim to address these ineffective incentives and alter landowner non-compliant behaviours. The implementation of incentives can, therefore, have significant effects on human environmental behaviours, which can either benefit or cause harm to ecosystem services.

Ecosystem services, such as fresh water and clean air, are predominantly public goods. Yet, their physical provision (i.e. forest land) is often privately owned. In the Brazilian Amazon, land tenure is clear, and private properties constitute 53% of the biome (Rosa, Souza, and Ewers 2012). For Lombok, however, land tenure, as across

much of Indonesia, and ownership are poorly defined, and often there is confusion between national and traditional laws over tenure definitions (Contreras-Hermosilla and Fay 2005). Policies and institutions require structures that provide incentives for private landowners to provide or protect ecosystem services (Kemkes, Farley, and Koliba 2010). Traditional institutional approaches to manage ecosystem services have used command and control regulations, or set aside sections of the ecosystem from the economy by creating PAs or other conservation systems. More recent approaches, however, have sought to remedy market failures through public policy (taxes, user fees), subsidies, tradable permits, or economic incentives such as PES (Jack, Kousky, and Sims 2008). This change has focused on encouraging behaviours through market signals, rather than through explicit directives to address environmental externalities, such as deforestation and unsustainable land use (Corbera, Brown, and Adger 2007). These tools provide ecosystem services' public goods through the collective action of individual resource users (Kemkes, Farley, and Koliba 2010).

The use of markets as an institution often arises when resources are perceived to be scarce (Kinzig et al. 2011). These mechanisms are used to provide incentives for individuals to consider the environmental costs of their actions. These incentives are often economic, but may also include social rewards or can be driven by underlying customary norms. By influencing natural resource behaviours, incentives such as PES aim to integrate the short-term immediacy of conservation goals with the long-term slow pace of economic and social change for specific development objectives. Incentives used in Alta Floresta aim to address the economic externalities of deforestation on private properties. They also can serve as a redistributive mechanism between different social groups and ecosystem users (Ferraro and Simpson 2002, Barrett and Arcese 1995, Adams and Hulme 2001).

1.5.1. Economic incentives

PES assumes compensation will provide incentives for conservation, and will not lead to ecosystem conversion, and therefore market failure (Kemkes, Farley, and Koliba 2010). The creation of a market value for ecosystem services offsets lost opportunity costs to local providers (Engel, Pagiola, and Wunder 2008). There are many types of PES that focus on specific ecosystem services. Due to their commercial scale, however, four main schemes have emerged: carbon sequestration, watershed protection, biodiversity protection, and landscape beauty (Wunder 2005b). Widely accepted criteria for PES schemes include: A voluntary contract for external beneficiaries of services, such as downstream users, to pay service providers (for example, local landowners), on the condition they adopt land practices and resource uses that restore or maintain ecosystem conservation (Wunder 2007, 2005b). The PES approach has been implemented in both developed and developing countries. Its application has been diverse, ranging from small-scale watersheds to ecosystems spread across entire countries (Wunder, Engel, and Pagiola 2008, Kemkes, Farley, and Koliba 2010).

It is argued by some that, despite the subjective nature of PES's selection of ecosystem services, their valuation, and classification, its implementation is preferable to a lack of valuation and accountability, which currently drives ecosystem degradation and misaligned policy priorities (Spangenberg and Settele 2010). Economic incentives are therefore perceived by some as a cost-effective method for conservation (McAfee 2012). Others, however, suggest that combining conservation and poverty alleviation is likely to compromise institutional efficiency (Sanderson and Redford 2003), and Berrada (2004)[1] describes PES as, "an attack on collective life" (as cited in McAfee and Shapiro (2010)). The introduction of incentives may, therefore, be unpredictable in practice, undermine existing communal relationships and disempower rural providers.

Since the early implementation of PES under Wunder (2006)'s definition, the discourse about economic incentives for conservation and development has developed in different ways to focus on varying definitions of incentive schemes (Muradian 2013, Muradian et al. 2010, Muradian and Rival 2012, Muradian and Vira 2013, Pirard 2012b). As such, PES definitions have widened to include schemes that are defined as 'PES-like' – i.e. fulfilling most, but not all criteria, or self-organised programmes (Wunder 2007). That includes the Sloping Land Conversion Program (SLCP) in China, which is aimed at protecting watersheds and reduce soil erosion, and is financed by central governments, not voluntary buyers (Bennet 2008). Other 'PES-like' programs include Mexico's PSA-H PES scheme that uses hybrid market-like mechanisms and state regulations to protect national watersheds (McAfee and Shapiro 2010). Other approaches include collective action, where social norms provide incentives for positive environmental behaviours (Muradian 2013). Such projects expand Wunder's (2005) original definition to include public policy-linked schemes and non-economic incentives.

Economic efficiency considerations are important for ecosystem service valuation. The estimation of values can help to identify economic trade-offs between, and across, different users and providers of ecosystem services. The use of incentives such as PES to create efficient and equitable natural resource use does not represent a "silver bullet" for conservation or development (Ferraro and Kiss 2002, Engel, Pagiola, and Wunder 2008). Economic incentives may not be suitable to manage all environmental problems. They can be an insufficient guarantee for ecosystem service provision, or may 'crowd out' intrinsic, underlying social norms that generate positive environmental behaviours (Perrot-Maitre 2006, Pagiola, Arcenas, and Platais 2005)

1.5.2. Non-economic incentives

[1] Barreda, A. 2004. Invasiones invisibles, subsidies perversos, guerra continua [Invisible invasions, perverse subsidies, continuous war]. Orjarasca, *La Jornada*: 20-23.

Not all incentive-based institutions rely purely on economic compensation to motivate behaviours. The management of ecosystem services "typically involves social dilemmas" (Muradian 2013). These dilemmas occur at different scales of decision-making, and relate to the behavioural choices of natural resource users (Muradian 2013). A wide range of incentives motivate behavioural choices and the extent of compliance with environmental management institutions (Cardenas, Stranlund, and Willis 2000). Individual and collective behaviours are often influenced by self-interest and social norms such as altruism, reciprocity, wishing to avoid social disapproval, and fairness (Kreps 1997, Narloch, Pascual, and Drucker 2012). Social rewards, and punishments, therefore, can be used to promote pro-social behavior (Fehr and Falk 2002).

The use of incentives to influence behaviours are "a means of social communication and hold social meaning," (Muradian 2013). Where incentives are communal, their use to control and solve social dilemmas can promote greater cooperation and collective action (Travers et al. 2011). In practice, incentive-based institutions are more likely to be based on hybrid governance systems such as collective action, compared to market-driven economic rewards or hierarchical, top-down approaches (Muradian 2013, Muradian and Rival 2012, Sommerville et al. 2010). Muradian et al. (2013) and Cardenas and Carpenter (2008) suggest that these hybrid forms of hierarchical control and market-based regimes can enable greater efficiency and equitable distribution of resources. This may foster institutions to use existing motivations, social norms, leadership, and penalties to enable compliant behaviours.

Compliance

The economic and non-economic incentives discussed so far have been directly used to motivate pro-environmental behaviours. The use of economic and non-economic motives for land-use decisions, however, may not always drive pro-environmental behaviours. Incentives can also be indirect, which may motivate resource user behaviour through negative incentives such as the threat of sanctions (Houser et al. 2008). Sanctions, such as fines, imprisonment, or embargoes, can have 'incentive effects' that are used to prevent non-compliant behaviours such as deforestation or pollution. Key to determining the effectiveness of sanctions to motivate complaint behaviour is landowner awareness of the risk of punishment (Andrighetto and Villatoro 2011). The impact of these indirect incentives on compliant behaviours is determined by: 1) The perceived potential economic benefits of non-compliance; 2) The cost of punishment; 3) The likelihood of non-compliant behaviours being detected; and 4) The anticipation of future offensives (Becker 1968).

Compliance, therefore, is determined by the cost effectiveness of pro-environmental behaviours over rule breaking (Keane et al. 2008, Leader-Williams and Milner-Gulland 1993). This may not always promote cooperation with institutions, if a sanction's cost is lower than the benefit of non-compliance. Sanctions, often viewed

as hostile in nature, may also generate institutional distrust, and reduce the likelihood of compliance (Houser et al. 2008). Regulations to alter landholder behaviours must, therefore, take this into account to provide sufficient 'incentive effects' to motivate compliant, pro-environmental behaviours.

1.6. The implementation of incentive-based institutions

The implementation of incentive-based institutions raises questions of how to feasibly apply this approach to obtain conservation and development outcomes. This section discusses the trade-offs incurred when using this management approach. It also addresses issues of efficiency and equity for resource users and ecosystem services protection, and the importance of context for incentive-based interventions to 'fit' and 'interplay' within SESs.

1.6.1 Trade-offs

Any management approach will create trade-offs between ecosystem conservation and livelihoods because of the inherent interdependence between the two concepts (Rodriguez et al. 2006). The design of ecosystem services management illustrates these trade-offs. Optimizing the provision of one ecosystem service will result in trade-offs for the provision of other ecosystem services. By maximizing pasture habitat for cattle revenue in Alta Floresta, for example, that provision may not improve hydrological services or promote greater biodiversity and forest habitat. The focus on one ecosystem service, however, can minimize transaction costs between a broad selection of providers over a much wider region (Wunder 2005b). Larger-scale programs can benefit from reduced transaction costs with a greater selection of providers. That allows for multiple objectives to be pursued at the same time such as poverty reduction and conservation (Wunder, Engel, and Pagiola 2008).

Trade-offs can occur between multiple ecosystem services. That includes along spatial scales – with local or regional effects – and along temporal scales – i.e. rapidly or slowly. Trade-offs also affect ecosystem services' 'reversibility' – i.e. whether ecosystem services are likely to return to their original state if the impact of the trade-offs stops (Rodriguez et al. 2006). Trade-offs may not always be an explicit choice. Interactions among ecosystem services are often not fully understood (Walker et al. 2002), and multiple outcomes are sometimes not considered (Chhatre and Agrawal 2009). Management approaches are typically linked to the short-term needs of humans, and lead to a hierarchy of ecosystem service preference. These short-term demands currently focus on provisioning services. This focus may have unknown consequences for the longer-term, larger-scale provision of regulating, cultural, and support services (Rodriguez et al. 2006).

Trade-offs between the provision of different ecosystem services also include social outcomes under incentive-based management structures. The key questions are: who is actually benefiting from the schemes, and whether the 'real poor' are able to access benefits when they lack capital or land tenure (Arnold 2002, Sommerville et al. 2010). The claims and distribution of payments also affect resource entitlements between, and within, communities (Leach, Mearns, and Scoones 1999). Changes in access to, and control over, resources for different actors at various times under incentive-based management schemes also can impact social cohesion and cultural values (Corbera, Brown, and Adger 2007). It is important that these values and trade-offs are understood when implementing incentive-based institutions as sustainable solutions to resource conflict. Trade-offs between efficient and equitable institutional outcomes are unavoidable. However, understanding the context in which institutions are implemented and function is likely to increase the potential for efficient and equitable objectives to be met.

1.6.2 Issues of efficiency and equity

A uniform design of incentive-based measures may not fit all situations. To alter patterns of behaviour in an unpredictable world will not always achieve 100% efficiency or equity. Incentives offer a seemingly easy solution to complex environment problems, but can worsen ecosystem loss if not designed appropriately (Kinzig et al. 2011). The design of incentive-based mechanisms must be context specific. To ensure environmental behaviour changes are efficient and equitable, the design of incentive mechanisms should take into account the existing institutions, the scale of ecosystem and SES function, and the prevailing socioeconomic and political conditions (Kinzig et al. 2011). Different forms of incentives can be used to influence behaviours. These can be positive, i.e. providing rewards for compliant behaviours, such as with the case studies in Lombok, or negative, i.e. sanctions and punishments for non-compliance, such as those seen in the case of Alta Floresta.

Incentives may raise multiple issues related to equity and the elite capture of resources. Van Hecken and Bastiaensen (2010) suggest that PES can lead to a local bill for a 'global free lunch.' Concepts of social justice are central to the design and implementation of incentive-based mechanisms (Martin, Gross-Camp, Kebede, and McGuire 2014). The distribution of resources and the mechanisms that enable their distribution often determine human interactions. Institutions that focus on one equitable element do not always positively influence other parts of social justice (Sikor et al. In press). Conflicts over resources and institutional governance can spring from different beliefs of what defines 'just' environmental management (Martin, Gross-Camp, Kebede, McGuire, et al. 2014). The concept of 'just' environmental management draws on concepts that underpin incentive-based mechanisms: service providers need to be rewarded for benefits received by individuals outside of the resource base.

Inequality in environmental resource use is often based on people's access to natural resources, and not their economic wealth status (Martin, McGuire, and Sullivan 2013). Land tenure and property rights, especially over forests, are important in the creation of incentive-based policy that is designed to protect ecosystem services (Bremner, Farley, and Lopez-Carr 2014). Clear tenure definitions, which are understood at local and regional levels, are critical for the equitable distribution of benefits (Robinson, Holland, and Naughton-Treves 2013). Yet, the perception that local communities have towards land tenure often has a greater effect on land-use decisions, compared to whether tenure is formally recognised (Pascual et al. 2010)

Governance systems whose conception of justice is similar to that of the individuals who provide and use resources are more likely to be received positively, compared to systems that are based on divergent definitions (Martin 2013). Martin, Gross-Camp, Kebede, McGuire, et al. (2014) argue that questions such as who participates in decision-making, and on whose terms, are highly influential in determining the equitable resource distribution. Individuals, who may focus on non-economic factors of justice, may not accept the economically-driven outcomes of incentive-based mechanisms. To address these injustices, incentive–based institutions need to acknowledge and align governance with the underlying institutions, power relations, and social norms that drive behaviours.

1.6.3 The importance of context: Institutional fit and interplay

Institutions do not operate in isolation (Corbera, Brown, and Adger 2007). Existing institutions, which underpin society, have the potential to influence and interact with environmental governance institutions. These existing institutions, and the contexts in which they function, have the ability to enhance or undermine the productive management of ecosystem services (Agrawal and Ostrom 2001, Dietz, Ostrom, and Stern 2003).

The extent to which an environmental institution is aligned to address the local SES context will determine institutional 'fit' (Young 2002, Young, King, and Schroeder 2008). Institutions that do not match these contexts are likely to be incompatible and, therefore, weak in addressing the environmental issues, and be potentially damaging to the SES in question (De Caro and Stokes 2013). De Caro and Stokes (2013) provide a framework to analyse components of institutional 'fit' (Figure 1.2) and its influence to determine behaviours and compliance through institutional acceptance and social fit. This framework is linked to the components and actors within a SES as illustrated with Figure 1.1, and can help to identify factors that motivate land-use behaviours and determine institutional 'fit.'

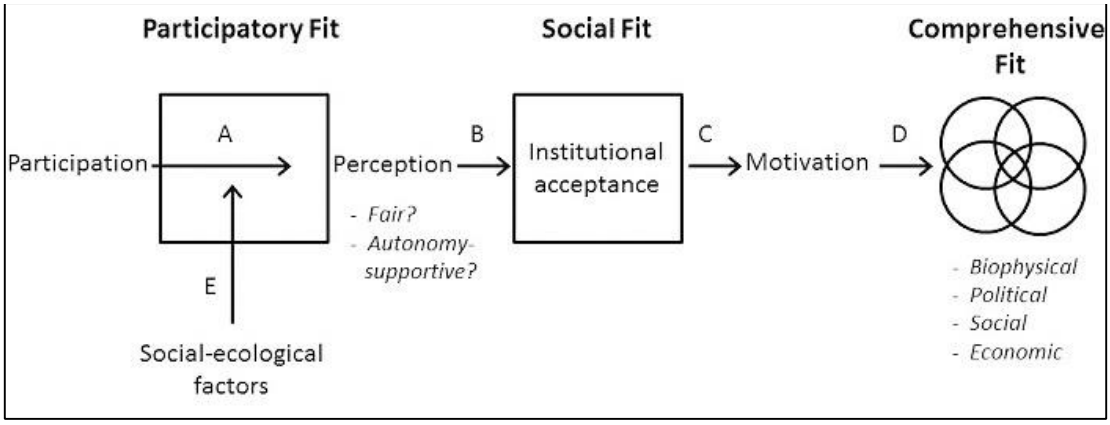

Figure 1.2. Behavioural process model linking participatory fit, social fit, and comprehensive fit (De Caro and Stokes 2013).

Participation in decision-making can be subjective and determined by factors such as social norms and local perceptions of participation. Participatory 'fit,' i.e. aligned to these local contexts, is important to empower local actors and provide procedural justice (De Caro and Stokes 2013, 2008). The extent to which communities perceive that participation has been just will determine the level of acceptance of institutional constraints on natural resource use, i.e. social fit. This acceptance facilitates institutional signals, which provide incentives and motivate compliance to formal and informal institutional rules.

A community's ability to cooperate is dependent on existing social norms and motivations that guide cooperative behaviours (Ostrom 1990). Institutions that match these social norms, existing socio-cultural institutions, and ecological dimensions are more likely to 'fit' a SES and increase positive outcomes. Links between institutions, local contexts, existing institutions, cultural norms, and socio-economic conditions are likely to enable institutional function (Mehring et al. 2011). The impact of incentives on underlying motivations and social norms may either 'crowd out' (undermine) or 'crowd in' (reinforce) intrinsic positive environmental behaviours (Clements 2010, Bowles 2008, Rode, Gomez-Baggethun, and Krause 2013, Vatn 2010b, Muradian et al. 2013). Extrinsic incentives for short-term economic gain that alter individuals' moral responsibilities may result in changes to values or mind-sets, which 'crowd out' social norms (Bowles 2008, Rode, Gomez-Baggethun, and Krause 2013). In contrast, institutions that provide incentives for intrinsic motivation that promotes cooperative behaviours may strengthen and complement existing social norms to conserve the environment. It is important to understand how extrinsic incentives interact with existing intrinsic motivations. They can generate incentives, which promote cooperative action and reinforce existing social norms ('crowd in') to manage common pool resources, rather than weaken ('crowd out') underlying social norms and behaviours (Muradian et al. 2010, Clements et al. 2010, van Noordwijk et al. 2012).

There is no uniform application of incentive-based institutions to manage ecosystem services. Their implementation is highly context specific and outcomes are often unpredictable (Kemkes, Farley, and Koliba 2010). Benefits from ecosystem services, coupled with socioeconomic, political, and demographic factors, influence attitudes towards, and perceptions of, the environment. They also affect the types of resource use (Infield and Namara 2008). The choice of ecosystem service governance is dependent on a SES's socio-economic, biophysical, and political context, and the context's dynamics (Jack, Kousky, and Sims 2008). For example, environmental benefits from ecosystem services vary significantly across sources, locations, and from initial conditions. How these resources are accessed and distributed, and the level of heterogeneity in the opportunity costs of the land-use providing ecosystem services will also impact policy outcomes. The existing political processes and power relations will also affect whether incentive-based institutions align or compete with existing institutions. Over time, these contexts and their dynamics will change, and may affect how incentives signal behavioural adaptation towards sustainable land use.

These contexts are likely to determine the equity, and environmental and cost efficiency outcomes of regulation (Hanna 2001). Adequate institutional arrangements, political support, and the specific individual characteristics of ecosystems may determine how effective incentives can be. To determine how incentives interact within a market system, policymakers must distinguish the scale at which they are made, and whether the ecosystems are a common pool resource, public good, or market commodity. Complex institutional dimension, including social norms, may mean that incentive-based institutions are insufficient in managing ecosystem services (Goulder and Kennedy 2011). Public policy, therefore, also has a critical role to increase the efficient use and equitable distribution of resources where market forces are unable to do so. This concept will be examined in Chapter 6.

Incentive-based institutions encompass a diverse mix of instruments that can communicate the importance of conservation (Pirard 2012a). Yet, the realisation of benefits for both efficient ecosystem services management and greater equity for resource users varies significantly in its implementation (Spiteri and Nepalz 2006, Fauzi 2013). The institutional structure that works best to provide incentives to manage land-use decisions needs to create signals that direct these decisions towards social goals, which reduce environmental externalities. It is therefore crucial to understand the context in which these institutions emerge and function to align policies with the reality for communities on the ground that can improve the effectiveness of conservation initiatives and the equity of rural development.

1.6.4 The "messy" middle

The reality of incentive-based or other governance institutions on the ground cannot always be exclusively attributed to specific theories and policies behind their

implementation (Lichbach 2009). Lachapelle, McCool, and Michael (2003) argue that the original model to manage natural resources requires conditions that are rarely attained in the projects in which they operate. They suggest that natural resource problems are, instead, typified by various and often contradictory goals, minimal scientific agreement on cause-effect relationships, restricted time and resources, a scarcity of information, and institutional inequalities related to information and political power. The extent to which theories can explain specific problems and address certain particular situations can, therefore, be described as the "messy" middle. This view allows for a problem-centred approach that synthesises perspectives and theories, and moves beyond a reductionist approach. That includes identifying determinants of behaviourial change, which may include institutions, ideas, cultural meanings, and material drivers. Weber (2009) argues that social action (i.e. behaviours) is based on the 'orientation to meaning and motivation by interests.' This thesis seeks to explore how this "messy" middle relates to the theories driving institutional governance of natural resource issues. This includes social elements like values and norms, and dimensions like individual and community interests, identities, and institutions (Lichbach 2009, Lachapelle, McCool, and Michael 2003).

1.7. Research objectives and principal research questions

The research explores the complex realities on the ground related to incentives-based institutions, and the communities and ecosystem services on which they act. It investigates the distance between theories behind PES and the often-unpredictable policy outcomes. This is done by examining the links between governance structures and their ability to provide incentives for landowner land-use decisions and to motivate cooperative behaviours. An ecosystem services approach is applied to explore the challenges in enabling efficient and equitable outcomes for ecosystem services governance in developing countries. The use of this concept, within a SES, enables the investigation of interactions between ecological functions, and the economic, social, political, and cultural drivers that provide incentives for land-use decisions. This study simplifies the concept of SES into social and ecological outcomes that interact through institutional structures and responses. Ecological outcomes include: Water availability, climatic variation, spring density, forest cover, and elevation. Social outcomes include: Water access, wealth, infrastructure access, and population density. Institutional responses include: Water infrastructure and institutional governance.

A mixed methods approach was used to address multidisciplinary social and environmental science issues to answer the following principal research questions:

1: To what degree can institutional design be used to help determine access to, and availability of, natural resources?

2: What factors have played a role in the emergence of different institutions aimed at managing ecosystem services? How do these factors help to influence the design and function of institutions?

3: Within the political, biophysical, socio-economic, and cultural contexts, how can institutional design help to formulate policy and determine the 'fit' of ecosystem services management approaches?

4: How can institutional incentives influence behaviours that lead to greater compliance with ecosystem services management?

5: Can institutional incentives have a material effect on the efficiency and equity of ecosystem services management when placed in the wider political, biophysical, socio-economic, and cultural contexts?

1.8. Structure of thesis and description of papers

The thesis is presented in the structure of four research papers that will address the five principal research questions (Chapter 3 to 6). **Chapter 2** presents an overview of the methods used across the case studies, and introduces the study sites. It is intended for each paper to be read as an individual piece of research. As such, the papers feature a section for background information and separate methodology. Three of the four papers originate from the same data collected in Lombok. Consequently, some data overlaps are unavoidable, particularly when describing specific research methods.

Chapters 3 to 5 focus on Lombok, Indonesia. **Chapter 3** explores the impact of water availability and resource access for communities across the island. Lombok is under pressure to provide water and other natural resources for a rapidly expanding population, yet within the constraints of finite resources (Klock and Sjah 2011). The paper address question 1, and explores the concept of 'water scarcity,' as perceived by local users and for the purpose of managing ecosystem services. It identifies how local users experience water stress across Lombok. The study also outlines the factors that affect water availability and access, and how this impacts rural communities' ability to cope in times of water stress. It outlines how institutional governance can function to address contextual water stress issues.

Chapter 4 investigates the concept of equity in resource distribution through incentive-based institutions. It looks at whether these institutions require inequity to emerge, or if they enable greater equity through the management of ecosystem services. Local institutions are central to determine ecosystem services conditions

(Agrawal and Ostrom 2001). The paper focuses on institutional use and adaptation of incentives to manage water resources through religious, economic, and customary laws that motivate collective conservation activities.

This paper address questions 5, 3, and 1, and explores the equitable outcomes of incentive-based institutions, and how underlying power relations, and political, economic, social, cultural, and biophysical perspectives must be taken into account. This approach can enable a greater understanding of the interactions between societal factors and institutions, and can reduce the elite capture of benefits.

For the purpose of this paper four case studies were used. One of which, Gitek Demung, illustrated a hybrid nature of incentives, using both local customary rules, or *adat*, and monetary means to motivate environmental behaviours. It was decided to include this case study as an incentive-based institution for this chapter, as there were strong elements of the elite capture of benefits that had emerged from parts of the monetized institution. In Chapter 5, however, this community was also analysed as a control village. This approach aimed to simplify the incentives used in the incentive-based institution case studies in Chapter 5 to enable ease of analysis.

Chapter 5 explores the extent to which incentive-based institutions, which govern ecosystem services, are effective when placed in the context of a specific SES. Institutions' 'fit' with other social constructs is determined by influences and interactions between existing and newly created institutions. Where institutions do not 'fit' a SES, governance may be weak and ecosystems can become vulnerable to degradation (Ekstrom and Ostrom 2009).

This paper addresses questions 2, 3, and 4. Institutional 'fit' has critical implications for the design, implementation, and outcomes of incentive-based interventions on the ground. An understanding of how institutions 'fit' and interact within a socio-cultural context is relevant when designing incentive-based institutions to manage ecosystem services. A one-size-fits-all approach is unlikely to work. This paper therefore focuses on the need to take into account the influence and interplay of other institutions to increase the likelihood of compliance within a local context.

Chapter 6 looks at the impact of policy reform on land-use and deforestation on small and large property holders in Alta Floresta, within the State of Mato Grosso, Brazil. The research focuses on understanding the impact of Brazil's Forest Code (FC) (a hybrid market-based, government-regulated policy) reform on landowner decisions on the local ecosystem. Incentives to comply with policies are determined by trade-offs of detection, the severity of punishments, and any perceived economic benefit of non-compliance (Andrighetto and Villatoro 2011, Keane et al. 2008, Travers et al. 2011).

This paper addresses questions 4 and 5. It enables a greater understanding of how policy changes may not always generate equitable outcomes. Inequality may create perceptions that under policy reform, compliance for some resource users can be optional. Where policy provides sufficient incentives – economic and enforcement – motivations to comply, and not to exhaust ecosystems services, may be more likely (Walker et al. 2013).

A conclusion of the main findings of the research, and their implications for further ecosystem services research and policy outcomes, is discussed in **Chapter 7**.

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2 Research design, methods and study sites

Research that aims to inform conservation and development interventions, such as incentive-based institutions, requires a multi-disciplinary aims to inform conservation and development interventions, such as incentive-based institutions, requires a multi-disciplinary mixed methods approach that includes social and environmental science methods (Newing, Eagle, and Puri 2011). Limited comprehended of the drivers of land-use behaviours and the incentives necessary to alter them may arise from a restricted focus and narrow epistemological approach of the researcher. The use of social science methodologies, such as Participatory Rural Appraisal, Rapid Rural Appraisal, can enable local perspectives to be understood. Natural resource availability can be determined through the use of environmental science methodologies, such as spatial analysis. The combination of both of these methodologies can build a clear understanding of resource-use behaviours.

2.1. Research design

2.1.1. Case study selection

This thesis used case studies from Lombok, Indonesia and Alta Floresta, Mato Grosso, Brazil. The conversion of natural forests to agricultural land in both Indonesia and Brazil has had significant impacts on the functions of local forest habitats, and the provision of ecosystem services at local, regional, and global scales. This ecological change has also had significant affects on agricultural and rural development (Tomich et al. 1998).

Land-use patterns vary significantly between Lombok and Alta Floresta. The differences are the result of factors such as land type, agricultural use, natural resource availability, landowner capital, and the implementation of institutions that guide land-use decisions (Lambin et al. 2001, Meyfroidt, Rudel, and Lambin 2010). In Lombok, small landholders, densely populated communities, expanding settlements, and resource use dominate land-use change. Natural resources are managed through regional government regulation, subsidies, and small-scale community institutions. In contrast, land-use change patterns in Alta Floresta are driven by large-scale agricultural expansion where the benefits of deforestation significantly outweigh that of forest conservation (Angelsen and Kaimowitz 1999, Ewers et al. 2009). In this Brazilian case study, ecosystems are managed through government policies, subsidies, and hybrid market-based approaches.

Several questions arise from the use of these two different study sites in this thesis. Specifically, whether the same ecosystem services approach can be applied to examine the equity and efficiency implications of institutional management that provides incentives for positive land-use behaviours; and, whether equity and efficiency implications can be examined across different governance mechanisms. Landowner behaviour in both locations is influenced by political, socio-economic, biophysical constraints. Complex interactions between socio-political actors and ecological processes determine land-use decisions at local, regional, national, and international scales (Munroe and Muller 2007). This thesis explores these interactions across the Lombok and Alta Floresta study sites, and how interlinked institutional relationships determine landowner decisions through 'PES-like' local-scale initiatives in Lombok, and regional-scale hybrid state regulations and market-like mechanisms in Alta Floresta.

'PES-like' and hybrid market-based institutions

The use of a strict definition of PES is difficult when using empirical data because of the specific contextual nature of each case study. For the purpose of this thesis, the research will use Muradian's (2013) argument of 'incentives for collective action' – i.e. individual landowner actions that result in community – or regional-wide positive environmental behaviours. That definition allows for the comparison of the 'PES-like' and hybrid market-based and government-regulated case studies within the existing literature on incentive-based mechanisms.

How these case studies answer the research questions?

The use of these case studies illustrates how initiatives that provide incentives to manage ecosystem services can be developed from existing policies, social norms, and collective activities (Muradian et al. 2013). This approach builds on the broader concept of valuation of ecosystem services, and how the use of incentive-based institutions can motivate landowner behaviour in relation to these values. These case studies highlight that the realities of implementing community-led and policy-driven governance are not systematic. They also demonstrate how dynamics between these existing dimensions, and the drivers of ecosystem services use, influence land-use decisions. Both Lombok and Alta Floresta provide examples of why understanding context in governance design, as well as allowing for the non-rationale nature of human behaviour in the real world, is important.

The Alta Floresta case study offers a broad regional view on the impact of large-scale governance mechanisms, which are used to motivate land-use decisions to protect forests and watersheds. This was achieved through regulation and, more recently, market-based offsets. The Lombok case study illustrates that the small-scale nature of

institutions can provide a detailed understanding of how incentives manage watershed at local levels.

2.2. Methods

2.2.1 Methodology

A mixed methods approach was used in this study. This allowed biophysical quantitative and socio-cultural and economic qualitative data to be integrated, and associations between data to be analysed (Johnson and Onwuegbuzie 2004, Sumner and Tribe 2008). An integrated understanding of the social, ecological, political, and economic processes within the SESs was required to understand how incentive-based institutions governed ecosystem services and the dynamic changes within them. The interdisciplinary nature of the research draws on the empiricist approaches of natural science. This thesis therefore takes a critical realist ontological perspective. The objective social reality of these environmental behaviours, while assumed to exist externally to human beings, can only be known imperfectly (Piergiorgio 2003). The integration of a pluralistic methodological approach enabled the acknowledgement of these perceptions and their influence on personal beliefs, and therefore behaviours. This approach provided a more holistic understanding of the issues surrounding incentive-based institutions in both Lombok and Alta Floresta.

The use of mixed methods also enabled data to be collected concurrently. This strategy allowed different question types to be employed (closed and open), data to be validated through triangulation, and the comparison of data through transformation (Driscoll et al. 2007). Spatial analysis of satellite images and environmental datasets also allowed patterns of land use to be mapped and quantified under different institutional governance structures. This approach is useful to understand the scope and scale of ecosystems, how their services may be valued by landowners, and how management approaches are implemented (Nelson et al. 2009). Spatial analysis highlighted synergies and trade-offs between multiple ecosystem services, conservation policies, and economic and socio-cultural values of the land (Berry et al. 2005). This method was predominantly used in Chapter 6 to examine the impact of changes in ecosystem management requirements on land-use decisions and the provision of water and forest ecosystem services; and, in Chapter 1, to determine water access and resource availability for rural households across Lombok, and the implications of this availability for each household.

For socio-economic data collected within Lombok (Chapters 3 to 5), a combination of questionnaire-based interviews, rapid rural appraisal (RRA) and participatory rural appraisal (PRA) techniques were employed. Consequently, data on socio-economic status, economic use of natural resources, and perceived values of the environment could be collected in both qualitative and quantitative formats. Methods based on

these PRA and RRA principles enabled greater participation from, and interaction with, communities involved in the study (Chambers 1994b). This approach also allowed for a deeper understanding of the complexities of a topic. In particular, the perspectives and motivation for certain behaviours through on-site learning, flexible methods, local participation, and feedback of research findings (Chambers 1994a). The high level of study community involvement allowed a degree of ownership, and also enabled less vocal groups in communities, such as women and the poor, to be acknowledged and to participate.

Central to PRA and RRA are techniques such as semi-structured interviews, focus groups, and participatory mapping (Chambers 1994a, Mukherjee 1997). Homogenous focus groups enabled the relaxed discussion of opinions, understandings and perceptions of concepts, and the social-ecological system. The combination of these methods allowed information to be triangulated and to gain further insights into the topic outside potential restrictions of the questionnaires. There were, however limitations to this methodological approach. Semi-structured questionnaires were built around the interviewer's perception of the drivers of behaviour, and socio-economic and environmental values within an SES. As such, the data gathered from the study sites should be considered objective (Mukherjee 1997).

A pilot of the questionnaire was useful to reduce the potential bias from outsider perceptions. This was conducted for both the questionnaire and focus groups in Lombok. It identified local perceptions of the topic that may have differed from that of the researcher, and areas of the questionnaire that required clarification for respondents. The pilot aimed to reduce the potential bias arising from outsider perceptions of the drivers and roles of behaviours and values towards the environment. Questions were ordered in a logical manner, related topics grouped together, and general questions directed to precede specific questions (Saunders, Lewis, and Thornhill 2003). Open-ended questions obtained more qualitative data, and structured closed questions generated quantitative data that allowed for numerical analysis of responses.

Triangulation was also used to cross-check answers and reduce some of the bias in responses. There was an assumption that individuals' responses were truthful. However, outsider behaviour, and answers about controlled and compliant behaviours, may have had significant influence on responses. Rapid appraisal of communities, in particular to understand local perceptions and values, may not always be appropriate to understand long-term social change and underlying cultural norms (Mukherjee 1997).

For the purpose of this thesis, however, this methodology was useful to gain insights of the underlying motivations behind behaviours and values, and access and availability to resources. This is important when dealing with the problematic nature

of PES definitions, the social norms that underpin cultural activities, and the underlying religious sentiment present in most surveyed villages. The highly contextual cultural constructs of values, both real and perceived, were often dependent on the resource and the society in question (Brondízio et al. 2009). For this analysis, a distinction was made between those communities that actively governed through incentive-based institutions, compared to those that governed merely through underlying social norms.

2.2.2 Application of methodology

This section introduces the application of the above approaches through the two case studies. Primary and secondary data was used and collated for the purpose of this thesis.

Two field seasons with a total of nine months was spent in rural Lombok to collect primary data from household surveys, focus groups, and key informant interviews. Permission to conduct research in Lombok was granted by the Ministry of State for Research and Technology (RISTEK), Indonesia with institutional support on Lombok from the University of UNRAM and CSIRO, Australia. Between November and December 2011, preliminary focus groups and pilot household surveys were completed. This first field season introduced the researcher and the study to the communities involved, and refined the research methodology. A second season of research was conducted between May and November 2012 during which time in-depth questionnaires, focus groups, and informal informant interviews were conducted in case study communities across Lombok.

Different approaches to reasoning may evoke different interpretations to be drawn. Inductive reasoning was used for both of these case studies to determine causation. This approach enabled open-ended and exploratory observations of rural communities to be made and behavioural patterns to be deduced by the researcher. The data alone was used as the basis to derive empirical generalisations and theoretical conclusions *(Miller and Brewer 2003).*

Lombok – Questionnaire-based interviews

Two separate household surveys were conducted on Lombok. The first was based on RRA principles to collect baseline data from ten households in 30 villages across Lombok, totalling 300 surveys. These villages, and the household respondents, were randomly selected. This selection aimed to generate a representative sample of communities and their use of natural resources across the different land types on Lombok (Kothari 2004). This survey used semi-structured interviews to determine socio-economic status, access to and availability of water resources, and agricultural revenue across the island in relation to effort to obtain water as a unit per household. Secondary data from International Non-Governmental Organisations (INGOs), such

as Fauna Flora International (FFI), and BAPPEDA (*Badan Perencana Pembangunan Daerah*, or Regional Body for Planning and Development) were used to generate spatial analysis of environmental data using ArcGIS, included in Chapter 3. This data included information on vegetation type, average annual rainfall, elevation, and water availability. Analysis of both questionnaires and environmental data was conducted at village level.

The second survey used PRA principles and methods to obtain baseline data and an in-depth understanding of values and social norms for both communities with and without incentive-based institutions. Approximately 30 households were surveyed across six villages, totalling 171 respondents. A comparative case study approach was used between communities with incentive-based institutions and appropriate control communities (Yin 2003). This survey used both semi-structured interviews and focus group discussions to determine socio-economic status, access to and availability of natural resources, and impacts and perceptions of institutions to manage the environment. Analysis was conducted using both community and household level responses. Triangulation through focus group discussions and informal interviews provided more in-depth understanding of contexts and institutional functions.

One of the research assistants, Dipta Sjah, translated questions into Bahasa Indonesian. Prior to conducting interviews, it was ensured that all research assistants understood the information required from the survey. It was also often necessary to translate the Bahasa Indonesian questionnaire into Sasak. In translating the questionnaires twice, however, it was apparent that some information and colloquial understanding might have been lost in translation and cultural understanding. However, this bias could not be avoided, as it was essential to communicate in both languages in rural areas of Lombok.

i. Socio-economic status

Data on household structure was obtained regarding, age, years in education, occupation, religion, and time in village. Information regarding livelihoods was also gathered to identify the natural resources obtained from the environment. A wealth ranking proxy was used within both surveys. Land tenure, area of land farmed, and crop type grown were also an important indicator of land use across the study sites.

Determining socio-economic status through wealth ranking is useful to identify households' responses in relation to their wealth and perception of wealth (Chambers 1994a). This can be deduced using indicators such as household income, assets, education levels, expenditure, and housing characteristics (Rutstein and Johnson 2004). Due to time constraints and the easy access to credit across Lombok, it was not feasible to conduct rigorous wealth ranking, as standardisation proved difficult. Therefore, both surveys generated a wealth proxy of house size (number of rooms) to determine household socio-economic status, under the assumption that the larger the

house, the wealthier the household. This was developed following pilot focus group discussion of household wealth indicators.

ii. Water and land resources

This section of the questionnaire was conducted to establish a base understanding of availability of, and access to, water resources for household consumption. These questions were included in both household surveys. Information was obtained on water infrastructure, effort to obtain water, water quality, and extreme water events such as flooding and drought that had affected households. Data was also collected on direct use benefits from the environment, such as NTFPs, timber, and agricultural revenue. This data were used in the first survey to determine revenues across the island in relation to effort to obtain household water.

iii. Values

Respondents' values of the environment and their perception of institutions (see paragraph below) were included in the second survey. Identification of environmental values was useful to establish the context in which natural resources were used, and, therefore, to later understand the role of institutions, their 'fit,' and equity outcomes. Questions examined respondents' perceptions of the environment, the benefits obtained from its services, and where they believed institutional responsibility was held.

iv. Incentive-based institutions

It is difficult to untangle the complex and dynamic roles of multiple institutions within rural communities. It is likely incentive-institutions are influence by, and interact with, other existing institutions. To understand the impact of incentive-based institutions, and whether they were aligned within local contexts, respondents were asked questions on the existence of, and their participation in, local institutions. For the purpose of this study, respondents' participation was defined as being a member of, or adhering to, the belief system and socio-cultural norms of an institutional group. Following focus group discussions, these institutions were grouped as: Village management, Religious, Farmer groups, Traditional/ *Awiq-awiq*/ *Adat*, and Other. Data was also collected on respondent perception and understanding of environmental management in their communities: Why it had emerged; What the rules were; Who is involved in decision-making; and, Whether compliance was enforced.

Alta Floresta – Spatial analysis

Spatial analysis was used to examine land-use decisions under changing policy requirements in Alta Floresta. Spatial analysis was useful to identify relationships between ecological, social, and economic values of natural areas (Bryan et al. 2010).

For Alta Floresta, this method enabled trade-offs between conservation and economic gain to be examined, and the implications for the efficiency and equity of ecosystem management to be understood. This was conducted using eight 2008 QuickBird images of 10m resolution to determine land cover, and two LANDSAT-5/TM images of 60m resolution to determine deforestation rates between 2002-2011. The images were classified using band 3 (0.63-0.69µm), band 4 (0.76-0.90 µm), and band 5 (1.55-1.75 µm) in IDRISI and ArcGIS, and projected on UTM 21S (datum SAD69). The high-resolution images allowed distinct land cover to be categorised as: forest, pasture, scrubland, water, and bare-ground. Ground-truthing of property boundaries was conducted by the municipal administration of Alta Floresta, which determined geographic position and property size.

Data illustrating deforestation rates between 2002 and 2011 in Alta Floresta were obtained from PRODES, the deforestation monitoring program at the Brazilian National Institute for Space Research (INPE). Two LANDSAT-5/TM images dated 2008 and 2011 of the municipal district were used and overlaid onto the QuickBird images.

i. Socio-economic status

Within Alta Floresta, cattle ranching accounts for more than 95% of revenue from land use. Cattle-herd size was therefore used as a proxy to determine wealth ranking between properties. Based on property interview data, pasture area explained 86.7% of cattle-herd size and a mean density of 2.07 head per hectare of pasture was calculated for each property (M. Medeiros, unpublished data).

2.2.3 Measures of compliance

Compliance to policy requirements through forest set-asides and reforestation was determined using ArcGIS spatial analysis tools. Differences between compliance under requirements for the reformed and original legislation were calculated to determine local landowners' 'amnesty' under the legislation. The addition of deforestation data, while increasing the potential of bias due to differences in resolution, provided a clearer indication of legislation efficiency in managing ecosystem services and influencing land-use decisions, as well as differences in equity between landowner economic statuses.

2.2.4 Measuring equity and efficiency

A lack of baseline data for the Lombok case studies meant that it was beyond the scope of this research to determine whether outcomes were attributed to specific incentive-based approaches or to other factors within the socio-ecological system (Ferraro 2009). However, similarities and distinguishing characteristics between

communities with incentive-based institutions and control villages were used to identify links to the equitable distribution of benefits and resources, and the efficiency of governance mechanisms (Pascual et al. 2010). These characteristics included: Effort to obtain water; Level of participation in institutions and decision-making; Local perceptions of environmental responsibility; and, The conservation of natural resources (i.e. provision of ecosystem services).

In Alta Floresta, however, this study was able to determine efficiency and equity outcomes of natural resource governance. This analysis was conducted through the application of different institutional forest set-aside requirements under original and revised policy instruments. Efficiency was measured through the extent of forest ecosystem that was protected, i.e. level of compliance. Equity was measured as a distribution of policy reform benefits across different landowner wealth rankings, and landowners' ability to meet reforestation requirements and enter the market for deforestation offsets.

2.2.5 Measuring interplay and 'fit'

While there is much discussion on institutional interplay and fit within the existing literature, clear definitions are still lacking. Key elements that are suggested to enhance institution fit through SES adaptive management are, however, described by Galaz et al. (2008) and Olsson et al. (2007). These elements were developed to identify indicators of fit between ecosystem dynamics and institutional governance systems within the case studies. They included: Bridging organisations between local actors and communities with other institutions; Leadership; Focus of resource management; Timing; and Adaptability. The presence and extent of these elements indicated the degree of institutional 'fit' or 'mis-fit' within the case studies. Where institutions 'fit' local community contexts, interplay was assumed to be positive.

2.2.6 Analysis

Qualitative and quantitative data analysis was used to identify significant variables within each chapter. Questionnaire data was coded and recorded in Excel. Spatial data was extracted from ArcGIS and also recorded in Excel, log-transforming data where necessary to control for non-normal distribution (Osbourne 2002). For normally distributed data of continuous variables, parametric tests were used (regression, t-test). Data that was 'distribution free' and, therefore, did not fit the assumptions of parametric tests was analysed using non-parametric tests for rank and categorical variables (Mann-Whitney U test, Spearman rank correlation coefficient, Chi-squared) (Fowler, Cohen, and Jarvis 1998). Spatially-explicit General Linear Mixed Models (GLMM) were used to test the relationship of fixed and random effects of landowner compliance (Chapter 6). This model was used to analyse land-use decisions within hydrological basins and to control pseudo-replication (Bolker et al. 2009). All

analysis was conducted within Stata 12.0 and NVIVO. Statistical significance was measured with a probability value of 0.05.

2.3. Study site selection

Two different study sites were selected to examine the issues of equity and efficiency in managing ecosystem services by the provision of incentives for land-use decisions. It was important to select case studies that highlighted the social, cultural, economic, biophysical, and political dimensions that influence these decisions. It was imperative to understand how the dynamics of these dimensions impacted these decisions, and therefore equity and efficiency outcomes of ecosystem management.

The Lombok case studies presented in this thesis illustrated how these contexts influenced access to and availability of natural resources, and, therefore, how institutions developed to manage resulting land-use decisions. This provided an small-scale arena in which to examine how – with different drivers of resource use and management – institutions aligned with the contexts in which they functioned. This was demonstrated through the diversity of stakeholders, and how individuals placed different demands on the use of common pool resources.

The study communities were specifically chosen because of the existence of incentive-based institutions that influenced land-use decisions and managed ecosystem services provision. Each mechanism was designed to provide incentives for environmental behaviours to benefit downstream users and protect the functional environment. These programs used religious motivations, traditional *adat* social norms, and economic compensation to encourage more sustainable use of water and forest resources. The communities and local governance institutions managed two separate schemes at the village level, and a third scheme was initiated and managed externally by an intermediary stakeholder group. To measure the impacts of incentive-based institutions on access to and availability of resources, land-use decisions, environmental values, and perception of benefits, appropriate control communities were selected through matching (Pattanayak 2009). These were chosen due to their comparative experience of environmental resource issues (i.e. in close proximity to incentive-based institution communities, within the same watershed, at the same altitude etc.), and similar population sizes, water supply, and socio-cultural and economic statuses.

The Alta Floresta case study presented in this thesis illustrated to what extent ecosystem services management can be used to provide incentives for compliant land-use decisions. It was important to identify how the institution, in particular after its reform, affected landowner agricultural efficiency (in terms of productivity and revenue) and how socio-economic status impacted the ability (and desire) of

landowners to comply with conservation requirements or to enter a market to offset illegal environmental behaviours. This case study offered a broad regional view on the impact of large-scale government mechanisms, which were used to motivate landowner behaviour. The municipal district of Alta Floresta was chosen to examine and model the relationships between landowners and the social, biophysical, economic, and political contexts in which they made land-use decisions, and the efficiency and equity outcomes of institutional governance. The landscape was clearly defined as pasture or forest, which enabled a clear spatial analysis of the relationship between economic ability to meet the cost of compliance and the conservation of forest ecosystem services.

In the following section, the study sites are discussed in more depth and the institutions are examined that manage ecosystem services.

2.3.1 Study site: Lombok, Indonesia

Lombok, Indonesia, the 'Island of a Thousand Mosques,' is an island within the Nusa Tenggara Barat Province, eastern Indonesia. As one of the most densely populated islands in Indonesia, with a population nearing 4 million people, there is intense pressure on limited island resources to meet growing population and agricultural demands. Expanding settlements, agricultural intensification, and inadequate infrastructure are degrading upper catchment areas. This significantly affects water availability (Pirard 2012, WWF-Indonesia 2001). The impact on water resources contributes to hydrological ecosystem services stress, and creates issues for sustainably managing water supplies (Klock and Sjah 2007).

After the 1997 fall of President Soeharto's centralized 'New Order' regime, significant changes in formal governance have taken place throughout Indonesia. The reforms of the political system were called *Reformasi.* These included the decentralisation of governance to provincial, district, and local levels. It has resulted in shifts in formal governance and the realignment of power relations. Some argue, however, that decentralization of governance has merely 'reorganized, but not transformed' power relations in local contexts (Fritzen 2007). Indonesia contains multiple traditional, religious, ethnic, economic, and political institutions. The complex mix of complementary and competing institutions has had a varied impact at local and regional levels (Ostrom et al. 1999).

Ecosystem services management on Lombok

Ecosystem services management on Lombok is complex. There is significant variability in topography, climate, land-use, and governance institutions across the island. Multiple institutions have emerged during the *Reformasi* period to govern ecosystem services. This institutional response presents a highly applicable

framework in which to research the emergence of institutions that are designed to manage ecosystem services for greater equity of resource distribution and sufficiency of use.

The province is divided into four regencies (*kabupaten*), and one municipality *(kotamadya)*: Mataram City, West Lombok, North Lombok, East Lombok and Central Lombok. Within each *kabupaten*, the land is divided into villages (*desa)* and sub-villages or hamlets (*dusun*). Farms on Lombok, as with much of Indonesia, are small-scale, and often cover less than 0.5ha. Tenure is difficult to ascertain in Indonesia. Different interpretations of unclear formal and customary laws undermine land rights and existing complex land registration systems (Resosudarmo et al. 2014). Land tenure is also determined by its location. Outside forested lands, the Basic Agrarian Law (1960) secures land tenure through titles. Within forested lands, the New Forestry Law (1999) provides management and lease rights. Legitimate *de jure* land rights are difficult to obtain and communities frequently act with customary *de facto* rights. This structure creates complex conflict between customary and statutory land tenure (Resosudarmo et al. 2014).

Multiple institutions, from central and regional government to local customary laws, manage land and water conservation strategies on Lombok. At local *desa* and *dusun* levels, water is managed through two institutions: Water User Associations (WUAs) and *Subak* (a tradition-based institution). As part of decentralization of water management, WUAs were introduced in the early 1980s by the government throughout Indonesia (Klock and Sjah 2007). *Subak* is a traditional institution, which enables water distribution through payments for irrigation access (Sayuti et al. 2004).

Traditional local Lombok Sasak customary laws are also influential in protecting forests around springs to enable water flow. This thesis focused on WUAs on Lombok, and how they used different approaches to provide incentives for ecosystem conservation for water provision. Monthly, in-kind, payments called *suwinih* were made to WUAs for infrastructure maintenance and WUA officers. The amount varied across Lombok between US$1-3 (Klock and Sjah 2007). This study used incentive-based approaches by WUAs to study how the motivation of behaviours enabled more effective and equitable water allocation and ecosystem services management. For the purpose of this thesis, case studies were defined as ‘incentive-based’ when WUAs used incentives to motivate behaviours, and ‘control’ when WUAs did not use incentives. Other institutions to manage natural resources were in existence in both ‘incentive-based’ and ‘control’ study sites. But for the purpose of this study, a focus was placed on the elements of natural resource institutions that provided incentives for pro-environmental behaviour.

Description of case studies: Lombok

i. Religious - Asih Tigasah, Ledang Nangka Village, East Lombok Regency

The community-based programme in Ledang Nangka was initiated in 1993 by the local village government to reduce conflict over water access. Situated on the plains below Mount Rinjani, deforestation is not a direct threat to water supply, but agricultural and population expansion has placed increased pressure on access to the resource. A local water management company, BUMDES, was created to reduce conflict and maintain water supply to households and the local mosque. Monthly payments are made to BUMDES to manage the programme, maintain and pump water to households and the mosque, and oversee a community *embung* (reservoir). Non-compliance by community members led to fines or removal of access to the piped water infrastructure.

The mosque played a central role in this community programme, and retained 45% of all payments. Religious sentiment is prevalent throughout Lombok, but is particularly apparent in East Lombok Regency where orthodox Islam underpins much of society and policy (Klock and Sjah 2011). In Ledang Nangka village, programme activities like budgets, and communal activities to maintain water supply and project developments, were communicated in the mosque during Friday prayers. Virtually all community members attended the mosque, and this communication was an effective mechanism to enable transparency. The use of the mosque to communicate programme details and requirements also enabled BUMDES to draw on the community's religious heritage to ensure adherence to rules surrounding water resources.

ii. Traditional - Gangga, Genggelang Village, North Lombok Regency

Traditional Sasak customary laws known as *adat* play a key role in certain Lombok communities. The laws determine and control individual and collective behaviours (Krulfeld 1966). *Adat* in Gangga used *awiq-awiq*, the *adat* law of the village, to motivate collective activities to manage the environment. Situated at the top of the water catchment, close to the border with Mount Rinjani Protected Forest, the village had experienced significant conflict with other communities over water supply. Illegal logging by outside companies following the decentralization of power also degraded the forest around springs that supply water.

Significant importance is place on *adat* in the more traditional communities found in North Lombok. Islam still plays a role in the societal beliefs and norms of *adat* communities. The religion divides Sasak culture into *Waktu Lima* and *Wetu Telu* communities. *Waktu Lima* follow a more orthodox Mecca-oriented version of Islam, based on the Sunni sub-sect of the religion. *Wetu Telu*, the religious minority, follow

certain orthodox Islamic principles, but also draw on local, pre-Islamic norms that share a common ancestry with Hinduism and Buddhism (Harnish 2005, Avonius 2003).

Islam has been *"*driving force of change*"* in Lombok (Harnish 2005). Inter-Islamic conflict between *Wetu Telu* and *Waktu Lima* remains with *adat* activities (Avonius 2003). Under the New Order regime of former President Soeharto, *Wetu Telu* customs were punishable and individuals participating in these religious rituals could be arrested. Since the *Reformasi* era began, there has been a revival in *adat*, which has gained significant influence in the community governance structures in northern Lombok (Avonius 2003). *Wetu Telu*, or 'three laws,' now refers to *adat, agama* (state sanctioned world religions), and *pemerintahan* (government and civil law).

Adat in Gangga was based on a network of mutual social obligations that enabled community organization. The community used *adat* to develop informal institutional rules, or *awiq-awiq,* to deal with conflict over water use and protect further degradation of forest resources. These informal rules aimed to ensure greater equity in resource access. They also focused on the management of infrastructure to prevent future extreme drought events.

Awiq-awiq regulated the protection of forest around springs (33ha) by prohibiting logging and land degradation. It also supported pipe water infrastructure through ad hoc payments. Non-compliance with community obligations was met with *maliq,* or taboo in nature, and was punished through the removal of household piped access or fines. *Awiq-awiq* in Gangga relied on collective activities to protect natural resources. It was based on the use of accepted social norms to encourage positive environmental and social behaviours, which ensured water resource sustainability.

iii. Economic - Lebah Suren, Sedau Village, West Lombok Regency

The economic incentive-based scheme in the Dodokan watershed, West Lombok Regency was the closest case study to a archetypal PES scheme on Lombok, based on Wunder's (2005, 2006) criteria. High levels of land degradation, illegal logging in the Mount Rinjani protected forest, and unsustainable harvesting practices have decreased the quality and quantity of local water resources. (Prasetyo et al. 2009, Fauzi and Anna 2013). Rising levels of tourism and urban expansion also have increased demand for ecosystem-related products, and have worsened habitat degradation. The increased pressure on springs for water reduced the overall number of springs by 40% since 2003, (Fauzi and Anna 2013, WWF-Indonesia 2001, Prasetyo et al. 2009).

To restore the watershed, following an economic valuation by WWF Indonesia-Nusa Tenggara Program and a willingness-to-pay assessment by KONSEPSI (a local NGO), a beneficiaries-financed scheme was initiated in 2007 that was based on

administrative contracts (de Buren 2013, Prasetyo et al. 2009). By providing financial incentives to upstream communities, the project aimed to conserve and restore forest areas, particularly around springs. An intermediary public body – IMP (*Institut Multi Pihak*) – of multi-actor stakeholders, which consisted of local government agencies, NGOs, Lombok's drinking water company (PDAM), and representatives of upstream communities, implemented the scheme.

Lombok's local regulation, *Peraturan Daerah 4/2007,* on the management of environmental services includes provisions for "PES." These rules provided the basis on which to add a monthly tariff on water rates in West Lombok Regency and Mataram Municipality of Rp 1,000 (US $1) per household. The program came into force in 2009. Conditional agreements between providers and the IMP began in 2010. The IMP allocated funds for forest restoration through tree nurseries and the planting of trees in community forest (HKm) areas in upstream regions to compensate for unsustainable harvest practices and land use. To date, more than Rp 445 million (US $45,500) has been distributed to four farmer groups in various villages that cover approximately 300ha of upstream forest land (Fauzi and Anna 2013). The selection process for community proposals to receive payments was unclear. There also was little, if any, control or mapping of conditional activities, and it was difficult to ascertain the program's level of success (de Buren 2013). The control of fund transfers from users to providers through legislated tax undermined the voluntary nature of PES. Legal loopholes also allowed the Mataram Municipality to avoid the tax contributions within the West Lombok Regency.

Lebah Suren is a community that receives funding from IMP under the PES-like scheme. A single farmer group, who owns land within the HKm community forest, received finance towards the restoration of deforested land through the plantation of fruit and timber trees. The group also received money for "economic development." This development funding was a flexible payment to provide micro-finance within the community. To date, only one year of payment has been received in 2011 and the community "*will not be applying again as* [they] *do not have the need,"* village head, Lebah Suren. Much of the community was focused on sustaining two communally owned hydroelectric power generators that provide electricity for the sub-village. This focus drove forest protection, as the community must maintain water flow and foster collective activities such as pipe maintenance to prevent *"people downstream taking too much water".*

While this case study exhibited user-pays principles and directness, it did not fulfil all of the criteria for a typical PES scheme as documented in the existing literature. It did not meet the criteria of conditionality, voluntary contracts, and additionality (Engel, Pagiola, and Wunder 2008, Ferraro and Simpson 2002, Kemkes, Farley, and Koliba 2010, Muradian et al. 2010, Sommerville et al. 2010, Tacconi, Mahanty, and Suich 2011, Wunder 2005, 2006, Wunder, Engel, and Pagiola 2008). Conditionality within

the program was weak due to a lack of continued payments to community groups and low levels of monitoring and enforcement. It also was difficult to determine the extent of additionality in Lebah Suren, as there were multiple institutions at play within the community.

2.3.2 Alta Floresta, Mato Grosso, Brazil

The highly biodiverse Brazilian Amazon ecosystem provides multiple ecosystem services which benefit local, regional, and global environments and communities (de Souza, Miziara, and Junior 2013). The protection and maintenance of these ecosystem services, however, compete with the growing demand to convert forest habitats for agricultural land. The complex social, economic, ecological, and political processes and interactions drive deforestation of native vegetation in rural land-use systems. This is having an impact on the function of forest habitats and hydrological systems, through the loss and degradation of riparian forest areas.

Since 2005, overall deforestation has decelerated, with a reduction of 70 % between 2005 to 2013 (Nepstad et al. 2014). This has been based on a combination of increased political focus to address the drivers of deforestation through regional policies; punishment for illegal forest clearance such as the introduction of restrictions on access to markets and rural credit, fines and embargoes; and a period of low commodity prices (Della-Nora et al. 2014). Further legislation expanded protected areas and indigenous territories by 68 %, which now cover 47 % of the Brazilian Amazon (Nepstad et al. 2014).

For the agro-industrial Amazon frontier, however, deforestation remains relatively high, particularly within private properties (Rosa, Souza, and Ewers 2012, Bowman et al. 2012). The drivers of deforestation and their impact on land-use decisions remain. These include: Landowner response to commodity markets, and an increased global demand for soy and beef products; Economic subsidies to expand pasture; Weak enforcement and monitoring; and, Corruption (Brando et al. 2013). This results in inefficient management of ecosystem services and inequitable outcomes in addressing deforestation. The outcome of the recent implementation of institutional reform to motivate landowners to protect forest within private properties is, as yet, unknown. This may have implications for both private landowners and the provision of ecosystem services.

Ecosystem services management in Brazil

Forest ecosystems and the services they provide are managed and protected through multiple policies and regulations in Brazil. These include national policies such as the National Plan for Deforestation Reduction in 2004 and the National Policy on Climate Change in 2010. In total, protected areas, indigenous reserves, and legislation requires the protection of forest on private properties. With approximately 53 % of native

vegetation based within private properties, the conservation of forestry resources in these landholdings is important to maintain ecosystem function. The policy and regulatory approach has attempted to manage land conversion for agricultural expansion on private properties through the Brazilian Forest Code (FC) (Soares-Filho et al. 2014, Stickler et al. 2013).

iv. Case study description: Alta Floresta, Mato Grosso

The municipality of Alta Floresta within the State of Mato Grosso, Brazil is situated along the 'Arc of deforestation' in the Amazon. Land conversion to meet growing agricultural demands for cattle ranching and monoculture cropland expansion has driven deforestation (Rosa, Souza, and Ewers 2012, Rudel 2005, Lapola et al. 2014) (Aguiar, Camara, and Escada 2007, Fearnside 2005, Laurance et al. 2002, Michalski, Metzger, and Peres 2010). Rates of deforestation are sensitive to socio-ecological system dimensions and interactions. In particular, political change, economic markets, and demographic fluctuations impact deforestation behaviours (Rosa, Souza, and Ewers 2012, Rudel 2005). Land conversion as a result of deforestation has a significant impact on ecosystem services across multiple scales (Hayhoe et al. 2011, Fearnside 2005). In large-scale basins such as the Amazon, the governance of ecosystem services requires an effective and high-impact response.

The FC was implemented in 1965 and required private landowners to maintain 80 % of their land as legal reserves of forest, and to protect riparian forests along rivers and streams. For private landowners, there was considerable opportunity cost in setting aside land that could potentially be used for agricultural revenue. For ecosystem services, further deforestation risked habitat fragmentation, changes to hydrological services through loss of riparian forests, and loss of biodiversity, carbon storage, and soil nutrition. The FC implementation has generated controversy from both landowners and those looking to conserve forest and slow deforestation (Stickler et al. 2013). Attempts to reconcile landowners' desires to maximize utility with forest conservation have been complex. A lack of legislative clarity, weak enforcement, the perceived cost of compliance, and high agricultural revenues were influential in the outcomes of the FC in changing landowner behaviour.

Changes in 2012 to the Brazilian FC governance of forest ecosystem services on private properties significantly reduced conservation requirements. These policy changes created divergent benefits for small and large properties. That includes different implications related to the amnesty of environmental debt and the opportunity to purchase or sell surplus forest areas to offset forest areas on non-compliance. The impacts of these differences on providing incentives for compliance presented a highly applicable case study, in which to research the equity of large-scale ecosystem services management institutions and their influence on land-use behaviours.

2.4. A critical reflection on the different methods used in Lombok and Alta Floresta

As with all methodologies and their application, there are limitations and constraints to the case studies used in this thesis**.** The use of the two case studies is unusual due to differences in geography, institutions, and scale between Lombok and Alta Floresta. They were chosen, however, to identify the complex reality of incentive-based mechanisms in their local understanding, implementation, and outcomes.

Spatial analysis is a useful tool to determine governance responses by landowners to incentives, in particular over long timeframes. The lack of available macro-scale data for Indonesia, the micro-scale nature typical of Indonesian farmers, and the complexity of tenure across Indonesian provinces meant that such a study was not feasible for this thesis. The high-resolution images of a municipality in Alta Floresta enabled the use of this methodology to enable understanding through aerial observations of actor-specific responses to policy incentives. A broader spatial analysis across Lombok was used to identify baseline environmental parameters. The use of multiple images with different resolutions and various sources presents limitations and greater margins of error. In addition, the generalisation that spatial analysis can generate may omit some of the complexities of heterogenetic landscapes and the multiple variables that influence landowner behaviour and environmental variation (Godar et al. 2014).

In the Lombok case studies, there are number of assumptions in the application of matching. To select relevant comparative variables, the complexity of underlying processes and dynamics within, and between, villages must be understood (Ravallion 2005). The comparative variables used in this study were based on observations over a short period of time. This may, therefore, give rise to bias related to unobserved variables, variables that were influenced by incentive-based mechanisms, or variables that were not controlled for (Clements 2012). These limitations are important to consider, especially in the context of monitoring and evaluation of PES programmes where baseline information is often absent and the construction of PES itself may be built on assumed observations.

The use of both the Alta Floresta and Lombok case studies was important to illustrate the complex reality of implementing incentives at local and national levels, when the projects are community- and policy-driven. It is important for practitioners of PES and incentive-based conservation to understand the realities of such natural resource governance. Due to time constraints in data collection and data availability, the use of these two case study countries was required. While this does give rise to issues of comparability through geographical, institutional, and land-use model differences, the two case studies provided insight into different methodologies when investigating

incentives-based institutions and the broader theoretical issues that arise from their implementation.

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3 Surrounded by water, but not a drop to drink? Implications of island water stress on Lombok, Indonesia

3.1 Abstract

Water resources are increasingly perceived as 'critically stressed', particularly in island ecosystems where resources are finite. On Lombok, Indonesia, a rapidly growing population is placing pressure on catchments. These areas must provide adequate water supply and access for multiple urban and agricultural sectors. Household surveys conducted in communities across the island's catchment identified use, access, and availability of water resources in relation to wealth and environmental variables. While there are multiple definitions of 'water scarcity,' it provides a clear example of the unpredictable nature of applying theoretical definitions and resource governance to the complex realities on the ground. The perceived nature of localized scarcity is stark for Lombok's rural populations in the upper catchments in isolated regions. Inadequate access to water and relevant infrastructure can have significant implications for agricultural productivity and crop revenue. These limitations can exacerbate a cycle of poverty, a lack of access to resources, and potential inequality. Management of water may allow a more sustainable use of the resource. This management must come from a demand-driven perspective to improve efficiency of resource use and enable improved access to water infrastructure for rural communities.

3.2 Introduction

Water is a complex resource fundamental for survival. Hydrological ecosystem services provide benefits for human-wellbeing, biodiversity, and the economy (Kemkes, Farley, and Koliba 2010, Nelson et al. 2009a, Carpenter, Mooney, Agard, Capistrano, DeFries, et al. 2009). Water availability, and allocation and access to the resource, is a major constraint for agriculture, livelihoods, poverty, and wellbeing (Rijsberman 2006, Rockstrom et al. 2004). When scarce, water has biophysical, social, economic, and political effects. These effects can lead to ecological and societal instability that may threaten the sustainability of natural resource use.

Water resources are inextricably linked with, and affected by, the social-ecological system (SES) in which they are found (Anderies, Janssen, and Ostrom 2004). Ecosystem services, including water, interact with, and are interdependent on, the social system(s) within the wider SES. The resilience of water resources in a SES can be both enhanced and lost. It can be driven by interactions between social and ecological systems. Yet what factors impact the availability and access of water resources?

The governance of local water resources faces multiple challenges because of the extent, nature, and complexity of water-related conflict, security, and institutional cooperation. A multidisciplinary SES management approach is required to understand the contextual dimensions of the biophysical, social, economic, and political factors that determine availability, access, and demands for consumption (Calder 2005). Conflict over water resources can arise from these interconnections. Where multiple stakeholders hold diverse values and place many demands on water for land-use, tensions over rights can be created. Access rights are often highly complex. There are political considerations related to land-use, power relations between stakeholders, and historical management issues related to the resource (Calder 2005). Consequently, the dynamic interrelations between hydrology, ecosystems, land use, and population requirements must be understood. These interconnections can help determine drivers of water stress, and create sustainable and multi-use management systems.

This paper investigates what factors determine the availability of household water resources for communities on Lombok. Determinants of water availability can be physical or social, and are closely linked to SES dynamics (Anderies, Janssen, and Ostrom 2004). Water related conflict is a key issue for communities on Lombok. It is necessary to understand factors influencing household access to and availability of water resources to implement efficient and equitable governance. This paper aims to identify areas of water stress and vulnerability for Lombok communities. It also seeks to determine whether current infrastructure availability and management approaches are sufficient in the face of increasing pressure on natural resources and whether 'water scarcity' definitions are reflective of the realities present on the ground on Lombok.

3.2.1 The concept of water scarcity

The concept of water scarcity is complex and is connected to multiple definitions. Both a biophysical phenomenon and a social construct, water scarcity depends on the scale in question (global or local), and whether it is a supply or demand issue (Cook and Bakker 2012, Falkenmark 2003, Falkenmark and Lundqvist 1998, Falkenmark, Lundqvist, and Widstrand 1989, Rijsberman 2006, Mehta 2001, Lankford et al. 2013, FAO 2007). True physical water scarcity may impact supply, but available water that is unable to be used efficiently can affect demand. Symptoms of water scarcity include severe environmental degradation (including river desiccation and pollution),

declining river basin water availability, and increasing problems of water allocation where some groups win at the expense of others (FAO 2007).

It is important to understand how the concept of water scarcity is constructed. Depending on which definition is used for governance, the "real causes of scarcity may be obscured, leading to inappropriate" solutions (Mehta 2001). Water scarcity, in itself, may be a perceived concept. Dwindling rainfall and increasing droughts can mask wider climate uncertainty or regional variations. Scarcity also can be felt more intensely now than in the past, despite total volume and temporal variation remaining unchanged (Mehta 2001). While definitions can often be limiting, it is important to assess relative scales of resource scarcity. These relative scales determine their value to resource users: "As scarcity of water goes up, so does the competition for water among users", (Rijsberman 2006). Defining water as scarce is dependent on: (1) How 'needs' are defined – i.e. whether environmental needs are also accounted for; (2) The proportion of resource that can be made available to satisfy these needs; and, (3) What temporal and spatial scale is used in defining water scarcity.

Definitions also determine the indicators that are used to assess water scarcity. The indicators include: the Falkenmark Water Stress Indicator where areas with less than 1,000 m3 of water available per capita per year are experiencing water stress (Falkenmark, Lundqvist, and Widstrand 1989); Water Resources Vulnerability Index; Water Poverty Index (Sullivan et al. 2003); and physical and economic scarcity indicators (Rijsberman 2006).

For the purpose of this paper, I will define water scarcity as when individuals have reduced access to safe and affordable water for household consumption and their livelihood needs (Rijsberman 2006). The scope of this paper will focus on local assessments of water scarcity and stress using proxy indicators. Proxy indicators will include acquisition effort to obtain household water supply, infrastructure availability (household water source), and river basin water balance. This definition and research method were chosen because of data limitations and because problems relating to water availability are often local (Rijsberman 2006, Sullivan et al. 2003). The study examined issues impacting access and availability of both domestic and agricultural water resources. When investigating acquisition effort, however, this paper focused only on domestic water supply. Water management of domestic water supply on Lombok is examined in later chapters (Chapter 4 and 5), and therefore investigating the context of scarcity is useful to inform further discussion regarding benefits from and alignment of management institutions.

3.2.2 Island water systems and water scarcity

Water resources are highly dynamic. They can have significant temporal and spatial variation in quality and quantity. This is highly apparent on island ecosystems because island SESs are heavily constrained by their size, isolation, geology,

typography, climate, and hydrology. Social capital and economic development issues also affect island SES. On islands, the finite availability of a narrow natural resource base is a limiting factor: "Water scarcity is common on islands," (Hophmayer-Tokich and Kadiman 2006). A highly sustainable management approach is therefore crucial. While water scarcity is common, its causes can arise from varying physical and climatic conditions, depending on the island in question. Even islands with high rainfall may have limited groundwater storage capacity (through limited surface area, steep topography, easily eroded soils and short river channels). That can create freshwater scarcity during dry seasons (Khaka 1998, Hophmayer-Tokich and Kadiman 2006).

Land use types are also highly significant in the scarcity of resources. They determine water availability, allocation, and access. Many deforestation and land clearance processes and outcomes can increase pressure on, and problems with, water resources. That can lead to excessive run-off (Hophmayer-Tokich and Kadiman 2006). The rural poor are particularly vulnerable to changes in water availability, and extreme events such as floods and droughts. These events can cause shifts in market prices related to natural resource management that affect livelihoods. This vulnerability to market fluctuations has the potential to create both a cycle of poverty and a high level of water scarcity (FAO 2007).

The way in which institutions function is key to the cycle of land use, water availability, and poverty. Effective governance of water resources, including managed allocation, is vital to reduce water stress. Where governance systems are weak or fragmented with multiple agencies, unequal water resource distribution may add to local water scarcity. Water scarcity for the poor is therefore significantly linked to institutional function. The level of transparency of decision-making and the degree of equitable outcomes guaranteed by those in power also play a role (FAO 2007).

3.3 Lombok

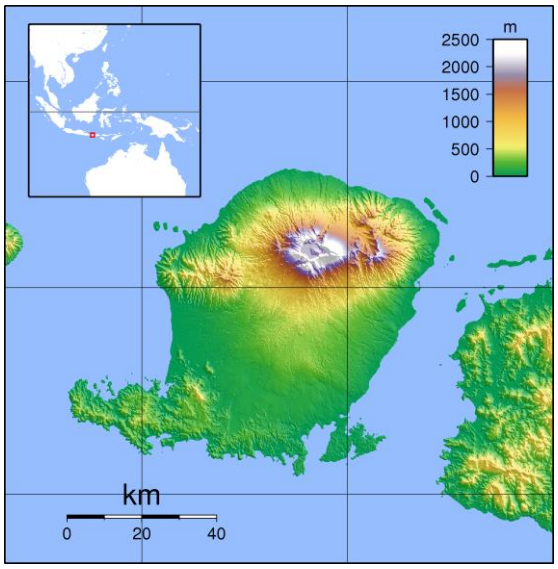

Figure 3.1 Location of Lombok within Indonesia, illustrating altitude variation. Source: Creative Commons http://upload.wikimedia.org/wikipedia/commons/8/83/Lombok_Locator_Topography.png

The island of Lombok is part of Nusa Tenggara Barat (NTB) province in eastern Indonesia (Figure 3.1.). It is facing increasing pressure on limited water and forest resources to support its rapidly growing population, demands from agriculture, and changes in climate. Situated between 8°12' and 8°55 South and 115°46' and 116°28' East, Lombok has an area of 4,619 km^2, and spans just 60 km by 80km at its widest point. The island is dominated by Mount Rinjani (3,726 m), which plays a significant role in the island's hydrological cycle. The mountain functions as one of Lombok's main water catchments (FFI-Indonesia and BATBP 2012b). Three of the four main Watershed Management Areas (SWP DAS) are connected to Rinjani. The fourth is fed by Mount Sabiris (716 m) in the south west of the island (Asatawa 2004a, Rosalita 2012).

3.3.1 Water use and drivers of watershed degradation on Lombok

Lombok's highly variable and seasonal climate makes the island inherently vulnerable to changes in environmental variability (Butler et al. 2010, Asatawa 2004a, Butler, Habibi, et al. 2014). Rainfall is one of the most important climatic factors, and it averages 1,593.36 mm per year (Butler et al. 2011, Rosalita 2012). Variation in precipitation distribution is greatly affected by steep topography. That specifically includes Mount Rinjani in the central north, its surrounding hills, and the low-lying plains to the south of the mountain. The northwest of the island receives the greatest amount of rainfall. Precipitation patterns create a defined wet (November to February, 200-500 mm per month) and dry (June to September, 25-100 mm per month) season (Rosalita 2012). As rainfall is one of the most important water resources, it has led to the dominance of rain-fed agriculture and *embungs* (water reservoirs).

Surface water from rivers, streams, and springs, is used for domestic use and irrigation channels in rural areas. Surface water availability is determined by topography, climate and land cover. Current surface water potential has been calculated as 3,904.54 Mm^3 (Rosalita 2012). Urban areas connected to domestic and industrial use rely on ground water sources when surface water is unavailable. Current ground water area has been mapped at 3,761 km^2 (Rosalita 2012).

Topography in Lombok can be split into three categories: Upper slopes, lower slopes, and alluvial plains. The categories determine water availability through patterns of spring and river distribution. Surface water is used for all types of water needs, except in main towns such as Mataram, the capital city on Lombok, where ground water is used for domestic industrial use (BAPPEDA, 2012). Agriculture across the alluvial plains dominates the use surface water. In these regions, dams, irrigation channels, and *embungs* have been created to divert water resources for irrigated fields, land fisheries, livestock, and plantations. Potential water availability is divided between four main basins, with 197 sub-watersheds. One is located north of Mount Rinjani with area of 1,124 km^2; and three are situated south of the mountain with an area of 2,366 km^2 (BAPPEDA, 2012).

3.3.2 Land cover and land use

Lombok is a complex agro-ecosystem. Its ecosystem services are "dependent on and impacted on by people" (FFI-Indonesia and BATBP 2012a). Forest cover on Lombok (1,465.74 km^2, 31.73 % of the island) is limited to the upper catchments on Mount Rinjani and isolated patches in the southeast. The island's forests range from upland dry-land forests to mangroves along the coast. There is significant variation in the management of forests according to stakeholder type, their use, and government involvement (Asatawa 2004a). Forests are classified and protected as: National Park, Protected Forest, Community-Production Forest (*Hutan Kommutasi* - HKm), or Limited Production Forest (Figure 3.4) (Asatawa 2004a). Community-Production and Limited-Production forests allow for restricted extraction and use of forest resources. Limited local opportunities for alternative livelihoods and low levels of enforcement create a dependency by some communities on these resources for subsistence and income generation.

Figure 3.2 Aerial view of land use and forest on the slopes of Mount Rinjani, Bayan, North Lombok (Photo: P. Habibi, 2012).

Since the reform era (1998-1999), significant deforestation has converted large forest areas to plantation agriculture (Figure 3.2). Between 1999-2006, 57.15 km^2 of forest (3.49 %) were cleared and a further 197.92 km^2 (13.50 %) was converted from primary to secondary forest (FFI-Indonesia and BATBP 2012b). Deforestation and forest encroachment have also been exacerbated by policy changes. Removal of government kerosene subsidies in 2008 led to an increased use of fuel wood for both households and industry, particularly for tobacco curing. Distrust of the local government, and a lack of tenure within Community-Production forest (including customary *adat* forest rights) have discouraged long-term conservation.

Further conversion of forested lands to agriculture has affected total water yield by altering the balance of infiltration, evaporation, and runoff in the hydrological resource (Costa, Botta, and Cardille 2003a, Calder 2005). While the effect of forest ecosystems on water is complex and site specific, the loss of forest riparian habitats compromises the functional quality of ecosystem services and the watershed (Sweeney et al. 2004, Calder 2005, Wunscher, Engel, and Wunder 2008).

3.3.3 Water use and drivers of watershed degradation on Lombok

What does the notion of 'water scarcity' mean on Lombok? There are multiple factors driving the degradation of watersheds on the island at geographical and temporal scales.

i. Demographics

Lombok's rapidly growing population, high poverty rates, and lack of alternative livelihoods have placed pressure on the island's limited resources. Lombok had a population of 3.17 million in 2010, with an annual growth rate of 1.17 %, (FFI-Indonesia and BATBP 2012b, Fachry, Hanartani, and Supartaningsih 2011, Klock and Sjah 2007, BPS 2010, Fachry et al. 2011). The island's population is expected to grow to 4.46 million by 2050 (Fachry et al. 2011). The local populace has exposed Lombok's ecosystems to deforestation and degradation of watersheds within the expanding settlements (Suhartanto et al 2012). While Lombok's overall population growth rate has steadily declined between 1971-2010, urban populations have increased by 41.7% over the same period (Fachry, Hanartani, and Supartaningsih 2011). Poverty levels have also declined from 30.4% in 2001 to 21.6 % in 2010. Lombok's Human Development Index currently stands at 64.66, and reflects a low life expectancy (67.5 years, compared to 71.0 years in all of Indonesia), low levels of literacy, education and income of the population.

ii. Land use

The average farm size on Lombok is 0.47 ha per household. Approximately 80% of water resources are used in crop agriculture, although farmers' productivity on agricultural land is limited (Sayuti et al. 2004, Rosegrant and Ringler 2000). Paddy-field distribution is centred around the lower catchment of Mount Rinjani where irrigation is possible, and rainfall is greater. Tobacco plantations and vegetable smallholdings are located throughout the southern plains, which rely more on rain-fed water supplies. The majority of Lombok's agricultural production is rain fed, and there are few irrigated fields (ratio of 2.5:1.0 respectively) (Klock and Sjah 2011). Multiple cropping occurs relative to climatic seasonal changes. Approximately two rice-intercropping harvests and one fallow period take place at the end of the dry season.

Upland catchment communities predominately rely on agroforestry, including plantations of cacao, coffee, and coconut. Lowland communities focus on intensified crop production, primarily driven by industrial tobacco plantations that supply 70 % of all Indonesian tobacco (Choy 2012). This industrial and intensified agricultural production in lowland communities places significant pressure on local water resources, soil fertility, forests, and the long-term sustainability of the ecosystem.

iii. Water use

There are multiple uses of water from within Lombok's catchments. These includes domestic and industrial use in the urban centres, and agricultural and ecosystem maintenance in the rural catchments (Table 3.1) (Franks, Lankford, and Mdemu 2004). Water allocation systems present a significant challenge. They must supply

both urban and rural domestic and agricultural demands (Klock and Sjah 2007, 2011). Indonesian water utilities (PDAM) are responsible for distribution and conservation of water. This includes managing pipelines and protecting water resources at their source. PDAM services do not always reach rural communities. The coverage drops to 14 % of communities in the rural West Lombok Regency (Klock and Sjah 2007). Rural populations therefore rely on wells or, in higher elevations, springs, which, if communities can afford the infrastructure, are piped to households. For these marginal communities, access to clean water comes at a higher price, both financially and in effort needed to obtain water for their household needs (Asatawa 2004a). For upland communities, the reduction in spring numbers has increased the distance and time spent to collect household water (Klock and Sjah 2007, Asatawa 2004a).

Table 3.1. Water consumption in Lombok by use (million m3 or mcm) (Klock and Sjah 2007).

	Domestic	Agriculture	Industry	Other
Consumption	294	5,762	35.62	663
Percentage	85.0	0.5	4.3	10.2

Growth in population, agriculture, and economic activities increases the demand of freshwater supply (Suroso, Abdurahman, and Setiawan 2010). Expanding human settlements continue to extract a greater proportion of water that had previously been allocated for agricultural production. Limited infrastructure also can not meet urban water demands, which creates a deficit water balance and reduced water flow (Asatawa 2004a). In the West Lombok Regency, for example, the Sesoat River flow rate dropped from 16.03 m^3/sec in 1996 to 9.09 m^3/sec in 2002 (Klock and Sjah 2007). Urbanisation also affects water quality because of a growth in water pollution and inadequate waste management systems. Currently, 6.0 % of Lombok's inhabitants rely on unprotected water supplies and 43.8 % of households lack proper sanitation facilities (Fachry et al. 2011).

The water balance on Lombok is becoming critical. Surface and groundwater struggle to supply irrigation needs, and the domestic and industrial demands of a growing population (Suroso, Abdurahman, and Setiawan 2010). In Lombok, the existing surface water supply (2,024.98 Mm^3/yr) is unable to meet current demands (3,606.32 Mm^3/yr) (Rosalita 2012). While there is an estimated potential surface water availability of 3,904.54 Mm^3 per year, infrastructure and water resource limitations are creating water balance deficits in some watersheds. Decreased and unreliable surface water availability is increasing demand for, and reliance upon, groundwater wells. Rapid development in the upper catchments is reducing reabsorption, and in municipal areas, water consumption is exceeding the ability of

groundwater aquifers to recover supply (FFI-Indonesia and BATBP 2012a, Rosalita 2012).

These issues related to expanding populations and settlements are linked with a degradation of upper rural watersheds, which has led to increases in floods and landslides. The growing pressure on Lombok's limited water resources has exposed the vulnerability of the poor to changes in resource availability. It also may lead to the potential for increased elite capture of resource benefits. These issues present serious challenges, in both urban and rural areas, to the equitable and sustainable supply of water across Lombok (Klock and Sjah 2007).

iv. Climate change

Vulnerability to climate change on Lombok is particularly apparent in the water sector because of the sizeable changes in precipitation and temperature, extreme climatic events, and sea level rises (Suroso et al. 2009). The island is affected by the El Nino Southern Oscillation. This can generate periods of drought or years with high rainfall (Klock and Sjah 2007, Butler et al. In Press, Corrected Proof). Increased climatic variation, including a rising fluctuation and uncertainty in seasons and a significant decrease in rainfall, is predicted by 2030 (Figure 3.3). These predictions suggest that the greatest reduction in monthly rainfall will be experienced along the slopes of Mount Rinjani. For northern Lombok in particular, total monthly rainfall is likely to decrease by 20 %. Together with climatic events such as floods and extended droughts, these ecological changes have a significant impact on both food and water security on Lombok (Sayuti et al. 2004).

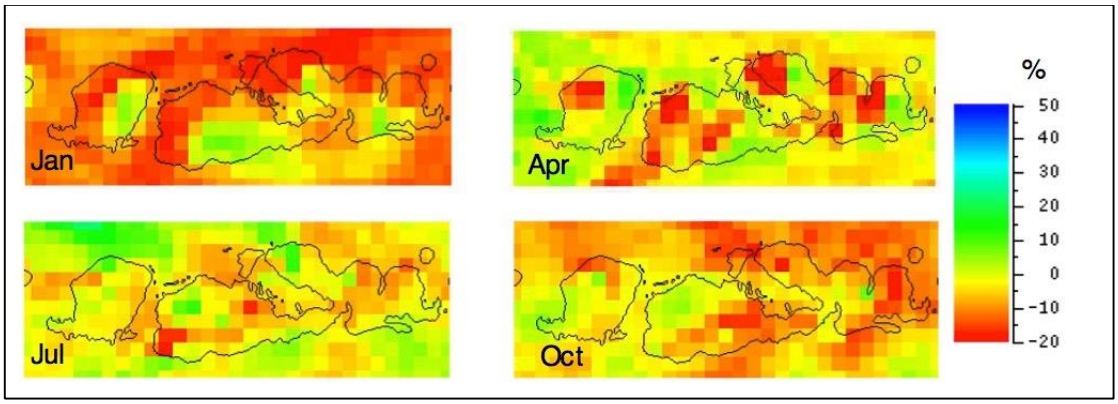

Figure 3.3. Best estimates of projected changes in total monthly rainfall by 2030, as a percentage of 1970s climatology for January, April, July and October 2030 in NTB downscaled to 1km. Climate simulations are based on the SRES A2 emissions scenario (Source: CSIRO) (Butler, Habibi, et al. 2014).

v. Socioeconomic and governance

Water scarcity is also human-induced on Lombok. Social, economic, cultural, political, and biophysical factors affect the access, availability, and allocation of the

island's water resources (Asatawa 2004a). These include illegal logging, weak governance, pressure from population expansion, lack of education, and natural resource management conflicts (Asatawa 2004a, FFI-Indonesia and BATBP 2012b).

Recent modernization, increased tourism, and urban expansion have led to a move away from traditional and cultural conservation methods. Those include *awiq-awiq* (traditional Sasak cultural morals), *bada musyawarah* (community decision-making), and *goyong rotong* ('community spirit') (Klock and Sjah 2007). High demands for water from urban areas' and the tourism sector that was traditionally allocated to agriculture, are depleting surface water and groundwater (Haryani et al. 2007). Rural water resources are under increasing pressure to provide for urban systems. This has resulted in reduced food security, and reliance on rice imports for example (Sjah and Baldwin In press). These demands – coupled with deforestation – have led to a 40% reduction in the number of springs around Mount Rinjani (WWF-Indonesia 2001). Traditional approaches to manage access to and availability of water at local levels, in the face of wider competition for resources from tourism and urban centres, may now be insufficient to enable water security for rural communities (Sjah and Baldwin In press).

Top-down government approaches, sectoral fragmentation, and elite capture have created resource-controlled approaches and widespread mistrust. That facilitates stakeholder competition, a lack of coordination, and poor-information disclosure. The Indonesian government has historically governed water management on Lombok. This governance structure arose since 1990, when the country's government introduced an increase in paddy-intensification and economic development within eastern Indonesia (Sato 2006). Water User Associations (WUA) were initiated in the 1980s to give local communities the responsibility to manage the distribution of water (Klock and Sjah 2007). However, the effectiveness of WUAs is significantly reduced by fundamental weaknesses in their institutional scope, and local perceptions of their strong links to central government.

Fragmented sectoral approaches to managing water also have fed stakeholder confusion. Different agencies manage water according to land use. For example, building pipeline infrastructure for surface water is the responsibility of the Department of Public Works (*Perkerjaan Umum*); groundwater is managed by the Department of Mines and Energy; and, the Forest Department (*BPDAS - Balai Pengelolaan Daerah Aliran* Sungai) is accountable for watershed conservation (Asatawa 2004a).

Conflicts over water resources often emerge because of misunderstandings between upstream providers and downstream users. Inconsistent policies also affect access to clean water. Upstream users typically make claims to property rights related to water resources. That includes how water resources are used, stored, diverted, and,

ultimately, disposed of. Equally valid are downstream users' demand for clean drinking water, despite their distance from the water source (Asatawa 2004a). For example, the rural communities in the upper catchments of the Dodokan watershed, which feeds Mataram, have an unequal ecological responsibility to protect water sources to meet the municipality's demands. During the dry season, some downstream villages without access to piped water have little water flow. And in Muncan, a village in southern Lombok, households may only get water once every two nights (Klock and Sjah 2007).

Different stakeholders require water resources for different land uses. This tension creates different values on how resources are viewed, accessed, and used. Conflict can vary from minor disputes between communities, to large scale district level conflicts (Asatawa 2004a). Where there is a lack of inequitable access to resources, insufficient resolution of conflict, or continued poverty, tensions between stakeholders can escalate, and may drive unsustainable resource use (Asatawa 2004a).

3.2.4 Implications of water stress on Lombok

How communities cope with water stress and the resulting impacts have implications for the long-term sustainability of the resource. To implement any institutional governance that reduces water stress for communities and the environment, it is important to understand the drivers of water scarcity and the factors that limit or enable coping mechanisms. This paper seeks to understand factors that affect the availability of water resources for communities across Lombok.

3.4 Research questions

This paper therefore addresses the following research questions:

1: How extensive is the variation of water availability – and access to the resource for communities – across Lombok?

2: What factors can affect the availability of and access to domestic water resources?

3: What are some of the implications of domestic water availability and access for agricultural revenue?

3.5 Methods

3.5.1 Study site selection

A comparative case study method was used to survey a set of households within 30 villages (*desas*) across all of Lombok (Figure 3.4) (Yin 2003). These were randomly selected to generate a representative sample of communities. This method enabled the extrapolation of data on their socioeconomic, natural resource use, and, specifically, access to and availability of water across different land types. Villages and households were used as embedded units of analysis to allow for analytical generalization of both the environmental and socioeconomic variables that influence water availability and access to the resource. Ten households in each of the 30 villages across Lombok were randomly selected and sampled for socioeconomic and demographic characteristics. They were additionally sampled for their access, use, and infrastructure related to domestic water use, and agricultural revenues. While the research also examined access and availability of agricultural water supplies, examination of the impact of water acquisition effort was calculated for domestic water resources only. This constraint does limit understanding of the impacts of water scarcity on agricultural revenue. For the purpose of this study, however, it provides an insight into the wider impacts of water stress on households on Lombok.

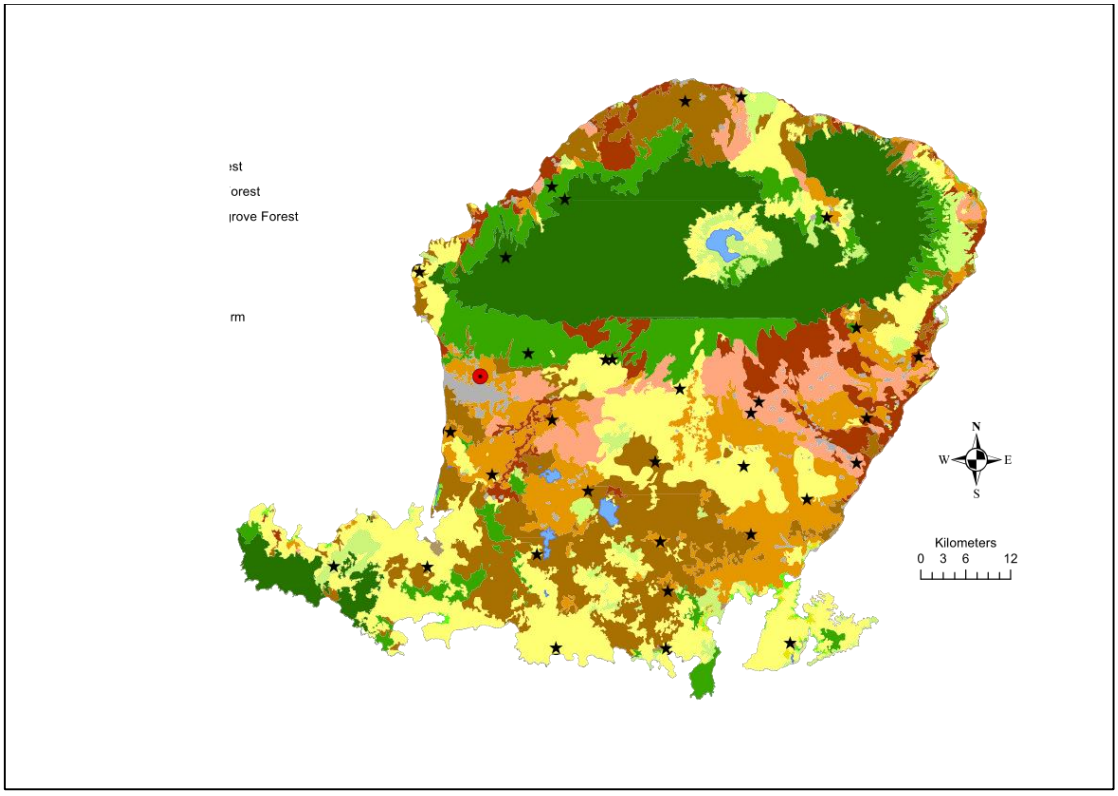

Figure 3.4. Land cover in relation to survey villages (Source: Own elaboration, Data: BAPPEDA 2012, FFI-Lombok 2011).

Environmental and demographic spatial data was gathered from secondary sources such as BAPPEDA (*Badan Perencana Pembangunan Daerah* - Regional Body for Planning and Development) and Flora Fauna International, Indonesia. These secondary sources included data on river basin water balance, distance to Mataram, sub-district area, forest area, paddy area, population size, and average rainfall per year. Data determining the water balance of river basins was calculated by BAPPEDA. This used catchment area, annual rainfall, and surface water availability (Mm^3/sec) to determine surface water availability within sub-watersheds. Surface water potential was categorized as 'sufficient', 'deficit', or 'extreme deficit', according to 2020 projected demands (with projected population size) and water availability (Rosalita 2012). Due to lack of data on groundwater area these categories were used in this study as a proxy for water availability. The multiple case study design allowed for the comparison of these variables across a water stress gradient.

The use of secondary data from government and NGO resources may increase the margin of error in analysis. The village scale of environmental data, particularly in relation to household scale socio-economic data, may reduce applicability of environmental variables. For example, the location of a household within a catchment may generate variation in environmental variables at village level. However, due to time constraints in data collection and limited data availability, this study used village scale data in relation to household responses.

3.5.2 Survey Methods

Household surveys focused on poverty status, natural resource use (with a focus on water access and availability), and livelihood strategies. In total, 300 households were sampled. Prior to data collection, a pilot survey and initial focus group discussions were undertaken for training purposes. The trial also helped to inform and evaluate the questionnaire. Quantitative responses were sought through the questionnaire, while qualitative discussions were held around natural resource availability, and changes in access and availability to the resource. This approach enabled a greater depth to the responses beyond the researcher's own *a priori* epistemological approach.

Trained researchers from the University of Mataram conducted the surveys. Data collection took place between June-August 2012. The collection of a wealth variable from indicators such as household asset value, income, and expenditure (Filmer and Pritchard 2001, Rutstein and Johnson 2004) was beyond the scope of this rapid and wide-scale survey.

During the pilot, early focus group discussions surrounding the concept of wealth were used to develop a wealth ranking using house size (room number) as a proxy for socioeconomic status between households. While this wealth proxy may lead to some ambiguity, principal component analysis was also conducted on the percentage of

respondent income spent on food, school fees, medicine, transport, electricity, and other expenditures. Expenditure on food was the key principal financial component. When this data was correlated with a separate wealth proxy (years in education and occupation), it was apparent that respondents' expenditure on food also related to their occupation. For example, traders and businessmen would buy nearly 100% of their food. Farmers and labourers, in contrast, bought a lower percentage of their food.

Agricultural revenue per year also positively correlated to the number of rooms in a household using regression (r^2=0.2271, d.f.1, p***). Consequently, a wealth proxy of room number to denote house capital will be used in the analysis. Questions and responses were translated into Bahasa Indonesia with the help of the multilingual research assistants. During training, it was ensured that the assistants understood the information required from the survey. Nonetheless, following the pilot survey, cultural and language differences were apparent, and some of the meaning of the survey may have been lost in translation. To increase comprehension, the finalized questionnaire was simplified and included local names and colloquialisms. Interviews lasted approximately 40 minutes and were conducted in *Bahasa Indonesia.*

3.5.3 Analysis

Spatial analysis using ArcGIS 10 extracted environmental and demographic data at village level. This analysis may have lost some of the scale of the data because questionnaires were conducted at household level. Some households within villages, for example, were spread along a gradient (e.g.: from sea level to Mount Rinjani slopes). Yet the village level analysis allowed for an approximation using the environmental data available.

Questionnaire data was coded, and Stata 12.0 and Excel were used for all statistical analysis, suitably transforming data where necessary (Osbourne 2002). To analyse normally distributed data of continuous variables, parametric tests were used where possible. The stringent assumptions made by parametric tests, particularly with environmental data analysis, may not always be suitable (Fowler, Cohen, and Jarvis 1998). Therefore, non-parametric tests for rank and categorical variables were also used to analyse 'distribution free' data (Fowler, Cohen, and Jarvis 1998). Statistical tests were two-tailed with a probability value of 0.05. Where Indonesian Rupiah (IDR – Rp) values are used, rates were taken from 2 September 2012: 1USD: 9530Rp using http://www.xe.com/currencycharts/?from=USD&to=IDR&view=2Y.

Where multiple factors were involved as explanatory variables, General Linear Mixed Models (GLMM) were used for multivariate analysis of both fixed and random effects on responses from different distributions (Bolker et al. 2009). GLMMs were developed to test the relationship of variables impacting water acquisition effort per capita and sources of water for household consumption across the island. These models were built using explanatory variables such as distance to Mataram,

population density, and a proxy of wealth (house size). Environmental variables considered included altitude, forest area, spring density, and river basin water availability. To avoid pseudo-replication, forest area, spring density, river basin water availability, and altitude were modelled as random effects, and distance to Mataram, population density, and a proxy of wealth were modelled as fixed effects (Bolker et al. 2009). The significance and direction of each independent variable on access to and availability of water was indicated by the GLMM coefficients.

There are limitations to the data set because of the use of multiple survey locations with many differing levels of water availability, land use, and land types. Ecological impacts also often have random effects that imply the presence of non-normal distributed data. The effects of these ecological factors on household water source and acquisition effort characteristics cannot be clearly separated. Where interdisciplinary approaches are required between ecological and economic studies, it is important to distinguish between where importance is attributed in design criteria. As such, and for the purpose of this paper, *a priori* assumptions are made regarding cause and effect relationships (Armsworth et al. 2009).

3.6 Results

The survey villages illustrated significant environmental and socioeconomic variation across Lombok. Village area ranged from 5.04 km^2 to 184.45 km^2, with an average of 35.98 km^2. The villages' altitude varied from 7 m to 1,170 m above sea level. Population density was high throughout the test sites on the island, with an average of 396 people per km^2. The highest density was found in central Lombok, where the village of Medas had 1,292 people per km^2. While this is likely to be linked to the village's high urbanization and proximity to Mataram, it should be noted that villages within the central part of Lombok have been divided into smaller villages (and thus areas). This initiative aims to improve the governance of the growing populations. As a result, the division of villages into smaller villages may limit the applicability of population density data as village areas in other areas of Lombok are much larger. Low population density villages were found in remote areas in northern Lombok, close to the summit of Mount Rinjani.

Figure 3.5. Legal felling of timber within community production forest, Lebah Suren (Photo: L. Garrett 2012).

Forest cover per village ranged from 0 km^2 to 77.88 km^2 and paddy field cover ranged from 0 km^2 to 14.80 km^2. Paddy fields were located in the plains below the slopes of Mount Rinjani. Land cover is likely to be significantly related to island topography and proximity to Mount Rinjani where most of the protected and production forests are managed (Figure 3.5). Land cover was not related to illegal deforestation, although informants spoke of illegal deforestation occurring throughout the protected forest on a small scale.

3.6.1 Water distribution and availability across Lombok

There was significant variation in water distribution and availability across the survey communities (Figure 3.6). The four main watersheds, although unequal in size and population density, were distributed between Lombok's districts: North (Putih), West (Dodokan – the main watershed), East, (Menanga), and Central (Jelatang).

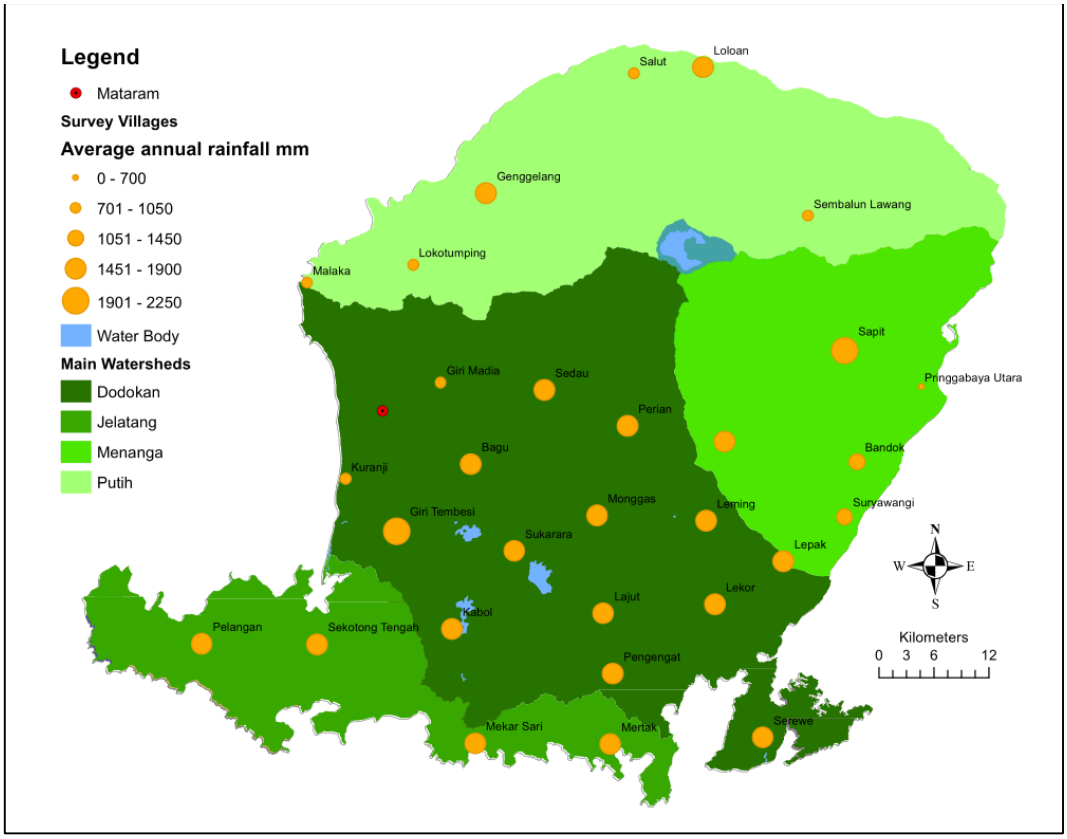

Figure 3.6. Annual rainfall distribution across the main watersheds on Lombok (Source: Own elaboration. Data: BAPPEDA, 2012).

Elevation and rainfall

As within many island ecosystems, topography played a key role in distribution of rainfall across Lombok. It influenced land use types and domestic water sources. The majority of the population was located within the plains of the island in central, west, and east Lombok. The topography in these regions allowed for intensive agriculture – dominated by rice, tobacco, maize and chili – throughout the dry and wet seasons. Rainfall patterns were also reflective of the island's topography and the impact of both Mount Rinjani and Mount Sabiris on the hydrological cycle of the island's ecosystem (Figure 3.6). It should be noted that rainfall pattern data across Lombok was limited, and only noted minimum and maximum rainfall levels. Significant climatic and seasonal changes in rainfall were observed in Lombok, based around distinct wet and dry seasons.

Across the island, the wet season lasted approximately 6 to 7 months, between September and February. The dry season, however, showed greater variation in parts of Lombok. Most areas experienced a minimum of 3 to 4 months with little or no rainfall. But for some survey villages, the dry season could last up to 9 to 10 months. The highest average rainfall was observed within Jelatang and Dodokan watersheds, and the lowest in north Lombok within Putih watershed (Table 3.2).

Table 3.2. Average annual rainfall (mm) within each watershed (BAPPEDA, 2012).

Watershed	Min	Max	Mean
Dodokan	513.57	2,805.00	1,659.29
Jelatang	400.00	3,000.00	1,700.00
Menanga	516.67	2,583.33	1,550.00
Putih	733.33	1,800.00	1,266.67

River basin water availability

'Sufficient' river basin water availability was found in villages within all watersheds. Jelatang watershed river basins, for example, had 75% sufficient water availability. The greatest 'extreme deficit' river basin water availability was found in Dodokan and Menanga, where the largest population densities were also found (Table 3.3). 'Deficit' and 'extreme deficit' river basin water availability was positively significantly higher in villages with higher population densities, lower average annual rainfall, and higher spring density.

Table 3.3. General liner mixed model analysis of environmental and socioeconomic factors relating to river basin water availability (n=296). Pearson values (z).

Variable	Pearson z value	Significance level
Elevation	-0.75	>0.05
Forest area	0.12	>0.05
Spring density	2.02	*
Distance to Mataram	-1.34	>0.05
Population density	3.20	***
Wealth	1.17	>0.05
Average rainfall	-7.09	***

Critical probability values quoted are represented as follows: '***'=p<0.001, '**'=p=<0.01, '*'p=<0.05, and '>0.05'= Non-significant (p=≥0.05) (Fowler, Cohen, and Jarvis 1998)

Villages with larger areas of forest were more likely to be situated in a 'sufficient' river basin, although this was not significant. Paddy field area was often larger in village areas with higher annual rainfall, and located within 'deficit' and 'extreme deficit' river basins. This relates to the tendency on Lombok for rain-fed paddy (and other crops) agriculture, compared to irrigated fields observed in other islands of Indonesia.

High population densities observed in urban areas located far from forest areas were additional socioeconomic factors in driving water stress for communities. This high demand was reflected in the large population size, agricultural expansion, and high demand by urban areas, which placed significant pressure on rural water resources. The highest population density (522 people per km^2, and an average of 447 people per km^2) was found in survey villages in East Lombok within the Menanga watershed. This watershed had 66.66 % of villages within an 'extreme deficit' river basin. That placed considerable pressure upon water resources. Wealthier communities were found in East Lombok, reflective of the high agricultural (tobacco) productivity in this area. In contrast, the poorest communities were found in southwest Lombok, within the Jelatang watershed, where occupations were mainly farm-based or based around trading. Education levels were also higher in East Lombok, with an average of 8.53 years, compared to 2.25 years in southwest Lombok.

3.6.2 Domestic water availability and sources

Water was sourced from multiple sources across the survey villages. In total, 54.39 % of households sourced water from wells, 33.78 % from piped water to households, 6.08 % from rivers and springs, 1.69 % from reservoirs, and 4.05% from other sources. Domestic water sources for households were predominantly determined by environmental rather than socioeconomic variables (Table 3.4).

Table 3.4. General linear mixed model analysis of environmental and socioeconomic factors relating to household domestic water source (n=300). Pearson values (z).

Variable	Pearson z value	Significance level
Elevation	2.99	***
Forest area	1.10	>0.05
Spring density	0.09	>0.05
Distance to Mataram	5.45	***
Population density	2.22	*
Wealth	1.18	>0.05
River basin water availability	-2.45	*

Critical probability values quoted are represented as follows: '***'=p<0.001, '**'=p=<0.01, '*'p=<0.05, and '>0.05'= Non-significant (p=≥0.05) (Fowler, Cohen, and Jarvis 1998)

The type of water source of surveyed households was not significantly correlated to wealth, spring density, or forest area (Table 3.4). Distance to Mataram and elevation was highly, positively significantly correlated with household water source (Figure 3.7). Households furthest from Mataram were observed to use springs and rivers for domestic water sources. Households in villages closer to Mataram were more likely to access water via wells or piped water systems. Wells were more likely to be used at lower elevations. However, respondents in two villages in East Lombok who used wells noted that the "*water* [was] *not clean*", and they were "*often sick,"* or had to boil or buy water to drink.

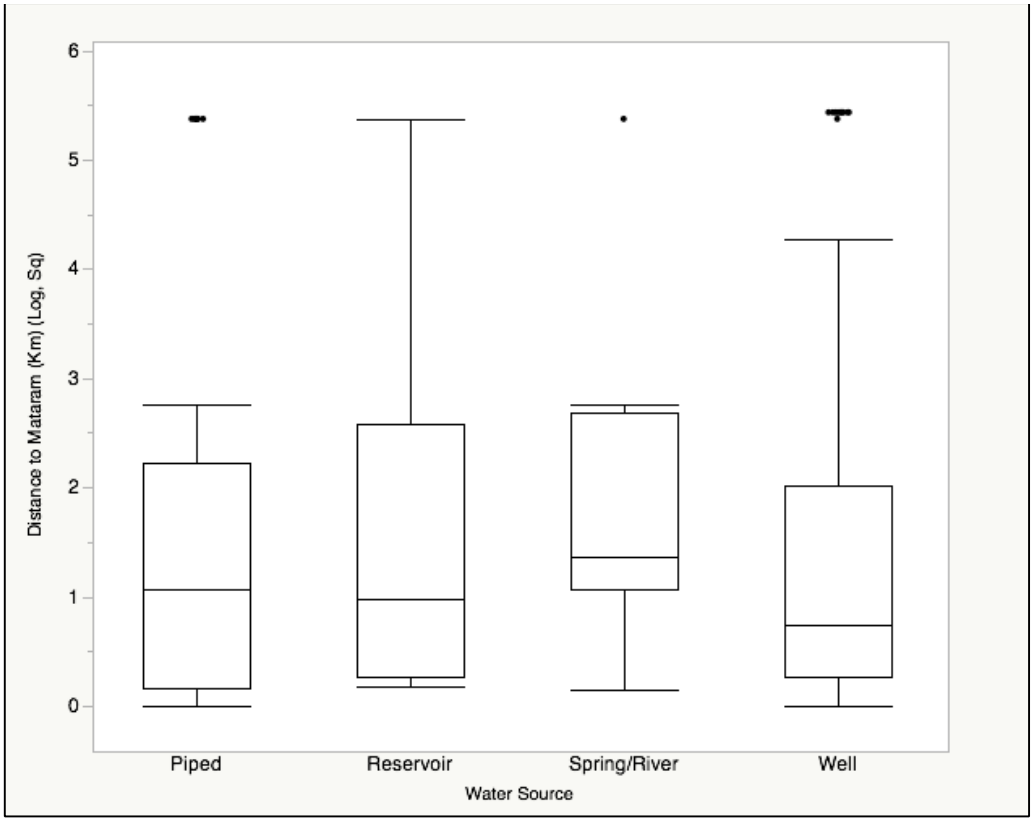

Figure 3.7. Domestic water source of survey households and distance to Mataram (km). n=300.

The source of household water was significantly different between watersheds (χ^2=48.805, d.f.3, p=***). Households within the Dodokan watershed had significantly more varied water sources. This diversity was likely due to the watershed's large area and the many different land types, topography, and land uses within it. Jelatang watershed respondents relied significantly on wells, with little piped water to households. Nearly three-quarters of respondents within the Putih watershed had access to water via pipes, either their own or shared with other households. Sourcing water from springs was limited to households in Dodokan and Putih watershed. This is expected because of the topographic dominance of Mount Rinjani and associated springs within the watershed. Respondents in Menanga had a strong reliance on wells and piped water to households.

3.6.3 Agricultural water availability and sources

There were three main sources of water for agricultural productivity: Rain, shallow wells, and irrigation channels. Crop type was associated with agricultural water source (ρ=0.2804, n=125, p***). Poorer households had less access to irrigation and wells (ρ=0.2832, n=125, p***), and relied on rain-fed rice. Wealthier households were more likely to collect non-timber forest products (NTFPs), tobacco and timber, and use shallow wells and irrigation channels. Irrigation and rain-fed agricultural sources were also more likely to be used in river basins with 'sufficient' water

availability, while more respondents used shallow wells in 'extreme deficit' and 'deficit' river basins (ρ=0.1812, n=125, p***).

3.6.4 Infrastructure and effort to acquire household water

Access to water infrastructure varied across the island, although the majority of communities surveyed had piped water into their households. Some households relied on freshwater collection for domestic consumption. To determine the cost per unit effort of water acquisition per household, the distance to collect water was multiplied by the number of times per day collected, then divided by the number of adults per household (Table 3.5).

Table 3.5. General liner mixed model analysis of environmental and socioeconomic factors relating to household water acquisition effort (n=300). Pearson values (z).

Variable	Pearson z value	Significance level
Altitude	4.99	***
River basin water availability	-5.12	***
Forest cover	-0.93	>0.05
Spring density	0.24	>0.05
Distance to Mataram	4.99	***
Population density	0.99	>0.05
Wealth	-0.39	>0.05
Domestic water source	3.91	***

Critical probability values quoted are represented as follows: '***'=p<0.001, '**'=p=<0.01, '*'p=<0.05, and '>0.05'= Non-significant (p=≥0.05) (Fowler, Cohen, and Jarvis 1998)

Water acquisition effort was highly positively, significantly correlated to domestic water source (Table 3.5 and Figure 3.8). Households using springs and wells had the highest water acquisition effort. Distance to Mataram and river basin water availability were also significant strong determinants of water acquisition effort. As discussed earlier, distance to urban areas affected the source of water for domestic use. Daily water acquisition effort per capita was greatest in villages furthest from Mataram. The rural nature of communities was a key determinant of infrastructure in place to supply households with water. During the dry season, respondents in a village in North Lombok noted that: "*we don't get a lot of water and have to* [obtain] *it from*

a different place." A respondent in Central Lombok reported that it was *"difficult to get water and we have to go very far",* while others said they "[bought] *water from outside the village to drink".*

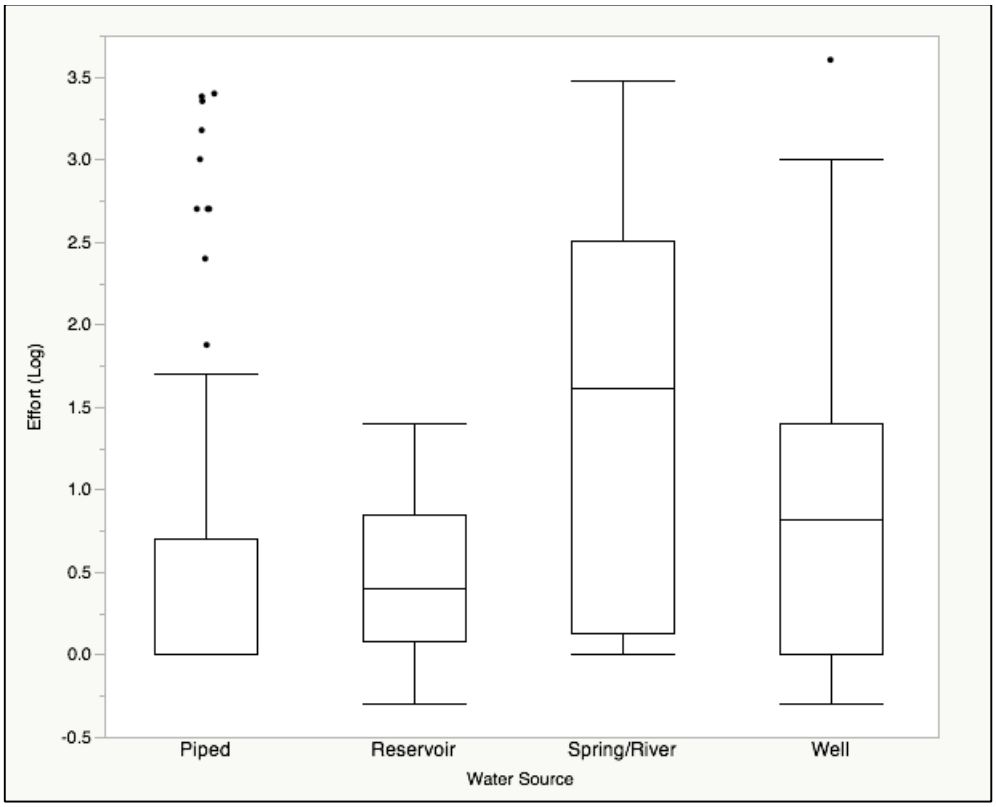

Figure 3.8. Household effort per capita to acquire water per water source (n=300).

Water availability within the river basin was more likely to be 'sufficient' when water acquisition was higher. Area of forest, spring density, population density, and wealth were not significant influences on water acquisition effort. Altitude played a greater role determining water source, compared to acquisition effort (r^2=0.6265, d.f.1, p>0.05). But for the sake of the model, the resulting impact on water acquisition effort was significant. For example, wells were used more frequently at lower altitudes than piping (which often used gravitational pull to pressurize pipes and was used more frequently at higher altitudes).

3.6.5 The implications of domestic water access and availability on farmer livelihoods

The impact of domestic water access and availability varied across household, village, and watershed scales. Environmental factors such as altitude, river basin water availability, mean annual rainfall, and seasonal variation played key roles in determining water access, availability to the resource, and water stress due to seasonality. This is reflective of the distinct vegetation types and land use observed across the island (Figure 3.4). This environmental variation influenced the demand for

and availability of water for household consumption. To focus on the implications of this variation in access and availability across agricultural livelihoods, the dataset was reduced to include only farmers and agroforestry workers. The labour time allocated for their household water acquisition was then calculated to examine its relationship with agricultural income.

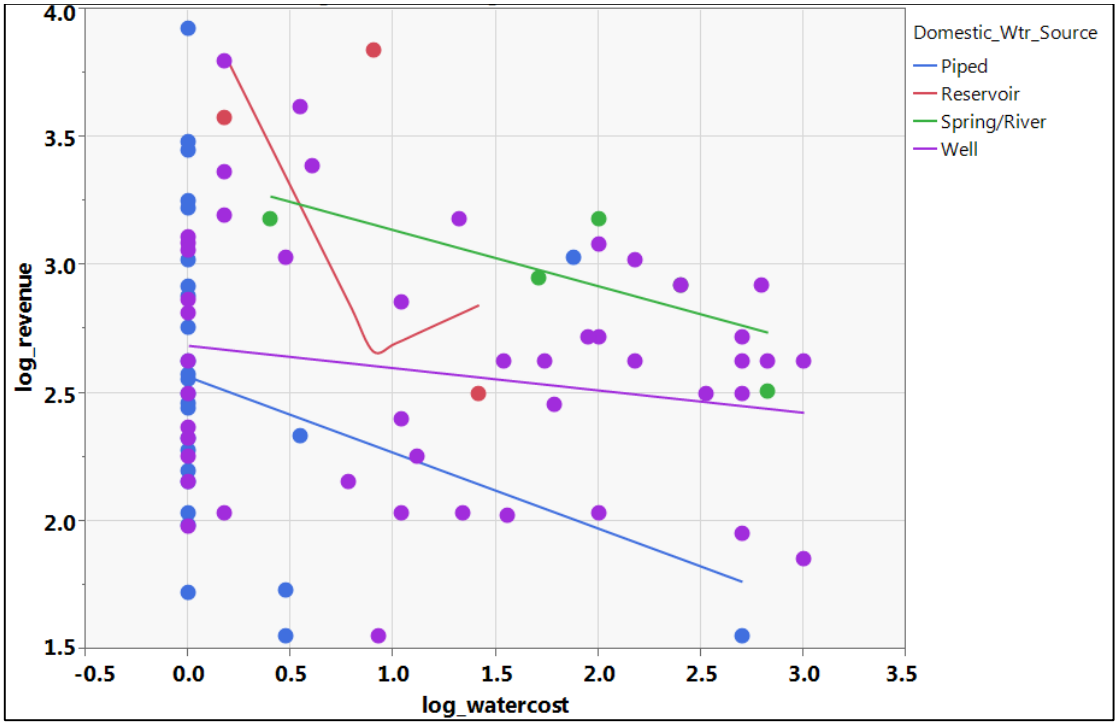

Figure 3.9. Impact of household water acquisition cost per capita per day on annual agricultural revenues (n=92).

Household revenue from farm and agroforestry livelihoods varied from US $35.77 to US $8,394.54 per year, with a mean of US$ 870.97. Income was determined by crop type (z=2.79, n=92, p**), and was greatest from tobacco harvests, lowest from non-timber forest products (NTFPs), and showed greatest variance from irrigated rice. Annual income was not influenced by productive water source (z=0.87, n=92, p>0.05). While annual agricultural income is likely to be influenced by crop type and market prices, effort to acquire domestic water was found to impact agricultural revenue, both directly and indirectly (z=-2.34, n=92, p**) (Figure 3.9). Respondents with a higher effort to obtain household water were observed to have a decreased agricultural income for intercropping and tobacco, but not for rice or NTFPs. This divergence may be linked to the time costs involved to collect domestic water, which takes time out of agricultural activities and productive output, or to the fact that, according to respondents, rice and NTFPs require less agricultural labour.

3.7 Discussion

3.7.1 Variation in water availability and access on Lombok

Lombok illustrates many of the characteristics of island natural resource dynamics. The island's geographic features play a dominant role in the distribution of resources, particularly fresh water. Water availability, allocation of resources, and water stress in Lombok shows significant variation, depending on biophysical variables. These water issues are influenced by the elevation of Mount Rinjani. The mountain topography determines land cover – forest or open plains, etc. – and, consequently, productive use across the island. Livelihoods are limited to certain geographic ranges: with rain-fed and irrigated rice on the base of the slopes of Mount Rinjani; tobacco plantations across the plains; and NTFPs on the upper slopes. These forms of agriculture create high dependence on the island's hydrological and climatic cycles.

There is intense pressure on Lombok to maintain sufficient water supply for urban, rural, and agricultural systems. Population density is particularly high in the central and eastern regions where agricultural production is also very intensive. In these areas, rapid cycles of rice, tobacco, and intercropping are prevalent throughout the year. Much of these crops are reliant on rainfall, compared to river basin water supplies, for production. However, demand from communities in these regions is increasing the vulnerability of river basin water availability, which is categorized as 'extreme deficit' in areas of high population density. Lombok's growing population is currently accentuating the limiting factors of island's finite water and land resource base.

How 'scarce' is water on Lombok?

This study used proxy indicators of acquisition effort to obtain household water supply, the availability of infrastructure, and river water balance to assess water scarcity. The data did not clarify the presence of true physical water scarcity, but highlighted societal scarcity of water resources. A more accurate assessment of physical water scarcity would be beneficial to ascertain the physical capacity of water availability. This could include measurements such as amount of water withdrawn per individual sharing each unit of water. Societal scarcity of water resources was, however, observed, for example, through the impacts of limited access to infrastructure to safe and affordable domestic water. SES interactions, in particular between this infrastructure, access to resources, and the institutional management of water use, are influencing the vulnerability of water resource systems to environmental factors such as climate change. While this does not necessarily lead to physical water scarcity as such, demand for water is high in agricultural areas, areas with high population density, and close to Mataram's urban area. These demands create stress and 'extreme deficit' river basin areas.

Future increases in population size, rapid agricultural intensification, and climatic changes which influence rainfall are likely to put the island at risk of further population-driven water scarcity and potential physical water shortages (Kummu et al. 2010, Falkenmark et al. 2007, Ohlsson and Turton 1999, Butler, Habibi, et al. 2014). Any water shortage, both present and future, faces further pressures from significant seasonal variation, which may be worsened by regional differences. These impacts influence both water availability and demand at varying scales across Lombok. Distinct wet and dry seasons are limiting factors to agricultural productivity and access to water for domestic household use, which is reliant on rain-fed agricultural systems. Due to time constraints, it was beyond the scope of this research, however, to examine the seasonality of water acquisition effort. Nonetheless, the identification of societal water stress and the potential for 'scarcity' as defined by Falkenmark (2003), Falkenmark and Lundqvist (1998), Rijsberman (2006) and Lankford et al. (2013) is still a useful tool to understand the management of water resources on Lombok.

Any water scarcity or stress is a limiting factor on economic development and agricultural productivity (Falkenmark et al. 2007). On Lombok, scarcity of water is currently not limited by physical water availability, but by its allocation, i.e. societal scarcity. Societal scarcity does often accompany physical scarcity (Kummu et al. 2010, Ohlsson and Turton 1999). Using infrastructure availability, effort to obtain household water supply, and river basin water balance as indicators of water scarcity, Lombok does indicate a resource under pressure. Greater infrastructure is available in 'sufficient' river basins, but these regions often have higher demands for obtaining household water supply from larger population densities. Households experiencing water stress were often far from Mataram, and therefore general public infrastructure and development. This impacted the household water source, with those further from Mataram more likely to rely on springs and wells, and also increased the acquisition effort to obtain domestic water. Lack of infrastructure to manage the pressure on ecological resources for communities further from Mataram is therefore impacting access to and availability of water resources for households.

What does 'water scarcity' mean for water availability and access on Lombok?

The data emphasized the significance of Mount Rinjani in determining not only water availability, but also domestic water resources across Lombok. Households at higher elevations had greater access to household pipes and community water reservoirs. Spatial scales vary significantly for water resources, which are impacted by local social and economic characteristics, and physical water availability (Sullivan et al. 2003).

On Lombok, the availability of water and its distribution is a localized issue. It is shaped by the topographical nature of the island. Use of wells for domestic water was found in survey villages of lower altitudes. That is expected, as communities access

the ground water resource within Mount Rinjani's alluvial plain. Piped water to households, together with reservoirs, was observed in greater frequency in the upper catchments. This is likely to be reflective of a higher reliability of water supply from springs and rivers descending Mount Rinjani.

Socioeconomic characteristics and wealth status were weak determinants of household water sources. It was difficult to ascertain whether wealth did not improve access to water infrastructure, or if access to water infrastructure increased wealth. More rural communities, i.e. those furthest away from Mataram, did show a greater reliance on reservoirs, springs, and rivers. This suggests that infrastructure is driven by urbanization. Communities far from central urban systems lack access to domestic water sources through piped water systems. This is reflective of PDAM's infrastructure and service scope, which do not always reach more rural populations. The impact of governance and WUAs was not apparent in this chapter of the thesis. Further research to understand their influence in managing water infrastructure and the implications for household consumption was conducted and will be presented in proceeding chapters.

3.7.2 Impacts of domestic water availability on livelihoods

How does water distribution and access influence the cost of acquiring domestic water for households?

Water allocation systems between urban, rural, and agricultural systems are complex and challenging (Klock and Sjah 2007). Domestic water sources are an integral part of household coping strategies, and affect economic productivity and individuals' health. As such, domestic water sources, although they only account for a small proportion of water withdrawals, can play an important role in poverty alleviation (Howard and Bartram 2003, Gleick 1998). Studies have shown that domestic water sources can influence levels of poverty through time spent (cost per unit of effort) obtaining household water resources (Sullivan et al. 2003). Links between wealth and domestic water sources, and water acquisition effort, were not made in this study. On Lombok, wealth influenced productive water sources, both directly and indirectly, as a result of crop type and water requirements.

A significant proportion of time spent collecting domestic water can perpetuate the cycle of poverty, lower agricultural productivity, and reduce livelihood revenue. Water sources influence any acquisition effort. Households surveyed on Lombok reflected this principle. Significantly higher effort was required to access wells, springs, and rivers than what was needed for piped or reservoir water sources. Reliance on water sources, which require a high effort to obtain access, increases the vulnerability of households to changes in water availability and access to these water sources (Klock and Sjah 2011). For example, a high dependence on springs on Mount

Rinjani, which are already vulnerable to degradation, may increase a household's vulnerability to reduced water availability.

Effort to acquire water was highest away from urban centres. That emphasised the lack of PDAM infrastructure in Lombok's rural communities, and the impact of this limitation on individuals' lives. Rural regions in Lombok, which are far from the political centre in Mataram, often have scarce economic and social capital, little of which is allocated to develop water supply infrastructure (Gleick 1998). High rates of urbanization and migration towards urban centres for employment have rapidly increased the demand for water from urban centres. Improving access to water by reducing effort requires a consideration of multiple users and across multiple scales (Lankford 2013). It is therefore challenging to implement water management policies to increase infrastructure far from this high demand, particularly because of the limited socio-political influences held by rural communities.

What are the implications for farmer revenue on Lombok?

Water acquisition effort may not be the single determinant of agricultural revenue. Yet it is clear that time spent away from productive activities to acquire basic household resources like water reduces the manpower and potential output of limited agricultural resources. Water acquisition effort may not be the single determinant of agricultural revenue. It may perpetuate a cycle of poverty. Income from farms and agroforestry plantations in surveyed households varied significantly according to crop type and household location. This is reflective of the influence of Mount Rinjani on the island's hydrological cycle and distribution of water resources.

Trade-offs between increasing agricultural productivity through extra manpower and obtaining water varied according to water source type. While time taken to obtain water is a significant factor that affects agricultural revenue, further variables such as crop type, pesticide use, number of harvests per year, the type of labourers employed on the land, and tenure may also influence annual revenues and should be included in further research.

Additionally, "No economic sector consumes as much freshwater as agriculture", with rain-fed crops accounting for the majority of water consumption (Rockstrom et al. 2010). Different crops have different water requirements throughout their growth cycle. Some of these crops are time dependent, which increases the significance of seasonal rainfall on agricultural output (Sayuti et al. 2004).

3.8 Conclusion

It is apparent that water resources on Lombok are stressed, and this research indicated societal scarcity for some areas of the island. This may lead to future physical water

scarcity, in particular when considering the impacts of climatic change. Rainfall projections indicate significant changes in seasonal rains in both timing and amount (Butler, Skewes, et al. 2014). The whole island is unlikely to experience a 'drying' as such; in fact some areas may remain unchanged in terms of rainfall. However, the northern part of the island is likely to experience significant rainfall decreases (Butler, Skewes, et al. 2014). These decreases may increase seasonal drying and alter monsoon timings, which are often key to agricultural cycles. River basin water balance indicates the impact of growing demand on surface water availability, with densely populated areas often situated in 'extreme deficit' river basins. Further research to model predicted temperature raises, and therefore evaporation, and extreme events (floods, droughts) should be conducted to present a clear indication of water resource vulnerabilities on the island, and how these issues may affect household water acquisition.

Trade-offs between upstream and downstream users, ecosystems, and livelihoods are likely to occur when balancing access, availability, and allocation of water resources (Rockstrom et al. 2010, Calder 2005). Within island ecosystems, the finite nature of resources is both a key determinant and driver in implementing effective resource management, particularly linked to water resources.

'Secure' water for the needs of any SES is complex and dynamic because of the many interdependent environmental and human variables. This supports the need to understand a more 'complex' reality of water scarcity due to the unpredictable nature of applying theoretical governance to communities on Lombok (Lichbach 2009). The mechanisms with which households, communities, and watersheds cope with water stress are predominantly determined by biophysical elements and interactions that control hydrological systems and cycles. Social, political, and economic capital also enables the maintenance of water supply systems through: infrastructure availability and distribution; management for increased supply; or more efficient use to meet demand. "Lack of social resources can also act as a bottleneck", (Falkenmark et al. 2007, Ohlsson and Turton 1999). When linked to time needed to obtain sufficient domestic water, which is taken away from other productive and revenue-generating activities, these bottlenecks may create a cycle of poverty.

Consequently, how can water be managed on island socio-ecological systems such as Lombok, which has an intensive agricultural land use, high poverty levels, and a high population density? Climatic changes are also increasing both community and ecosystem vulnerability to water availability (Falkenmark et al. 2007). Where alternative livelihoods are limited, it is difficult to intensify land productivity, protect ecosystem services, and alleviate poverty.

Lombok illustrates how expanding urban settlements have increased the demand for water away from rural areas, and how infrastructure has consequently been focused on urban systems. Large population sizes dictate demand for water resources, and

which societal sectors compete for them (Falkenmark et al. 2007). Rural communities themselves are often located in the upper catchments of watersheds (Rockstrom et al. 2010). It is these rural communities on Lombok that often lack domestic water infrastructure.

The agricultural sector on Lombok is also a high consumer of water. Export of 'virtual water' - i.e.: the export of water-intensive agricultural commodities such as tobacco – may also be transferring water resources out of Lombok (Dalin et al. 2012, Allan 2003). Diverting limited water resources to increase agricultural productivity will result in trade-offs for other water users and sectors, both upstream and downstream (Rockstrom et al. 2004). Finding a balance to satisfy urban population demands, agricultural intensification, and the development of rural water infrastructure is complex.

Already faced with a high effort to acquire domestic water, rural farming communities depend on unreliable crop water supply on Lombok. These communities are particularly vulnerable, both now and under future climatic changes, to changes in water availability. Changes in hydro-environments may also be increasing urban water scarcity and exacerbating the vulnerability of rural communities' water access (Variravamoorthy, Gorantiwar, and Pathirana 2008, Rosegrant and Ringler 2000). Increasing demand-led management to focus on developing infrastructure and increasing efficient water use may enable a more sustainable use and equitable allocation of water resources.

This paper has outlined some of the challenges facing communities on Lombok at household and village level in water stressed agro-ecosystems. It argues that smallholder farmers annual revenues are significantly affected by the access and availability of domestic water infrastructure, in particular proximity to urban infrastructure. Further study is necessary to determine if distance to infrastructure or rural wealth (for example, from crop type) affects smallholder annual revenues, or whether the wealth proxy used was inaccurate.

"The story of meeting the challenges of water scarcity is a social story", (Ohlsson and Turton 1999). For Lombok, this social component requires the need for increased efficiency in measures of water allocation and higher equity in resource access. Greater equity in resource access is related to limited nature of PDAM and a lack of water infrastructure in more rural areas. Stronger governance, including greater coordination between government departments managing land and water, may help increase the efficiency of water allocation within catchments.

Current water resource management and coping mechanisms to deal with water stress on Lombok are limited, but are focused on a 'supply-based' paradigm. This focuses on increasing access to water through improved infrastructure rather than

management of demand through end use efficiency. However, for marginal communities connecting to infrastructure or effort to obtain water within a supply-based approach is often costly. Marginal communities are often in rural upstream areas. Their role in maintaining upper water catchment quality is also higher. A shift towards a 'demand-based' approach is therefore vital to overcome both current and potential future water shortages (Variravamoorthy, Gorantiwar, and Pathirana 2008). A 'demand-based' focus on end use efficiency may improve limited water resource allocation. Increased efficiency of water use, and resource storage, particularly during the rainy season, may reduce the vulnerability of communities on Lombok to seasonal, and climatic, water stress.

An integrated approach that encompasses the multiple and competing goals is needed that would link better distribution and allocation of water resources. This could be achieved through improved governance and socio-economic measures, such as market-based incentives, with increased agricultural efficiency. Given predictions of climatic change and population growth, stronger, less fragmented institutional function, including improved infrastructure, is vital to manage limited water resources. To balance water demands from agriculture and expanding populations, improved and extended water-related infrastructure would foster improved access to water and could allow for a more sustainable use of Lombok's water resources.

3.9 References

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4 Exploring the relationships between incentive-based management, collective action and social equity: Protecting hydrological services on Lombok, Indonesia

4.1 Abstract

The use of incentive-based mechanisms to resolve conflict over natural resources has been promoted to protect ecosystem services and enable greater equity in resource distribution. This paper investigates incentive-based institutions to manage water resources on Lombok, Indonesia and how they affect issues of equality. Different forms of incentives were used, and each was highly context specific. The importance of institutional structure to individual and collective behaviours linked to the extraction and use of natural resources is well documented. This paper argues that the long-term legitimacy of such schemes requires careful design and projects' implementation may not always be reflective of theoretical models. There should be a specific focus on understanding 'real world' dimensions such as the existing communal governing institutions, power relations, and social perceptions. This approach includes clear definitions of property rights, a high degree of transparency, and an appreciation of underlying cultural norms to ensure greater equity in participation and benefit distribution. Different institutional factors determine the extent of equity over efficiency. True markets for incentive-based systems may require inequality to balance the need to access natural resources to compensate for the opportunity costs associated with their use. Yet by solely focusing on efficient environmental outcomes – and not equity – the objectives of the incentives' may be undermined. That may therefore increase pressure on ecosystem services through the unequal distribution of resources.

4.2 Introduction

This section provides an overview of issues regarding the provision of hydrological services on Lombok, Indonesia, as highlighted in Chapter 3, and discuss Indonesia's political background, which is important to understand power relations and

governance, and their influence on natural resource equity. I then provide an introduction to the current literature surrounding the relationships between incentive-based management, collective action, and social equity. I discuss three case studies from Lombok that illustrate these interactions within the context of Indonesian power relations, and the implications of implementing incentive-based management of ecosystem services in the real world in which they function.

4.2.1 Hydrological services on Lombok

As one of the most densely populated islands in Indonesia, an increased pressure on resources for growing agricultural and local consumption contributes to hydrological stress and creates a major concern for water management (Klock and Sjah 2007). Central to the supply of water services is Mount Rinjani. Forests surrounding its slopes are considered highly significant in the hydrological cycle. They regulate water flow and control land erosion (Asatawa 2004b, Pirard 2012b, Aukland, Moura Costa, and Brown 2003). Degradation of these catchments, predominantly through deforestation, affects water availability (Pirard 2012b, WWF-Indonesia 2001).

As highlighted in Chapter 3, access to and availability of hydrological services for household consumption on Lombok is highly variable. Variation in surface water availability of basins is linked to the physical dimensions of the island itself, such as proximity to water sources, land cover and land use type, and altitude; and, social dimensions, such as population density, and infrastructure. Conflict over access to and availability of household water resources on Lombok has arisen following competition between sectors, such as agriculture, forests, opposing institutional management types, and large populations, demanding water. Governance of water supplies on Lombok therefore faces multiple challenges to meet these demands and sustainably manage limited water resources. The implementation of incentive-based management approaches at the community-scale raises questions as to how these demands for water can be aligned to avoid the elite capture of benefits, and to enable greater social equity and efficient conservation outcomes.

4.2.2 Governance on Lombok

Natural resource management issues are complex on Lombok. This complexity has led to a number of coping strategies – both social and technical. They have evolved to allow for the continuation of agricultural practices during dry season water shortages and the attempt to address conflict over environmental resources. The coping strategies include flexible cropping systems, water allocation mechanisms, traditional management practices, and alternative payment schemes implemented at island, regional and local scales (Klock and Sjah 2007).

Known as the "Island of a Thousand Mosques," Lombok's belief systems are central to the dominant indigenous people, Sasak, who represent 90% of the population. Belief systems, both traditional *adat* and Islam, are highly significant in governing both society and natural resources. The majority of the Sasak population follows a more orthodox *Waktu Lima* religion based on the five pillars of Islam. A minority of traditional communities follow *Watku Telu*, which also is based on the Islamic faith, The communities, however, also place significant importance on *adat*, which customary cultural laws that control individual and group behaviours (Krulfeld 1966). *Waktu Telu* communities are based upon a network of mutual obligations (*gotong royong*) for economic, social, and religious organization (Bowen 1986). Individuals are socially obligated to participate in communal aid and must follow the concept of *maliq*, meaning, "don't" for activities that are taboo in nature. Disobedience of *maliq* is typically met with strong social criticism, which is based on a predetermined belief system that uses supernatural ancestral sanctions to deter individuals' behaviour outside prescribed social norms.

Governance in the wider political context of Indonesian Reformasi

"Interpretations of changes in Indonesia's macro-political context go to the heart of the potential nature of "elite capture" at the community." (Fritzen 2007).

Since the fall of President Soeharto's centralized 'New Order' regime in 1997, a political system of *Reformasi* has driven significant changes in formal centralized authoritarian governance at central, provisional, district, and local levels. This change, with shifts in formal governance and the resulting realignment of power relations, presents a highly applicable framework in which to research the emergence of different institutional designs for managing natural resources and whether these institutions require or reduce inequality.

The decentralization of power in Indonesia is viewed as "political normalization," i.e. the process of decentralized power becoming the norm across Indonesia (UNDP 2004, Fritzen 2007, Bank 2004). Hadiz (2003, 2004) argues that while "democratic transition" is occurring in Indonesia with dramatic changes in institutional structure, the power relations themselves remain the same. Fritzen (2007) supports this view. He highlights the significant difference between *Reformasi* political and social institutions and the actual implementation at the local context.

The World Bank (2004) identifies community-level development, with donors as catalysts, to be vital to change local power relations. It empowers local communities through providing incentives for local governmental accountability (Fritzen 2007). Yet the rapid use of new governance forms, or those that poorly align with the local context, can allow elite manipulation and promote inequity (Fritzen 2007). Inequity and elite capture of benefits may not always malicious. For example, elites whose

actions, while disparate in power, control rather than capture benefits through altruism and sharing of some benefits with the poor (Dasgupta and Beard 2007, Mansuri and Rao 2004). It may be impossible, however, to avoid control of hierarchical powers in community development initiatives. It would be useful to investigate if, and thus how, and under what institutional framework, the role of such inequalities can be constructive (Fritzen 2007, Chowdhury and Yamauchi 2010).

The creation of local government infrastructure opens up vulnerabilities to inequity. Social heterogeneity (elite capture and poverty), political awareness levels, and social cohesion between local areas influence the power relationships that underpin local authority infrastructure (Chowdhury and Yamauchi 2010, Fritzen 2007, Platteau 2004). The complexity of multiple traditional, religious, and ethnic institutions in Indonesia results in a mix of complementary and competing institutions. These institution have a varied impact at local levels (Ostrom et al. 1999). Fritzen (2007) and Haidz (2003) suggest that while Indonesia is "democratized," decentralization of governmental structures has merely "reorganized but not transformed" power relations in local contexts. While Indonesia may be decentralized on paper, in practice, local systems of governance remain centralized.

4.2.3 How does incentive-based management of ecosystem services address inequity?

To protect ecosystems' long-term integrity, efficient and equitable institutions are required to manage the interconnections between societies, ecosystems, and environmental service delivery (Vatn 2010b, Vira 1997, Vatn 2010a). Given the complexity and dynamics of social and ecological systems, finding appropriate institutions to manage the environment is "one of the greatest challenges in the realm of environmental protection" (Ostrom 1990, Clements 2012, Ostrom 2007b). Institutions -- defined as, "the rules of the game" (North 1990) – are social practices, which determine participation in decision-making. They also define which activities are allowed and constrained, and what structures are used for social interaction (Mehring et al. 2011, Ostrom 1990). Groups of individuals within an institution's framework operate in material organisations. These are based on rules that can be formal, such as policy, property rights, and legal systems, or informal, such as social norms, local customs, or traditions which shape interactions (Corbera 2005b, North 1990). The local social, economic, political, and external environmental context will significantly influence these social practices, either formal or informal.

Vatn (2010a) describes three types of institutional structures that enable governance: Hierarchical ('systems of command'), Markets ('voluntary exchange'), and Community structures ('based on cooperation'). These types of structures influence a society's economic growth and human welfare (North 1990, Clements 2012). Human action and social change also can affect and reshape institutions. They influence

which individuals can make decisions, how these decisions are controlled (Corbera 2005b).

Regimes that manage environmental resources are types of institutions (Erkstom and Young 2009, Young, King, and Schroeder 2008). At various scales, institutions enable practices that address and govern ecosystem-based management. Institutions can have a strong influence over environmental resources. Institutions' function and structure also can affect societal behaviours towards the environment, which can consequently impact demand for ecosystem services (Swallow and Meinzen-Dick 2009, Dietz, Ostrom, and Stern 2003). Importantly, the most significant institutions that address environmental governance may not be specifically designed for that purpose (Erkstom and Young 2009, Young, King, and Schroeder 2008).

Institutions do not function alone. They interact with and within other institutions, and social, political, economic, and biophysical dimensions. This creates significant uncertainty in determining institutional outcomes. Governance often affects the outcome of other institutional arrangements, and can have both positive and negative results (Young, King, and Schroeder 2008). The dynamics, functionality, and multi-level nature of social-ecological systems make the 'fit' of institutions to the temporal and spatial scales difficult to achieve (Young, King, and Schroeder 2008, Erkstom and Young 2009). Effective institutional governance must take into account the local context that both influences, and is influenced by, societies in which they are placed.

Incentive-based institutions for ecosystem services seek to enable change in institutional structures to modify environmental behaviours. They also serve as a mechanism to redistribute benefits from ecosystems (Corbera 2005a). Incentive-based institutions try to integrate both biodiversity protection and sustainable development. The aim is to link the institutions with wider political goals such as environmental neoliberalism, conservation, poverty reduction, and ecosystem services frameworks (Clements 2012, Naidoo et al. 2008). In many locations, such command and control environmental institutions are limited in their scope, efficiency and overall effectiveness in protecting ecosystem services (Swallow and Meinzen-Dick 2009).
Traditional market processes rarely capture public goods and the value of ecosystem services (i.e.: water provision, carbon storage, and nutrient cycling) (Costanza et al. 1997, Travers 2009). Uncompensated benefits become positive 'externalities.' Processes such as deforestation drive natural ecosystem service degradation and loss (Landell-Mills and Porras 2002). The inclusion of environmental costs for lost services would, more often than not, reduce the economic efficiency of ecosystem degradation (Balmford et al. 2002). The use of compensatory incentives to offset lost opportunity cost can help resolve conflicts between natural resources and resource-users, and therefore make them more efficient in managing ecosystem services (Wunder, Engel, and Pagiola 2008).

Based on an ecosystem services approach, the use of such incentives (often economic, including Payments for Ecosystem Services (PES)) has generated strong interest. The criteria for incentive schemes are based upon Wunder (2005b) early studies. Funded either by direct or indirect services users, incentive-based institutions have the potential to mobilise financial resources to integrate the short-term immediacy of conservation goals with the long-term economic and social change of development objectives (McShane et al. 2010, Tacconi 2007, Ferraro 2001). Influencing individuals' natural resource-use decisions via incentives also can serve as a redistributive mechanism between different social groups and ecosystem users (Adams and Hulme 2001, Barrett and Arcese 1995, Kumar and Muradian 2008).

Where incentives are involved, the type of ecosystem service is important in an institutional design and governance context (Swallow and Meinzen-Dick 2009). The case studies in this research focused on watershed service provision through incentive-based institutions. These aimed to protect watershed integrity to enable adequate flow, withstand flash floods (a frequent event in Lombok upper catchments), while also increasing social equity of access to the resource. These mechanisms were often managed through the installation of water infrastructure and forest replantation. Institutions to manage watersheds are complex. Multiple actors, various organisation levels, and a high degree of interaction with other institutions were evident. As a common pool resource, ground water is seen as a public good, with a high cost of excluding free riders. The benefits of water resources are subtractive in nature and have a communal use, this denotes that, "when water is scarce, conflict is likely" (Wade 1987).

When dealing with natural resource management, the influence of incentive-based institutions on individuals' and organisations' behaviour and decision-making is convoluted, particularly when institutional 'interplay' is high. It is therefore difficult to align theoretical assumptions with the 'messy' reality of outcomes from incentive-based institution implementation For example, the culture and social norms that structure the society is highly significant (Rojas 2006). The impact of existing power relations and well-defined and enforced property rights also are essential to understand for the creation of functioning markets for incentives.

Local governance institutions play a key role in determining variation in forest conditions (Agrawal and Ostrom 2001). The role of local institutions in natural resource governance is highly dynamic. They have a multi-directional influence on socioeconomic, political, and environmental outcomes. Anderson and Agrawal (2011) argue that the structure and strength of these local institutions can affect socioeconomic contexts. They contend that governance institutions can mediate the positive or negative effects of these contexts, which arise from market forces, demographic pressures, and political regimes.

4.2.4 Collective action and maximising social utility

Incentive-based institutions draw from theories of economic rationality aimed at maximising individual benefit. Yet human motivation is complex (Vatn 2010b, Vatn 2010a). Rational choice alone cannot explain individual behaviour. And it is this very behaviour that incentive-based institutions aim to influence through rational utility maximisation (e.g. Hardin 1968). The use of economic theory to predict natural resource behaviours overlooks social utility maximisation, such as existing social and cultural activities such as collective property rights and customary laws (e.g. Vatn 1009). These communal local institutions, however, may represent significantly strong incentives and should be considered in incentive-based institution design to understand the foundations of behavioural motivation (McAfee 2012b, Kreps 1997, Gachter and Fehr 1999, Fehr and Falk 2002).

The type of resources and associated property rights also should not be overlooked. Exploitation for some resource types may occur under multiple property rights (Wade 1987). Water is a common pool resource with a joint subtractive use. Social organisation is required to distribute and ration water resources, and regulate individuals' access and use rights (Mosse 2003). Where resource appropriators help create and adapt rules, self-organised systems of resource governance can emerge. Where common goals, which cannot be achieved by individual actions, are obtained through actions of more than one person (Wade 1987), cooperative solutions can result. These cooperative behaviours to manage common resources, argue Mosse (1997, 2003), also can arise from moral conscience or social norms. This research will contribute to the debate surrounding the emergence of collective action and its role in managing common pool resources. It focuses on the implementation of incentive-based management to motivate collective action and how benefits are distributed.

4.2.5 What conditions enable collective action to emerge?

Wade (1987, 1988) suggests that motivation to prevent the depletion of common pool resources – a development on the Tragedy of the Commons (Hardin 1968) – drives collective action for environmental behaviours. Hardin argues that without regulation and property rights, common pool resources will be depleted. Wade proposes that it is the risk of resource depletion and scarcity, linked to ecological variation across water catchments, which has significant effect on the strength of any collective cooperation. Mosse (2003) furthers this viewpoint. He suggests that the very nature of physical control of water resources creates a social role for water, and, as such, influences social organisation. He argues that institutional responses are the result of ecological conditions, which influence water availability. These responses ultimately shape village-level strategies and power alliances, the historical variation of which is highly significant in local water management regimes (Mosse 2003).

*"*Cooperation is not, as Wade suggests, an all or nothing option (1987:187)." (Mosse 2003).

Water management systems are often embedded in social customs. Their evolution towards more formal regulation and visible organisational structures is not smooth (Mosse 2003). The likelihood for collective action is difficult to predetermine in the real world. While ecological determinants are significant, they are not independent from historical and political complexities, nor from the social dimensions of common pool resources that have also shaped institutions (Mosse 2003). This may suggest that collective action may be higher in smaller, homogeneic groups that try to reduce their vulnerability and communal dependence on natural resources. These relationships often exist through religion, folklore, social norms and traditional customs (Mosse 2003). In contrast, large groups, whose common interest has a wider scope, may require greater incentives, such as selective punishment, to achieve group objectives (Olson 1971, Varughese and Ostrom 2001).

By working towards a common objective, collective action has the potential to provide a catalyst to reduce the impacts of socioeconomic inequality on the environment (Anderson and Agrawal 2011). As such, drivers of this action, other than economic efficiency, such as religious or social norms, cultural obligations or education programmes, may have a greater influence on community cooperation. They can enable more positive environmental behaviours, which overcome transaction costs and barriers to participation by smallholders (Swallow and Meinzen-Dick 2009). Conversely, existing inequalities can undermine the likelihood of collective action. Differences in resource availability may affect the need for, and ability to undertake, such action.

4.2.6 Efficiency vs. equity in benefit capture arising from collective action

Socioeconomic inequalities negatively affect common pool resources (Anderson and Agrawal 2011). This heterogeneity may reduce the sustainability of collective action for natural resource management. That can include the exhibition of high levels of distrust, the unequal distribution of powers to make decisions, and the disproportionate allocation of benefits from the common resource managed by an institution (Neupane 2003, Seabright 1993, Moore 1993). These inequalities can create a potential vicious circle of free-riding, over-harvesting, and unsustainable environmental outcomes.

Conversely, others argue that these socioeconomic inequalities are essential to, and reinforce, ecosystem services incentive-based institutions (McAfee 2012b, Engel, Lopez, and Palmer 2006). Engel, Lopez, and Palmer (2006) suggest that to maintain cooperation and collective action for natural resource management, it is crucial to have inequality in both material goods and socioeconomic interests. This creates a

'market' in which to bargain for and provide incentives to obtain material or social benefits. McAfee (2012b) debates that the very logic of PES (i.e.: to provide incentives based on opportunity costs) in itself is "anything but neutral." She highlights that those better off are more likely to profit from deforestation and land degradation because they often have greater capital to do so, land tenure, and access to labour etc. To compensate for these high opportunity costs, significant incentives are required. As such, wealthier individuals may benefit more than the poor from incentive-based institutions. This valuation of opportunity costs, however, does not take into account the historical context of current power relations, which determine the current state of hierarchical opportunity costs. That includes the strength of purchasing and bargaining power, and the level of need for those buying and selling. This suggests that it is an inherent outcome of incentive-based institutions that costs and benefits are distributed unequally, thus maintaining, if not increasing, inequity.

Inequity of resource appropriation may lead to the elite capture of benefits. This phenomenon arises when those with greater political and/or economic power, and influence, appropriate public resources meant for communal benefit at the expense of the less influential or minority groups (NCAER 2009). Weak institutions, changes in resource ownership, and fluctuating values make rent seeking more attractive. Those who would have been entitled to receive benefits may be taken over by new actors (Kronenberg and Hubacek 2013). That includes less economically or politically strong areas of the community experiencing reduced access to public good than others. This inequality causes serious concern during the provision of public goods in areas where the poor are disempowered and are unable to counteract the power of the local elite (Platteau 2004, Chowdhury and Yamauchi 2010). The inequality can reduce cooperation and diminish ecological resources. To improve the equity of resource distribution, decentralisation of power is required (Bank 2003, Chowdhury and Yamauchi 2010). The benefits of decentralisation for greater equity in the distribution of public goods is, however, likely to be obsolete and ineffective if there is elite capture, especially at the local level (Chowdhury and Yamauchi 2010, Travers 2009, Vatn 2010b, Vatn 2010a).

Many assumptions must be made in analysing the extent and influence of elite capture on institutions. These assumptions are in addition to the multiple factors that also influence institutions and the phenomenon of elite capture on the ground (Platteau 2004). Many factors determine 'elites.' They range from class, ethnic group, traditional hierarchies, political affiliation and power, to groups historically discriminated against, religious affiliation and socioeconomic status (NCAER 2009). Galasso and Ravallion (2000) note that in communities that were unequal to begin with, elites captured larger benefit shares, and with a higher bargaining power, they also had a stronger influence on decisions over public goods.

Not all individuals in power, however, divert resources from their intended beneficiaries. In studies by Platteau (2004), where elites enable an improved situation for the poor, the outcome proved to be of greater importance to the poor than the elites who may have benefited from the potential appropriation of resources. Other studies found that elites operating in more informal institutions were less likely to capture benefits than those influencing more formal governance systems (Alatas et al. 2013*).* Understanding local power relations is essential to enable institutional effectiveness. Many projects change institutional structures, but power relations and hierarchies remain (Fritzen 2007).

Rights over access to, and use of, natural resources also influence power relations and hierarchies. They affect the equitable nature of their governance structures. Property rights are essential for market institutions to exist. Institutions such as PES are, in themselves, the creation of new forms of property. They may alter power relations and institutional trade-offs involved in those relationships.

Without a sense of resource ownership, individuals tend to seek short-term gains (Hardin 1968). Where there are large boundaries, it also is difficult to define the relationship between resources and user groups – such as understanding user demands, resource knowledge, and proximity. These blurred definitions can affect negotiations between participants of incentive-based institutions. They can lead to the commodification of resources, which generate new socio-economic hierarchies and changes in access to wealth and resources. A lack of defined relationships can potentially result in unequal bargaining power (Kronenberg and Hubacek 2013).

To understand incentive-based institutions, it is essential to examine the biophysical, social, economic, and political contexts in which they are based (McAfee 2012b). By their very nature, such institutions are significant in determining access to, and rights over, natural resources. They also define environmental values for specific societal groups. The processes, which drive institutional change and adaptation, create synergies and trade-offs for both natural resources and the wider society. That includes levels of inequality (Vira and Adams 2009, Redford and Adams 2009). The efficiency and equity of incentive-based institutions, including the 'interplay' between incentive-based institutions and other rural institutions, remains unclear. Incentive-based institutions that focus specifically on water resources may have a greater 'interplay' than others because of their multiple temporal and spatial scales and actors.

4.3 Research questions

This paper therefore addresses the following research questions:

4: Incentive-based management, collective action and social equity

1: Can incentive-based institutions function be determined by greater equality?

2: To what degree can incentive-based institutions influence equality within communities?

Understanding these questions may provide insights into the theoretical application of providing incentives to alter behaviours. This may determine whether an incentive-based institution contributes or prevents further deterioration of ecosystem services, and the institutions' impact on cultural and societal norms (Daily et al. 2009, Galaz et al 2008, Young et al 2008).

4.4 Methodology

Analysing the efficiency and equity of institutions is challenging and multifaceted (McShane et al. 2010, Clements 2012). Collective action is dynamic in nature, with multiple variables in play at any one time. These not only influence the social and ecological conditions of a system, but also the processes that underpin systemic changes. Multiple variables lead to high levels of uncertainty in measuring and determining cause and effect (Meinzen-Dick et al 2004). The uncertain long-term nature of these impacts and outcomes – whether positive or negative – make the identification and attribution of specific variables difficult in any short-term study. Yet by exploring these relationships, trade-offs and synergies can be shown that may influence the institutional design of incentive-based institutions related to ecosystem-based management.

4.4.1 Case study selection

Four comparative case studies were purposely selected to illustrate the role of incentive-based institutions. These were Lebah Suren, Ledang Nangka, Gangga, and Gitek Demung. Each study represented diverse institutional structures and contextual variables to the management of water provision in Lombok. The four case studies presented in this paper illustrate the complex relationships between stakeholders in the capture of common pool resources. All case studies were situated in the upper catchments on the slopes of Mount Rinjani and the incentive-based management observed in these case studies emerged as a result of conflict over, and access to, water.

The communities themselves largely initiated this management. In two locations, however, government or non-government organisations (NGOs) played a role. In Lebah Suren, government and NGOs were major instigators of the incentive-based institutions. In Gitek Demung, government PNPM (Practical Projects to Empower Society) projects also provided funding and institutional design. In all case studies

except Ledang Nangka, communities were isolated and dependent on the adjacent forest for the majority of their cash and subsistence livelihoods. These livelihoods were dominated by rice-based agriculture with irrigation and rain-fed systems. They also included agroforestry, and tobacco and maize agriculture. Incentive-based institutions had been initiated in the communities after conflict arise over water availability and access to resources.

4.4.2 Methods

Household questionnaires, key informant interviews, and focus groups were conducted using Participatory Rural Appraisal (PRA) principles (Chambers 1994a, Mukherjee 1997). Approximately 30 household questionnaires, two focus groups, and two to three key informant interviews were conducted per village. Households and focus groups were randomly selected, while key informants were chosen for their involvement in incentive-based management (e.g. WWF), or their role in village governance (i.e. Village Heads). While user groups in the case studies did not own property, and often shared natural resources with other user groups, they had similar de factor managerial rights. Some access rights had emerged after the decentralisation program in 1998. That included Gangga and Gitek Demung, where forest resources were opened to both outsiders and community members.

The questionnaires focused on understanding respondent perceptions and values of resources, their comprehension of incentives and their role in motivating environmental behaviours, and access to and availability of natural resources, in particular hydrological resources. Key informant interviews and focus group discussions focused on understanding why incentive-based management had emerged, how they functioned, and the extent to which community members were involved in decision-making, collective activities and receipt of benefits.

Where possible, male and female focus groups were conducted separately. These groups enabled more qualitative discussions beyond the semi-structured questionnaire. Focus groups and key informant interviews enabled triangulation of contexts and institutional function as perceived by the local community. All questionnaires, key informant interviews, and focus groups were conducted with the assistance of a trained researcher in Bahasa Indonesian, translating from Sasak where necessary.

4.5 Results

4.5.1 Case Study 1: Ledang Nangka village, East Lombok – Incentive: Religion

A local company, BUMDES (*Badan Usaha Milik Desa* - Village Owned Enterprises), was established in 1993 to manage water supply to reduce conflict over water access and maintain water supply to households. The company has used the influence of the local mosque to create informal rules, which determine environmental behaviours and ensure compliance across seven sub-villages.

Situated on the lower slopes of Mount Rinjani, the village is not directly affected by forest clearing. Agricultural and population expansion has, however, increased pressure on water supply, creating intra-community conflict over access. Payments are made by the community to BUMDES to pump water to households, manage a small reservoir, and maintain vegetation around the spring. The mosque retains approximately 45 % of all payments. Religious beliefs are predominant throughout Lombok, and the *Waktu Lima* belief is particularly evident in Ledang Nangka. The mosque had a separate water source, *"So that the community water does not disturb it. Therefore if there is community conflict, there is always water for religious activities,"* Head of BUMDES.

Friday prayers are used to communicate monthly budgets, communal activities required to reduce water contamination, and the project's overall progress. This feedback mechanism results in high transparency of, and high participation in, the institution. It draws on the community's religious belief to ensure that rules are adhered to as, "*we do not want to be bad Muslims,*" respondent, men's focus group. All households were able to benefit from the infrastructure (cleaner water, greater access and availability), as long as payments were made. Greater equity in water resource provision had reduced inter-community conflict. This was exemplified by the transparency of the management, and the use of religious fervour to motivate collective activities. This built upon underlying social norms and was, therefore, likely to induce stronger compliance and participation in communal action for the common goal of water provision.

4.5.2 Case Study 2: Lebah Suren, Sub-village, West Lombok – Incentive: Money

Situated within the Dodokan watershed, the main catchment providing water to Mataram and west Lombok, this case study is the closest to a typical 'PES' system. With state-induced formal rules, Lebah Suren showed the greatest impact of external institutional control over resources and the incentive-based institution. A multiple stakeholder intermediary, IMP (*Institut Multi Pihak*), manages the scheme, which

aims to increase efficiency of water provision for downstream users and protect forest habitats. The project was established after societal concern over the impacts of forest degradation on water flow to Mataram Municipality and an economic valuation of Mount Rinjani (WWF-Indonesia 2001). Stakeholders include, an international non-governmental organisation (WWF), a local NGO (Konsepsi), community representatives, and the Department of Forestry.

Service beneficiaries from West Lombok regency pay a consumer tax on their water use. The payment is used to cover the Dodokan project's costs, including payments to communities on the upper slopes. These communities compete for payments annually through proposals from local farmer groups. Three groups (approximately 75 individuals) per year receive funding for reforestation of 300 ha of community production forest (HKm) land that produces mahogany and agroforestry species. These species were chosen to enable the community to obtain benefit from the trees once they reach maturity. The money also is used for 'economic development,' which is decided by the community. Farmer groups received funds for the year period. Each year, a new proposal must be submitted. 'Economic development' funding is predominantly used towards small-scale microfinance. In 2011, legislation was passed to ensure consumer tax payments to fund the project. The regional legislation currently only applies to West Lombok. Service beneficiaries in Mataram Municipality, one of the highest consumers of the Dodokan watershed, are not required to pay for water services, although they draw water from the same source as West Lombok.

The IMP, the stakeholder intermediary, decides which community groups will be allocated funds. The criteria for selection are often unclear, which generates mistrust from unsuccessful community groups. The IMP monitors monthly implementation, including fines for non-compliance. Lebah Suren was one of three community groups currently receiving money from the scheme in 2011. Payments are only made for one year, after which communities must submit a new funding proposal. A single group within a sub-village receives payments and seedlings to plant within their HKm community production forest plots.

The community of Lebah Suren is focused on the provision of sustainable water resources. It prioritises water supply for two collectively owned hydroelectric power generators that supply the village. This focus appeared to drive much of the community's cohesion around communal activities, including water pipe maintenance and work by farmer groups. Many respondents were concerned that, *"Villages downstream are taking too much water. We need to protect it to get electricity,"* respondent, men's focus group; and, that "*Our electricity* [availability] *is disturbed often,"* respondent, women's focus group. Many respondents spoke of the need for constant pipe maintenance to prevent blocked water supply, and that it was the community's role to work together to fix this. Pride over the community hydroelectric

power generators was high (not all households had access to piped water, but all parts of the village had access to electricity), and many felt a desire to protect it from other villages. "*Other villages want access to it* [the hydroelectric power generator], *but we have to protect our water."*

Very few individuals of this community received economic benefit from this scheme. As a result, few were motivated specifically by these financial incentives to act collectively. Many respondents did not consider the scheme to be of significance for their households, or their community. "*I don't trust them* [IMP]. *I don't pay attention to them. I have no interest and I am too busy with my own work,"* questionnaire respondent. Collective action did, nonetheless, exist in Lebah Suren. While Islam is strong within the community, a more transitional culture of *Waktu Lima* appears to drive social norms and *gotong royong.* Communal activities to protect households from outsiders were developed from *Awiq-awiq* rules. "*We are able to protect our community better than others* [other villages] *as our community is so strong,"* respondent, men's focus group.

4.5.3 Case Study 3: Gangga, Sub-village, North Lombok – Incentive: Collective action/ *Adat*

Situated in the upper catchment, Gangga is a more traditional community based on the *Waktu Telu* religious belief. It uses collective action and *adat*, known locally as *awiq-awiq,* to reduce conflict over water availability and to protect the forest from illegal logging. *Awiq-awiq* are community-specific customary laws. These informal rules inform social norms and motivate cooperative behaviours. The sub-village is part of Genggelang village, and together with Gitek Demung, represents the fourth case study.

The sub-village borders the Mount Rinjani protected forest, and experienced severe logging from external companies following the decentralisation of the late 1990's. To remove these companies, local groups were organised to patrol and protect the community forest. UNICEF developed piped water infrastructure in Gangga in the 1980s. Conflict over the availability of water resources and the ownership of water pipe infrastructure along the water catchment arose in both Gangga and between other sub-villages. These conflicts were accentuated by drought events – the last of which occurred in 2010 – that damaged irrigation pipes.

To counteract the conflict over resources, the community developed new informal institutional rules to ensure equitable access and manage future extreme events. Building on existing social customary laws, the community has developed collective activities to protect the forest area around the spring, community agroforestry plots, and the pipe infrastructure. These existing social customary laws included: A ban on deforestation, slash and burn, and building activities within the forest; Forest patrols

to prevent non-compliance; and, communal pipe maintenance when infrastructure was damaged. These activities are led by the head of the sub-village, who oversees forest patrols to prevent illegal logging, and initiates communal activities when needed (i.e. after a flood has damaged pipes). "*If we take care of the forest, we have no water problems,*" Gangga village head.

All households have access to piped water with payments only required on an ad hoc basis for maintenance. Local customary laws require all community members to protect the forest, with punishment, such as social exclusion, fines or reduced water access, for non-compliance. Collective activities developed from these cultural norms have led to community members working to maintain the infrastructure for water access and protect the surrounding forest to ensure water resource availability.

4.5.4 Case Study 4: Gitek Demung, Sub-village, North Lombok – Incentive: *Adat/* Money

As a sub-village of Genggelang village (see case study 3), Gitek Demung is situated in the upper catchment of a small watershed, which stretches the length of Genggelang village. Following a drought event and increasing intra- and inter-village conflict over water availability, a local institution, PAMDES, was established. PAMDES was built on customary laws, *awiq-awiq*, and earlier water infrastructure developments in Gangga, monthly payments of US $1 are now made to the institution to ensure piped access. *Awiq-awiq* is used to protect the forest area (33 ha) around the spring to maintain water flow and enable greater equality in access for all sub-villages along the Genggelang's catchment. Payments are used for the salaries of PAMDES (70 %), contributions towards the village government (30 %), and forest maintenance (10 %).

Awiq-awiq customs ensure that financial punishments for non-compliance occur. "*It* [awiq-awiq] *is more effective than jail,*" head of village. Consumers accept payments as an assurance of access to water. Transparency is extremely low, which creates high levels of mistrust towards PAMDES by some community members. While the origins of *awiq-awiq* ensure that community members worked together and maintained acceptable social norms, there does not appear to be much participation of the broader community in the implementation and decision-making of the institution that manages water. Conflict remains both within Gitek Demung and between other sub-villages in Genggelang, including Gangga. During the study period, the head of PAMDES was driven out of the village following a severe water scarcity within downstream sub-villages at the height of the dry season. While community members want greater access to sustainable water resources (although not all had access to piped water via PAMDES, but continued to rely upon the spring), there appeared to be low levels of community cohesion

In Gitek Demung, inconsistent application of both *awiq-awiq* and PAMDES to manage household water resources appeared to generate both inefficient management and low equity in benefit allocation. Incentives for collective action, such as did not appear to be explicitly linked to either these traditional laws or financial motivations, i.e. underlying social norms, nor working towards common goals for improved access to and availability of water resources. Mistrust of PAMDES was evident: "*Water is not distributed evenly, as who* [ever] *pays more gets more water*," questionnaire respondent; and, "*If you have more money then you can afford to pay for better* [water] flow," respondent, mixed focus group. Many respondents felt that their community was not benefiting from this management, and, therefore, "*The community has to sort its own problems,*" female respondent, mixed focus group. The use of *awiq-awiq* did, however, provide indirect incentives to manage the environment (i.e. but not specifically household water provision), such as communal maintenance of HKm Community Forest. Yet, unlike Gangga, further upstream, who had more control over pipe, when water availability was low, they "*Had no other options,"* respondent, mixed focus group.

4.6 Discussion

These case studies provide an insight into the ways that incentive-based management motivated collective action, and how resulting benefits were allocated. They draw on the debates surrounding collective action driven by Mosse (1997, 2003) -- that collective action arises from moral conscience or social norms -- and Wade (1988) – that collective action develops in order to obtain common goals with greater efficiency.

In Lombok, public policies and incentive-based mechanisms appear to be strongly aligned (Pirard 2012c). Many of the incentive-based initiatives are linked to local, regional, and national policies such as reforestation through seedling plantation, which occurred in all four case studies. There were strong institutional differences among the case studies that range from how they were started to how they were governed. The very nature of market-based incentives denotes certain elements such as conditionality, additionality, and positive rewards. The incentive-based management observed in these case studies included positive incentives in the form of social rewards, and financial gain. Additionality was not clear in any of the case studies, but conditionality, such as fines or social exclusion for non-compliance existed and was enforced to varying degrees in Ledang Nangka, Lebah Suren, and Gitek Demung.

Analyses of the four institutional case studies on Lombok highlight how multiple factors impact the distribution of benefits under natural resource incentive-based mechanisms. All case studies illustrated a variety of institutional design, and that,

while theoretical assumptions can be drawn, the 'messy' reality of their implementation makes it difficult for correlation to be clearly determined. Both formal and informal rules were in place, and there was varying extent of respondent understanding of mechanisms' objectives and how they were enforced. Formal rules existed in Ledang Nangka, Lebah Suren, and Gitek Demung, which regulated payments and conditionality.

Can incentive-based institutional function be determined by greater equity?

The case studies show that the implementation of formal rules within an institutional framework is often accompanied by existing traditional informal rules, which shape underlying social norms and power relations. These underlying factors have significant implications for the design and implementation of incentive-based institutions. The combination of formal and informal rules can be complementary, which allows for the use of religious incentives alongside more formal rules in the case of Ledang Nangka. It can also competing, which involves new legislation to manage resources in parallel to traditional community rules in the case of Lebah Suren. Individuals' understanding and awareness of traditional, or more informal, rules appeared to be greater than more formal rules from either from IMP (Lebah Suren), or PAMDES and BUMDES companies (Gitek Demung and Ledang Nangka, respectively).

All case studies exhibited levels of heterogeneity and hierarchy. There was evidence of social hierarchies and significant power relations, which appeared to be involved in community and incentive-based institutional function. Traditional Indonesian hierarchies were evident, as local government administrators and religious groups had significant power and influence over communities, and the incentive-based institutions. The ability to determine clear relationships between hierarchies and behaviour was difficult due to the complex, intertwined nature of social relationships, intrinsic, and extrinsic motivation in practice.

As with much of Indonesia, Islam was a strong, underlying force within each community. Mosques played an important central role. They provided a strong focal point. This included communicating incentive-based institution information during Friday prayers as well as "*motivating the young"* (key informant, Ledang Nangka) to participate in community activities. It was only in Ledang Nangka where the mosque was used as a communication tool to influence compliance to the market via the community's religious devotion.

Where incentive-based institutions were built on clear hierarchies power relations appeared to be reinforced. It also indicated a stronger likelihood of compliance to institutional rules, which suggests that socio-economic equity is not required for this management to function. In cases where hierarchies were limited, or existed via social

obligations under *adat*, the existence of an incentivised market was unclear, though collective action remained high.

4.6.1 Conditions that enable collective action – Wade vs Mosse

Community discussions implied that collective action in Gangga and Gitek Demung evolved from existing informal rules that emerged from *awiq-awiq* and cultural community ties. These cultural practices are reflective of the *Waktu Telu* culture, where social obligations to the wider community control or influence social behaviours. Since 2008 in Gitek Demung, these norms had developed into a more hierarchical scheme when stronger management was required across a larger spatial scale to resolve conflict over water access. Both of these case studies support arguments by Mosse (1997, 2003) that collective action is driven by underlying social and cultural norms that motivate community cooperation. The use of economic efficiency arguments (Wade 1988) to design incentive-based initiatives would not be appropriate in these Lombok case studies. Incentives to alter environmental behaviours would, therefore, need to build on local intrinsic motivations, which drive social utility maximisation (Vatn 2009).

Informal rules also existed in parallel with more formal institutional rules in both Lebah Suren and Ledang Nangka. Lebah Suren's local collective action was significant in enabling use of water resources and hydroelectric provision. This builds on Wade (1988)'s debate that greater efficiency to reach common goals enables collective behaviours. Ledang Nangka's collective action relied significantly on direction from the central village mosque for both social and environmental management and guidance. This case study appeared to have developed collective management and use of water resources to enable greater equity and efficiency in water supply, yet used social norms (in this case, Islam) to maintain collective activities once efficient water supply had been achieved.

A community's capacity for collective action over resource management and social cohesion was stronger in communities with more informal rules, as evident in Gangga. It was unclear whether strong customary laws and communal involvement in activities in Gangga supported Andersson and Agrawal's (2011) view that informal rules mediated the impact of socio-economic inequalities on the environment. Socio-economic and political inequities were observed in Gangga. But further research is needed to determine the influence of collective action on these inequalities in relation to natural resource use.

Where collective action was strongest, inequity was lower and the impact of the incentive-based institution appeared to be weaker. Lebah Suren showed significant evidence of community cohesion through local groups such as farmer associations, and collective action activities. Despite residents spread over a large geographical

area, the focus of much of the Lebah Suren's community appeared to be maintaining electricity supply. The community's ownership of the two hydroelectric generators drove much of their collective activities. It ensured equal electricity supply, the maintenance of water pipes, and the protection of the water source. The collective ownership of the generators had greater importance to the community than the incentive-based institution, which, for many members, was a detached institution. This resulted in low levels of understanding of rules. It also led to a lack of awareness of the existence of the incentive-based institution scheme. There were low levels of involvement and benefit sharing because payments were only issued to a small group of individuals.

The customary laws of *awiq-awiq* in Gangga enabled significant levels of cohesion and collective activities among community members. Focus groups noted that issues were trusted to be resolved within the community. The belief in *awiq-awiq* was sufficient to ensure compliance with rules and equitable resource distribution. Strength of communal activities appeared to be connected to the small-scale area to be managed. It also included other social rules under *awiq-awiq*, a charismatic leader, and low heterogeneity in livelihoods, and individuals' socio-economic status within the community. This community bond created a strong representative body to protect environmental resources, and reduced the exclusion of certain social groups (Mehring et al. 2011).

This cohesion was less apparent in Gitek Demung and Ledang Nangka. In Gitek Demung, the incentive-based institution had been built on existing norms from *awiq-awiq*. But strong collective action did not emerge from this cultural heritage. A significant level of distrust between community members and village administration was evident. Residents of Ledang Nangka also were involved in less community-focused livelihoods, which often took place away from the village. The community's strong focus on religious activity, *Waktu Lima*, gave a greater emphasis on external concepts than localised communal social norms.

It is unclear whether these incentive-based institutions required a base of collective action to function. Most case studies did have underlying collective activities. The exception was Ledang Nangka, where the mosque influenced the incentive-based institution. Both Gangga and Gitek Demung drew on existing collective action traditions, and appeared to have a greater capacity for further communal goals. The institutions in place at Lebah Suren worked in isolation from any existing cultural activities. This is the result of the outside driven nature of the incentive-based institution spurred on by INGOs, NGOs, and local government agencies. Existing communal activities indicated the high potential for working for the collective rather than just individual benefit.

4.6.2 Efficiency vs. equity in benefit capture through collective action

To what degree can incentive-based institutions influence equity within communities?

The implications of the case studies' structures on benefit distribution was mixed. Improved access to water resources occurred across all case studies. There were considerable differences between the redistribution of benefits and empowering of local people between the communities. This disparity raises questions as to the ability of incentive-based institutions to enable greater equity in reality. Three out of the four case studies' (Ledang Nangka, Gangga, and Gitek Demung) institutions focused on distributing capital benefits on a community-wide scale. In contrast, Lebah Suren's downstream neighbours benefited along with a small group within the sub-village.

Downstream benefits were distributed indirectly from water and forest management in any upper catchment. This scheme was the only case study with a specific external focus as part of the design. Financial benefits for socio-economic development were limited to a small farmers group in Lebah Suren. This reaffirmed existing unequal resource distribution. It also led to the capture of benefits in this sub-village under formal rules (Alatas et al., 2003), while also emphasising the distance between the power of those implementing and those making decisions.

Conflict remained between, and within, the sub-villages of Gangga and Gitek Demung. The stress of the dry season reduced access and availability to sub-villages downstream from Gitek Demung, which also caused increased conflict. Political conflict and mistrust were evident over how benefits were generated and used from Gangga and Gitek Demung. A lack of transparency from PAMDES regarding its funding potentially worsened this conflict. It created mistrust among residents and fostered feelings of disempowerment. In Ledang Nangka, while the mosque received a significant financial benefit from the incentive scheme, residents believe this to be deserved and water resources were distributed fairly and transparently. This institutional structure supports Platteau's (2004) view that elite capture of benefits can be of lesser importance if it enabled improvements for the poor.

Significant variation in stakeholder involvement was also observed across the case studies. Whether the schemes were initiated from within the community or by external bodies, such as the government or NGOs, had an impact on how well institutions 'fit' the communities and on the levels of community participation. This division highlights the conflict of interest between policy and local context. It also shows the distance between those in power, often based outside the communities, who make decisions and those, often from inside the communities, who implement the activities.

The majority of the Gangga community was aware of the role of *awiq-awiq* in the activities used to manage access to resources. This awareness was fuelled by a strong community head who made decisions via community meetings. In contrast, only those individuals in the Lebah Suren community who were paid as part of the incentive-based mechanism were aware of the scheme operating in the sub-village. Others were unaware of changes to resource access. This lack of broad understanding illustrates the importance of participation at all levels – decision-making, design, implementation and monitoring – to maximise local understanding, empowerment, and opportunity to obtain benefits.

Empowerment was obvious in Ledang Nangka where the scheme was initiated and then run by the local community. Transparency was high through open and regular budget updates and project communication via the mosque. Trust in the local religious organisation linked to the incentive-based institution drove compliance by reducing the opportunity for free riders.

In comparison, a collective of NGOs, the local forestry department and community representatives facilitated the government-introduced scheme in Lebah Suren. This incentive-based institution exhibited the lowest involvement by the local community and less 'interplay' with local institutions. It also showed a least amount of equal distribution of benefits of payment schemes. While a single group within the sub-village were receiving payments and seedlings to plant within their HKm Community Forest plots, they had no involvement in the overall management or decision-making process. Community members who were not receiving payments did not directly benefit from the incentive-based institution through either capital or empowerment over resources. This lack of broad community involvement was contrasted by the widespread collective action regarding an existing hydroelectric scheme. This was created by the local community, and distributed both water and electricity equally to most sections of the community.

These disparate case studies reflect the current changes in power relations and political structures under decentralisation in Indonesia. In all four case studies, it was implied that elite control of institutional structures, management and, likely, benefits was widespread. This is supportive of the argument (Hadiz 2003) that power relations in local contexts have merely been reorganised, rather than transformed, under *Reformasi*. Inequitable influence on institutions between actors, either as a result of material capital or existing power relations, appeared to impact levels of participation and transparency of information. That led to control of information by those in power, such as low transparency in Gitek Demung, or the reinforcement of hierarchical prestige and power with the use of the highly influential mosque in Ledang Nangka. The four case studies show the need to understand the historical and political conditions of governance in a local context when assessing the impact of introducing newer institutional structures.

4.7 Conclusion

These findings have clear relevance for PES and incentive-based program design and implementation. They highlight the complexity of attributing the practicalities of natural resource management to the theories that underpin them. Human behaviour is determined by multiple factors, which are difficult to correlate with specific drivers or variables. Lombok illustrates a number of examples of incentive-based institutions, each influenced by their own political, socio-economic, cultural, and biophysical contexts. Using market-based approaches to conservation raises both ideological and practical concerns (Milne and Niesten 2009). There are many challenges for the implementation of incentive-based institutions on the ground. That includes poorly defined property rights, different institutional arrangements, and conflicts between customary and external driven objectives. These four case studies highlight the variation of equity and efficiency facing incentive-based institution interventions.

The case studies suggest that incentive-based institutions work best when built on existing collective action institutions that draw on intrinsic motivation and social norms. When they are developed in conjunction with local communities, incentive-based institutions have a great potential to show greater alignment with the cultural context and existing institutions. These institutions may not be specifically focused on natural resource management, but there is strength connected to building on existing social norms and customs (Mosse 1997, 2003). Where incentive-based institutions were instigated in isolation from existing institutions, such as in Lebah Suren, there was little evidence of 'interplay' with existing institutions. As a result, the incentive-based institution in Lebah Suren illustrated lower levels of local empowerment, equity in resource, and benefit distribution.

In particular, these case studies build on debates by Mosse (1997, 2003), and support the argument that incentives that draw upon social norms to generate collective action may be more successful for more efficient and equitable environmental management. Ultimately, these appear to drive greater efficiency in the context of Lombok than collective action built on increasing efficiency to obtain common goals as argued by Wade (1988) and Hardin (1968). Where efficiency is maximised, greater equity in distribution of resources are not always achieved. Incentive-based institutions in these case studies that were externally instigated focus on efficiency, whereas local-led institutions were driven by greater equity in resource distribution. A lack of equity was not required to enable these local initiatives to function, however, it is likely to be required to enable a market to allow for opportunity costs.

All programmes appeared to be at risk of elite capture of benefits because of the potential for rent seeking. Cultural hierarchies, a lack of clear enforcement, and existing Indonesian power relations also played a role. The presence of the elite capture of resources and benefits from incentive-based institutions remains

widespread because such benefits are highly context specific. Assessing social impacts is complex. The short time-scale of this study presents significant limitations to understand these long-established cultural norms. Further in depth research to understand the cultural drivers and perceptions of natural resource use within Lombok is therefore required.

The context-specific nature of each incentive scheme highlights the need to directly target mechanisms at local providers. Key to these case studies is the necessity to align incentive-based institutions with existing institutions and intrinsic motivations. This not only allows 'interplay' with underlying social norms, but also strengthens each incentive-based institution. Incentive-based mechanisms have been implemented as solutions to dynamic situations (Kronenberg and Hubacek 2013). Over time, changes will occur in the provision of ecosystem services, the demand placed on them, and societal preferences for how resources are used. The increased value of ecosystems through incentive-based institutions can also alter local perceptions and uses associated with ecosystem services.

There are many challenges for the successful implementation of these mechanisms within local contexts. The case studies in Lombok highlight the need to recognise that every scheme is influenced by its unique political, economic, biophysical, social, and cultural contexts, and that outcomes are very difficult to predict. It is paramount to understand how these existing institutions and their dynamics may interact with incentive-based institution design prior to implementation. This may determine whether incentives enable collective action that contributes to, or prevents further deterioration of ecosystems. The appreciation of variable local contexts before mechanisms are created may prevent the elite capture of benefits through rent seeking and inequitable resource distribution. Yet while it may increase equity among users, this approach may also lead to negative affects on the programs' environment efficiency outcomes, and eventually on the resource users themselves.

4.8 References

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5 How well do incentive-based institutions 'fit' the societal values of ecosystems on Lombok, Indonesia?

5.1 Abstract

Incentive-based institutions to manage ecosystem services have been widely implemented to influence land-use behaviours for sustainable natural resource use and environmental conservation. Incentive-based institutions, such as Payments for Ecosystem Services (PES), are based on Coasean principles that focus on compensatory measures, which can generate markets to solve environmental economic externalities. Environmental values are not, however, just driven by economic rationale. Human behaviours are driven by multiple, and often unpredictable, factors. Socio-cultural values and social norms also play a significant role in determining land-use behaviours. The sole use of economic values and financial incentives through incentive-based institutions may not always align with the local context in which they function. This has implications for the generalisation of policy and its practical implementation. Six villages in Lombok, Indonesia were examined to identify societal values and perceptions of the environment, and the relation of these social norms with incentive-based institutions. Villages that managed resources through incentive-based institutions illustrated higher institutional 'fit' and interplay when incentives were based on existing social norms. These institutions generated greater trust, community participation, and compliance. An understanding and inclusion of local perceptions and socio-cultural values of ecosystem services are crucial. The contextual nature of these perceptions and social norms, however, means that the criteria for PES application are unlikely to be met universally. The use of Coasean approaches to provide economic incentives may, therefore, not be sufficient. Policies, such as PES, that are based purely on theoretical principles may require a design to include the real world in which they function. As such, greater institutional 'fit' can be fostered when societal values are incorporated to promote collective behaviours for sustainable natural resource use.

5.2 Introduction

5.2.1 Institutions in ecosystem services management

Ecosystem management "typically involves social dilemmas" (Muradian 2013). These 'dilemmas' relate to the choices of decision-makers about natural resource use. The loss of wellbeing, for example, can arise from an individual who pursues short-term gains from natural resources over the long-term sustainability of the resource (Muradian 2013). The management of ecological systems reflects similar conflicts that underpin "issues of the commons" (Muradian 2013). Solving these issues requires institutional structures to constrain, and provide incentives for, human interaction (Folke et al. 2007, North 1990, Corbera, Soberanis, and Brown 2009). Limits consist of formal elements, such as rules, laws, and constitutions. They also include informal elements, such as culturally imposed codes of conduct, behavioural norms, and social characteristics of enforcement. Fundamentally, institutions create links between society and ecological systems to enable long-term environmental and development objectives.

Effective governance of ecological and social conditions requires specific institutional arrangements. Social systems are themselves dependent on the dynamic function of ecosystem services, which hold values for use and non-use (Muradian 2013, Muradian et al. 2013). These complex interactions between resource users, governance systems, and natural resources (social ecological systems, or SES) require institutions that provide incentives for sustainable resource use behaviours (Travers et al. 2011). Innovative socio-ecological theories also are required to handle the complexity and dynamism of SES interactions to protect the long-term use of natural resources (Armitage et al. 2012). The use of incentive-based management, such as Payments for Ecosystem Services (PES) is based on the Coasean principles. It centres on creating measures that compensate for opportunity costs by generating markets that solve environmental economic externalities, such as deforestation and degradation. Key criteria of PES schemes have been developed by Wunder (2005, 2008a), and include: Directness, Additionality, Existence of voluntary contracts, Conditionality, and a User-pays principle.

Studies have shown, however, that the contextual nature of SESs is highly significant in affecting behavioural outcomes from institutional arrangements (Travers et al. 2011, Ostrom 1990). Different institutional structures that govern SESs generate varying transaction costs for communities involved (Muradian 2013). Modes of SES governance can be categorised as hierarchical- (systems of command), markets- (systems of voluntary exchange), and community- (systems based on cooperation) management (Vatn 2010b). Many forms of governance, however, have characteristics of all three categories. As such, they are often represented through hybrid structures,

and may even be interdependent on each other for functionality (Muradian 2013, Vatn 2010b).

This paper seeks to examine the 'fit' of incentive-based management in the context of communities in Lombok, Indonesia. It studies elements of 'fit' in relation to the use economic and non-economic incentives to motivate sustainable land-use behaviours for water ecosystem services provision. It builds on current debates emerging in PES, specifically whether the use of Coasean arguments to design incentive-based initiatives are appropriate in all cases; and, whether fulfilling the PES ideal proposed by Wunder (2005, 2008a) is appropriate, or may be unlikely to 'fit' with the local social, economic, biophysical, or political contexts in which initiatives must operate.

5.2.2 Incentive-based approaches

Incentive-based approaches to manage ecosystems, such as Payments for Ecosystem Services (PES), are one such hybrid structure that has been widely implemented. The aim is to encourage behaviours that enable greater sustainability in resource use and to promote more equitable distribution of resources for resource users. Wunder (2005) initially defined the concept as the use of direct payments as incentives for land users to manage their land more sustainably to provide ecosystem services. This, he argued, could provide opportunity costs for conservation, rather than degradation of ecosystems, while also increasing benefits for resource users. Criteria for PES include voluntary contracts (Engel, Pagiola, and Wunder 2008b, Wunder 2006a, 2007, 2008b, 2005), the user-pays principle (Engel, Pagiola, and Wunder 2008b), conditionality (Kemkes, Farley, and Koliba 2010, Sommerville et al. 2010), directness (Ferraro and Simpson 2002, Muradian et al. 2010), and additionality (Ferraro and Simpson 2002, Sommerville et al. 2010). Not all incentive-based institutions necessarily adhere to strict criteria, or involve economic transfers (Hutton and Leader-Williams 2003).

Non-economic incentive-based approaches

Incentives do not just have economic meaning, but also hold social significance (Muradian 2013, Kreps 1997). Central to this is the opportunity for communities to control for social dilemmas of ecosystem management (i.e. the imposition of penalties for non-cooperative individuals or social rewards for compliance). Where incentives are communal or promote group decision-making, they often result in greater cooperation and self-organisation within communities (Travers et al. 2011). In particular, Ostrom (1990) placed great importance on the ability for communities to organize independently of governance structures and cooperate between themselves. Community cooperation enables a greater ability to self-organise the governance of natural resources, compared to government-imposed solutions. Higher cooperation between community members is likely to increase participation in decision-making that can create "collective choice arrangements" (Ostrom 2011). The ability of

communities to cooperate is partly conditional on existing social norms that guide cooperative behaviours (Fehr and Falk 2002, Ostrom 1990). This is a highly contextual component depending on each SES in question.

Coasen approaches to incentives

Early advocates of incentives, like Wunder, Ferarro and Kiss (Wunder 2001, Ferraro and Simpson 2002, Kiss 2002, Wunder 2006b), used Coasean approaches to solve economic environmental externalities. The Coase Theorem argues that, under certain conditions, a pure market approach can be used to internalise the cost of non-market environmental values (Muradian et al. 2010, Gómez-Baggethun et al. 2010, Pascual et al. 2010, Schomers and Matzdorf 2013, Engel, Pagiola, and Wunder 2008a). This market-based system enables an approach where beneficiaries directly pay service providers. For example, in the Vittel Vosges Mountain scheme, where 27 upstream dairy farmers in France are paid by the water company Vittel, which is based downstream, to farm using sustainable practices to maintain high water quality (Wunder, Engel, and Pagiola 2008, Schomers and Matzdorf 2013, Perrot-Maitre 2006). Coasean approaches are more likely to be found in initiatives where benefits are obtained at local levels. Large-scale initiatives often involve other institutions acting as intermediaries to establish and maintain the incentive mechanisms. This approach reduces the reliance of the initiative purely on independent markets to govern the distribution of costs and benefits (Schomers and Matzdorf 2013).

Not all incentive-based schemes fit the Coasean approach. For example, in government payment schemes, the state acts on behalf of service providers. Payments can be linked to environmental externalities or to the ecosystem service itself, which often is a tradable commodity (Schomers and Matzdorf 2013). Buyers are not always direct users, but pay for the provision of public goods. For example, Mexico's *Pagos por Servicios Ambientales Hydrologicos* (PSA-H) PES program was implemented at a national scale in 2003 to protect water services, i.e. public goods (Schomers and Matzdorf 2013, Southgate and Wunder 2009). Uniform mandatory water fees payments were made to contribute to the protection of existing forests to reduce aquifer exploitation. Payments were then distributed to private and communal farmers.

Beyond the Coasean approach, economic rationale cannot explain all land-use decisions (Vatn 2010b, Vatn 2010a). Social and cultural values, and the roles of environmental resources, are also influential in determining land-use behaviours for both communities and individuals (Gachter and Fehr 1999, Vatn 2009). Some incentive-based schemes may build on these values to create social or cultural incentives to motivate environmental and cooperative behaviours. These deeply-rooted social customs, it is argued, can provide incentives for collective action and

cooperative solutions that can used to govern natural resources (Mosse 1997, Wade 1987).

5.2.3 Institutional 'Fit'

Incentive-based governance systems do not operate in a vacuum (Vatn 2010b). They are likely to be influenced by, and interact with, existing institutions. Given this complexity, the context in which institutions function must be understood to sustainably manage the ecological system on which resource users depend (Muradian et al. 2013). Effective management of natural resources may be enabled, or undermined by, the interplay within, between, or across institutions and values (Agrawal 2002, Corbera, Brown, and Adger 2007, Dietz, Ostrom, and Stern 2003, Young 2002, Gehring and Oberthur 2008). These interdependencies may have significant implications for the ability of both ecosystems and governance to function. The value of ecosystem services develops from social perceptions that are, in themselves, not "ideologically neutral" (Gómez-Baggethun et al. 2010, Adams et al. 2003). Effective institutions require an understanding of the cultural, social, economic, and political context of the sites in question. They also need an awareness of existing institutional roles, and knowledge about whether these roles are strongly or weakly defined, especially when related to local property rights (Clements 2010).

Institutions to manage ecosystems services must match these socio-cultural, economic, political, and biophysical dimensions in which they aim to function (Ekstrom and Ostrom 2009b, Galaz et al. 2008). 'Fit' is the extent to which these governance institutions align to the dynamics of the SES. Institutional fit consequently provides the foundation for how the ecosystem processes operate (Galaz et al. 2008, Erkstom and Young 2009, Folke et al. 2007). The interdependent nature of these highly-dynamic processes within SESs occur at both temporal and spatial scales (Galaz et al. 2008). 'Fit,' therefore, becomes a function of the robustness and effectiveness of a SES's social institutions and the ecosystems in which they operate (Folke et al. 2007, Robbards et al. 2011, De Caro and Stokes 2008, 2013). Institutions that 'fit' the SES in which they aim to govern require adaptive co-management. That not only accounts for changes within biophysical systems, but also the interactions within socioeconomic systems (Young 2007, Olsson et al. 2007). The multi-level nature of actors' interaction patterns – often with contradictory objectives – is key to determining the ability for these actors to adapt and self-organise in the face of environmental and societal dynamics. Adaptive co-management combines both collaborative management and the dynamic capacity of governance structures to continually evolve SES, which would imply a better 'fit' (Olsson et al. 2007, Folke et al. 2005).

Elements of institutional 'fit'

The challenge policy makers is to establish institutions that govern resources, which not only 'fit' the ecosystems, but also are founded in the societies in which the institutions exist and where resources are used and valued. "Optimal fit between institutions and the resources they govern may not be the tightest fit" (Folke et al. 2007). Consequently, while the literature lacks clear definitions of institutional 'fit,' Olsson et al. (2007) and Galaz et al. (2008) describe key elements that enhance fit through SES adaptive co-management (Table 5.1).

Table 5.1. Elements of institutional 'fit' between ecosystem dynamics and governance systems. Adapted from Galaz et al (2008), Folke et al (2007) and Folke et al (2005).

Fit element	Definition and mechanism	Indicators
Bridging organisations between local actors and communities with other institutions	• Provides an arena in which to builds trust, resolve conflict, etc. • Provide strategies to manage social networks • Facilitate adaptive co-management	• Participation decision-making and outcomes • Incorporation of cultural norms
Leadership	• Key individuals that link within and between organisation levels • Facilitate communication of information within a local context	• Strong individuals guiding institution • Trust of institution • Public awareness of institution
Focus of resource management	• The scale of an institution is fundamental to the issue of 'fit'. The ability of an institution to cover the jurisdiction of an ecosystem or whether the control of specific resources is too narrow has impacts for efficiency and adaptability	• Scale of institution • Understanding of social and ecological mechanisms driving resource use • Directed institutional response to address drivers of change

Timing	• Whether an institution is implemented too early or too late to govern the ecosystem. • Institutional decisions and / or social responses time span may be too long or too short to affect the ecosystem	•Long-term solutions 2 Ability to respond to social and ecological drivers within time frame
Adaptability	• Institution has the capacity to adapt to environmental and social changes, both slow and abrupt	•Capacity for conflict resolution •Capacity to respond and adapt to feedbacks **2.** Institutional learning

5.2.4 Implications of Institutional 'Mis-Fit'

Institutions that do not 'fit' the resources, resource use, or social system, which they are intended to manage, create 'gaps' in governance (Ekstrom and Ostrom 2009b). Failure to take into account the interdependency between social and ecological systems can lead to functional 'mis-fit.' That can substantially contribute to the deterioration of ecosystem services (Ekstrom and Ostrom 2009a). Functional 'mis-fit' is "the failure of an institution or set of institutions to take adequately into account the nature, functionality, and dynamics of the specific ecosystem it influences," (Ekstrom and Ostrom 2009b).

The potential for institutional 'mis-fit' arises from the dynamic, and often unpredictable, nature of SES interactions and the values placed on resources (Muradian 2013). The highly contextual nature of social values of ecosystems by resource users creates complexities for institutional governance. Social values incorporate elements of human preference, site specificity, and market variability. These elements affect how resources are allocated, and what trade-offs are involved. Mis-fitting institutions are unable to create adaptive governance systems that can respond to these dynamic functions and values. They may reduce the resilience capacity of SES and face weaknesses in policy implementation (Olsson et al. 2007).

5.2.5 Implications for incentive-based institutions to manage ecosystem services

How incentive-based mechanisms emerge has significant implications for their alignment and interplay. Local actors are more likely to understand and value incentives that are built on endogenous social norms and institutions (Clements 2010). Compliance to incentive-based mechanisms is more likely with local support. Incentive initiatives, which can draw on a community's intrinsic motivation and

enable participation that helps to devise resource use rules, encourage cooperation (i.e. through collective action). These community-backed initiatives have the greatest effect in lowering resource extraction by individuals compared to top-down approaches (Travers et al. 2011).

In any resource management scheme, there are opportunity and transaction costs. The degree to which assets can be redistributed for other uses without sustaining high costs – the asset specificity – generates trade-offs for both resource users and the ecosystem. Asset specificity becomes a function of the 'economies of governance' and can be affected by market variability (Muradian 2013). Where trade-offs produce negative outcomes (i.e. actions that impact adversely on, or increases the vulnerability of, a SES), maladaptation can arise (Tomkins et al. 2013).

Motivation, and the recognition of responsibility to protect the environment, can be linked to existing social morals and norms. Introducing incentives, particularly financial pay-outs, to incite behaviours may induce changes in underlying social norms (Deci 1971, Ostrom 1998). The interplay resulting from incentive-based institutions may undermine ('crowding out') or reinforce ('crowding in') existing social norms and local rules that motivate pro-social cooperative behaviours (Muradian et al. 2010, Clements et al. 2010, van Noordwijk et al. 2012). This may work to either conserve biodiversity or destabilise intrinsic motivations within communities (Clements 2010, Bowles 2008, Rode, Gomez-Baggethun, and Krause 2013, Vatn 2010b, Muradian et al. 2013).

'Crowding out' of social norms by extrinsic incentives (often monetary incentives) can change the mind-sets and values within communities. It may alter individual moral responsibilities in favour of short-term economic gains (Bowles 2008, Rode, Gomez-Baggethun, and Krause 2013). In certain occasions, extrinsic incentives may have the opposite effect. They can strengthen and complement existing intrinsic motivation (i.e. 'crowd in') to protect the environment and managed resources. This can result from an institution or incentive, or local cultural preferences, which build on and enhance existing social norms. It also may lead to incentives enhancing social recognition. Incentives may be perceived as social rewards, and can use peer pressure and desire for social approval to promote compliance (Bowles 2008, Gachter and Fehr 1999).

The alignment of incentives-based governance is important to enable positive interplay with other existing institutions. It also fosters cooperation by communities to generate collective action. Building on existing institutions and underlying social norms linked to collective actions may reduce the effect of incentives 'crowding out' positive environmental motivations. The introduction of new institutions to communities, even with a good 'fit' and interplay, may still affect the communities' evolving social identities, sustainability, and the equity and efficiency of resource use.

Incentive-based institutions based on economic market values of ecosystem services are complex to implement beyond theoretical realisation. The very nature of ecosystem services creates difficulties in their commoditisation and can lead to opportunistic behaviours by resource users. The level of cooperation of resource users is dependent on social and institutional dimensions, and the incentives used. Incentive-based institutions based on a hybrid form of governance systems may encourage greater community cooperation over individual gains (Muradian and Rival 2012). This can be facilitated through underlying motivations, trust, monetary transfers, social norms, leadership, and penalties. The overall 'fit' of incentive-based mechanisms can be increased when built on these factors. This approach also allows greater and positive interplay with existing institutions to reduce transaction costs and the potential for 'crowding out' of intrinsic motivations.

5.3 Research questions

This paper aims to identify the importance of 'fit' for incentive-based institutions, using case studies on Lombok, Indonesia. It focuses on elements of 'fit' and 'mis-fit' in incentive-based institution emergence and design, and the realities of its implementation in practice. This has important implications for the application of such institutions and the current discourse surrounding PES. The principle research questions addressed in this paper are:

1: Can the conditions under which incentive-based community institutions manage natural resources be predicted?

2: How do these institutions 'fit' social-ecological systems?

3: What is the relationship between the 'fit' of incentive-based institutions and environmental behaviours?

4: How can institutional 'fit' be incorporated into incentive-based approaches to conservation?

5.4 Methods

5.4.1 Study sites

To identify elements of 'fit' of incentive-based institutions for communities, a comparative case study method and matching were used to select appropriate multiple case studies and controls (Yin 2003). Using villages and households as the units of analysis, the villages were selected according to the existence of incentive-based

institutions, and the controls were selected through matching. Different incentives were used in the sample villages, but they were selected to predict similarities and distinguishing characteristics between each group (incentive-based institutions and control) (Yin 2003).

Six villages were used as case studies: Ledang Nangka, Gerami, Lebah Suren, Lebah Sempaga, Gitek Demung, and Gangga. These were chosen due to local incentive-based institutions that manage natural resources in three villages: Gangga, Ledang Nangka, and Lebah Suren. Gangga, in north Lombok, relied on traditional *adat – awiq awiq*, or customary laws, which underpin social norms to motivate cooperative behaviours. Created in a village forum, these traditional Sasak cultural laws are often more accepted than official Indonesian law. They enable community groups to protect the forest from illegal logging, ensure habitat around the spring is not deforested, and punish non-compliance.

In Ledang Nangka, central Lombok, a local water management group, BUMDES (*Badan Usaha Milik Desa* - Village Owned Enterprises), used the local mosque to motivate positive environmental behaviours and ensure that people adhered to rules. Drawing on the community's strong religious behaviour, the mosque played a key role in communicating water management policies by influencing individual and community action. Payments were made to the mosque, which then distributed finances to the water user group, BUMDES, for environmental management activities like tree plantation (and for the mosque itself), and the communication required to promote communal activities and outcomes.

Lebah Suren, in west Lombok, is part of the Dodokan payment programme, where upstream community groups tender applications for funding to reforest HKm, (*Hutan Kommunicasi* – Community Production Forest) from a consumer tax. IMP (*Institut Multi Pihak*), an intermediary stakeholder group, managed the scheme. This group consisted of the Forestry Department, community representatives, and non-governmental organisations (NGOs). Payments to enable restoration of deforested land were made to one group of farmers within the community during 2011. However, despite no payments being made since, some respondents claimed, "*we do not need the money anymore,"* as replanting had already occurred.

The remaining three villages were selected as appropriate matched controls for household surveys against which the impacts of incentive-based community management could be measured. The villages were Gerami, Lebah Sempaga, and Gitek Demung. Matching was used as much as possible to provide estimates of outcomes in otherwise similar communities that did not manage their natural resources through incentivised management schemes (Pattanayak 2009, Ferraro and Pattanayak 2006, Ravallion 2005, Heckman and Navarro-Lozano 2004). The communities were chosen due to their comparative altitude within the same

watershed, proximity to incentive-based community management villages (thus experiencing the same environmental resource pressures), and the comparative population sizes, water issues, and socioeconomic status. The application of matching, in reality, is difficult and bias is often unavoidable. The method presents a number of assumptions that, in seeking comparative variables, may simplify complex underlying processes and dynamics between, and within, villages (Ravallion 2005). This case study used comparative variables that were based on observations over a short period of time. It is, therefore, difficult to accurately determine comparative variables under these circumstances. Bias will remain from a poorly-understood reality (Clements 2012). The use of a quasi-experimental approach, however, aimed to minimise as much as feasibly possible such bias in control selection (Ferraro and Pattanayak 2006).

To prevent confusion between incentive-based and control villages during the analysis and discussion, the communities will be numbered as per Table 5.2. Each 'pair' of incentive-based and matched control village will be labelled with the same number.

Table 5.2. Incentive-based (IB) and control (C) villages surveyed and names used during analysis and discussion.

Village Name	
Lebah Suren	IB1
Lebah Sempaga	C1
Ledang Nangka	IB2
Gerami	C2
Gangga	IB3
Gitek Demung	C3

5.4.2 Survey methods

To identify elements of the institutional 'fit' of incentive-based institutions, household surveys and focus groups were conducted of poverty status and natural resource use. There was a focus on water, livelihood strategies, and perceptions of environmental benefits and institutional governance. Two survey methods were used: (1) Household surveys of economic status, natural resource use, livelihood strategies, and perceptions of household benefits from the environment; and, (2) Informal qualitative focus group discussions around economic status, water and resource use, and resource

management through focus groups and key informant interviews. Data was collected with the objective of identifying key community characteristics that were more likely to generate elements of institutional 'fit' as per Table 5.1.

Household interviews lasted approximately 60 minutes and roughly 30 households were sampled per village, with 171 surveys in total. Surveys and focus groups were conducted with the assistance of a trained social researcher from the University of Mataram, and questions were translated into Sasak (the indigenous language), where necessary. For training purposes and to evaluate the questionnaire, pilot surveys were trialled and focus group discussions were undertaken prior to data collection. Data collection took place between June and September 2012.

Focus groups and informal interviews with key informants were conducted separately. They enabled qualitative discussions around natural resource use, the impacts of incentive or other environmental management, drivers of water availability and access change, and key livelihood strategies. Triangulation was used, where possible, between household questionnaires, focus groups, and key informant interviews to substantiate findings and reduce potential bias. Ten focus groups were conducted in total within all six villages (five male, four female and one mixed group). Where feasible, male and female focus groups were conducted separately. However, time constraints because of the harvest season and Ramadan only allowed time for a mixed sex (Gitek Demung) and male only (Gerami) discussions in two control villages.

To prevent fatigue, individuals for each group were different from those previously interviewed in the pilot studies. Group discussions, however, were difficult, especially among female groups. Often, one individual dominated the discussions, making it difficult for others to add their own answers. Village heads would often be close by to the discussions, which may have reduced the respondent's desire to speak freely for fear of speaking out of turn. To overcome this, focus groups were kept small to allow for greater participation. Village heads also would be distracted with the researcher's request to obtain village census information to prevent their contribution to discussions, where possible.

5.4.3 Wealth analysis

Ranking wealth status can be used to group households on the basis of their wealth, incomes, and other local perceptions of affluence (Chambers 1994). There are numerous methodologies that can be used to find a proxy of wealth, such as the Basic Necessities Survey and Demographic and Health Survey (Rutstein and Johnson 2004, Filmer and Pritchard 2001). Such methods use indicators such as household assets, education level occupation, household expenditure, and housing characteristics to determine household's relative socioeconomic status.

Income and expenditure, however, are difficult and time-consuming variables to measure accurately. Many respondents will not know the figures as an annual sum due to multiple income sources, or, more likely, they will try to hide it from interviewers. Measuring expenditure is equally difficult. Finding a proxy of wealth through net assets and services can be used as a reliable and measurable quantity of household economic status (Rutstein and Johnson 2004, Filmer and Pritchard 2001). Asset measures and proxies of wealth, however, do not always account for short-term economic and wellbeing fluctuations, so levels of vulnerability also need to be captured (Moser 1998).

The pilot study and early focus group discussions indicated that due to easy access to credit and price fluctuations across Lombok, an asset index for all case studies would be difficult to standardise. It emerged in discussions that house size was often linked to wealth status. For this study, a composite wealth proxy was developed using house size as a substitute for wealth indication. This was used under the assumption that the greater the wealth, the larger the house constructed. Houses in the villages were built in a similar format, construction style, and room size. The similar construction enabled ease of assessment of house size. House size was therefore used as a proxy for wealth ranking in the analysis when comparing variables between control and incentive based institutions.

5.4.4 Analysis

Qualitative and quantitative analysis identified conditions under which incentive-based institutions emerged, 'fit' the SES, and how the institutions were perceived by communities through individuals' environmental values and behaviours. The perception of issues about resource availability at household level were analysed through the ranking of environmental values, issues facing household water supply, and awareness of current management regimes. Baseline data was not available for the villages prior to incentive-based institutions implementation. But respondents' perceptions of the environmental and social conditions, which enabled incentive-based institutions to emerge, were analysed. Perceptions focused on issues that affected household water supply, and respondents' understanding of historical and current resource governance. The 'fit' and interplay between institutions, and how this may impact incentive-based institutional outcomes, were analysed through respondents' understanding of the resource regime, perceptions of wealth, and an environmental-benefit ranking.

Where appropriate, all data was coded and, using STATA 12.0, NVIVO and Excel, analysed statistically, transforming data where necessary. Data of continuous variables that were normally distributed were analysed with parametric tests. Rank and categorical variables with 'distribution free' data were analysed with non-parametric tests (Fowler, Cohen, and Jarvis 1998). All statistical tests were two-tailed

and had a probability value of 0.05. Critical probability values quoted as follows: '***'=p<0.001, '**'=p=<0.01, '*'p=<0.05, and '>0.05'= Non-significant (p=≥0.05) (Fowler, Cohen, and Jarvis 1998).

5.5 Results

5.5.1 Can the conditions under which incentive-based community institutions manage ecosystem services be predicted?

Environmental management, including incentive-based rules, emerged for multiple reasons across all of the communities. Both social and ecological factors underpinned the reasons that fostered particular incentive-based governance arrangements. A large proportion of respondents themselves did not know why resource governance had emerged (36.14 % in incentive based management, and 25.36 % in control communities), and incentive-based approaches to management varied across the survey communities. These approaches included monetary incentives, the use of traditional laws, or religious beliefs.

In IB1, an external intermediary, IMP, introduced economic incentives to compensate for landowner opportunity costs to restore forest on the slopes of Mount Rinjani. This was initiated to protect the water supply to downstream communities who pay USD $1 per month tax towards the initiative. The intermediary consisted of INGOs, community representatives, and the Department of Forestry. The programme provided financial payments for one farmer group in 2011 to replant trees to conserve the upper catchment. Programme decisions, development goals, and payment implementation were made by IMP, which controlled which community group within the watershed received payment, and which areas of forest were restored. Payments were conditional on replantation of deforested land and the development of economic activities, as compensation for livelihood lost to reforesting the land. Payments were no longer received after 2010, as the IMP allocated these on an annual basis, following community application. The criteria for which was unclear to community members.

The community-led programme in IB2 was initiated by the local government to reduce community conflict over access to water resources. A local water company, BUMDES, was established to manage water infrastructure for household water supply. This involved the development of a piped water network to households and the mosque, and the building of a community *embung* (reservoir). Monthly payments made to BUMDES maintained the system, managed the programme, and conserved the forest around the spring. This involved reforestation and protecting the area from agricultural encroachment. Non-compliance was punished through fines. 45 % of community payments to BUMDES were retained by the mosque, which played a

central role in communicating the programme activities and budget during Friday prayers. Nearly all community members attended Friday prayers. The conservation and management of water resources were therefore perceived by many to be associated with the mosque, and therefore the Islamic faith. Social morals related to Islam indirectly encouraged community practices to protect the environment, and comply with water management.

In IB3, traditional cultural laws, *awiq-awiq*, promoted social norms that determined and controlled individual and collective behaviours. These were used to provide incentives for the conservation of forest areas under threat from degradation and deforestation. This aimed to protect the water source that provided household and agricultural water for the village, as well as for villages downstream in the lower catchment. *Awiq-awiq* protected the forest around the spring, and also developed informal rules over water use, management of water infrastructure, and the resolution of conflict over access to, and availability of, water resources. Members of the community placed great importance on *awiq-awiq* and its role in community function and cooperation. Mutual obligation was a key element of traditional cultural laws. This provided intrinsic incentives for community members to adhere to social norms surrounding natural resource use, which punished the non-compliant with fines or social exclusion

Both incentive-based and control communities surveyed faced water resource issues of varying degrees of severity, particularly during the dry seasons. Responses to determine the frequency of water resource issues may have been biased because the period of data collection was during the dry season, when water stress was high. Nonetheless, respondents' experiences of water issues appeared to be determined by their position on the island and within the watershed.

Mount Rinjani has significant impact on rainfall distribution. Communities north of Mount Rinjani experienced less rainfall throughout the year. Communities in the upper watershed catchments were more likely to have access to springs than communities within the plains below. Beyond the impact of monsoons, access and availability of water varied throughout the year depending on location of respondents – upstream versus downstream, those closer to the water source versus those further away – and the infrastructure available to obtain water resources.

Experiences of environmental stress, in this case, water availability and access, which generated intra- and inter-community conflict, were a key factor in communities developing incentive-based institutions. Communities with incentive-based management experienced low water availability and high levels of soil erosion during the rainy season. Control communities, while also experiencing these issues, were affected to a lesser extent. They were, however, impacted more through irregular water flow to their communities. For incentive-based managed communities, low

water availability appeared to develop into conflict between community members, which was not observed in control communities. Respondents in incentive-based managed communities spoke of access to limited resources: *"There are too many households to support with the water"*, IB1; *"The embung* [community reservoir] *is too small to provide for everyone so it is difficult to get water"*, IB2; and, *"The community destroys the forest and disturbs the spring"*, IB3. Conflict over resources appears to have driven the initiation of management, either within the village, as per IB2 and IB3, or via third party implementation in IB1.

To resolve the conflict over access to water resources, household water infrastructure was developed. That involved either building more *embungs* (IB2) or developing a piped water network to households (IB1, IB2, and IB3). Household water sources were significantly related to whether communities had incentive-based management (χ^2=33.216, d.f.1, p***). Respondents in these villages (IB1, IB2, and IB3) appeared to have greater access to infrastructure, mainly from piped systems (68.89 % overall) (Figure 5.1). *Embung* reservoirs were only used in IB2 (26.67 % of respondents in this village). This is likely due to BUMDES' project development and the village location on the lower slopes of Mount Rinjani. *Embungs* were used more frequently in the lower catchment. Use of wells (59.34 %) for household water was observed in all villages, except IB2 and IB3. Use of springs was higher for control villages (29.67 %) and those positioned at higher altitude.

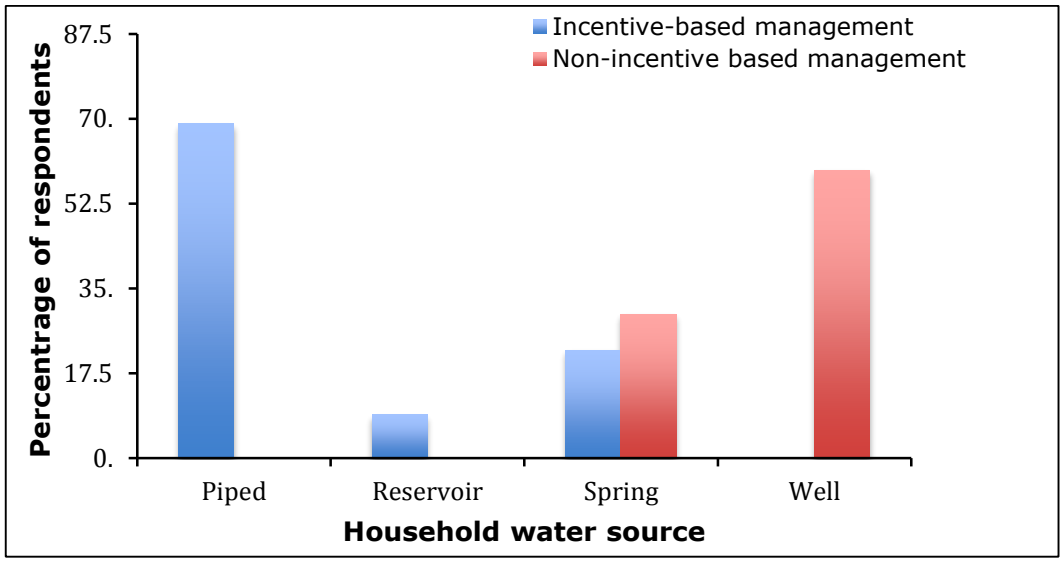

Figure 5.1. Differences in household water sources between incentive-based management and non-incentive based management communities (n=171).

It was unclear whether differences in water source infrastructure occurred solely as a result of incentive-based management, or whether they had developed from earlier government programmes to install piped access to water in the 1980s. This government-backed development had occurred in IB2, IB3, and C3. IB2 received funding to build a reservoir from UNICEF in 1978. The communities in IB3 and C3

were involved in a central government programme in the early 1980s to improve access to water via reservoirs and pipes. Infrastructure was already established in these communities. The infrastructure provided access to some members of the community, though for many, access to infrastructure was shared between groups of households. IB2's pipe system had developed through the long-standing incentive programme. The neighbouring village of C2 still relied heavily on wells, which "*often caused sickness*," female respondent, C2. IB1's pipe infrastructure had been established collectively as a community, while neighbouring C1 still relied on springs for household supply.

The mere experience of conflict over household water resource issues was not a sufficient driver for incentive-based management to emerge in communities. The analysis indicated that existing institutions, social norms, and socio-economic conditions influenced whether incentive-based institutions were likely to emerge. These communities appeared to have the ability and collective awareness to address natural resource issues. They also had adaptive capacities to manage resource-use behaviours. This was observed in higher levels of socioeconomic status, greater community awareness of environmental issues, and respondents' perception of community responsibility towards behaviours and the environment. Incentive-based management appeared to enable community capacity to address water resource conflict, and initiate and implement conflict resolution.

Cluster analysis was applied to differentiate between socioeconomic variables of households. It focused on land area owned, education level, wealth proxy, and reliance on natural resources. There was no significant difference between wealth proxies in communities with incentive-based institutions and control villages ($t=1.481$, d.f.160, $p>0.05$). However, time in education was significantly related to incentive-based management. Respondents in incentive-based institutions villages had more years in education ($t=2.814$, d.f.166, p**), with an average of 6.95 years compared to 5.35 years for the control villages. There was no significant difference between in reliance on natural resources between incentive-based management and control villages (38.85 % and 34.14 % respectively). Reliance on natural resources appeared to be related more to location than management type. Area of land owned was not significant between communities with incentive-based management and control villages, with only 10 % of all respondents owning land in urban IB2. Incentive-based communities owned less land than control villages ($\rho=0.058$, $n=80$, p**).

Respondents also were asked to consider who they believed was responsible for the protection of the environment. Community awareness of environmental responsibility played a role in the development of community action. Village government was perceived to have the greatest power over environmental management decisions across all communities, although this was greatest in control villages. As such, respondents from control villages perceived rules over natural resources to have

emerged following government programs (41.89 %), or through new village leadership (6.76 %) (Figure 5.2). Comparatively, incentive-based management was perceived to have emerged following conflict over resource access (12.20 %), greater community awareness of environmental protection (25.61 %), or improvements to household water flow (13.41 %). The recognition by these communities of their collective responsibility to develop management initiatives to resolve conflict was observed by the respondents themselves (11.11 % overall; 16.67 % in IB3, 13.33 % in IB1, and 3.33 % in IB2). This is reflective of the community-led management schemes that already provided incentives for behaviours in these villages.

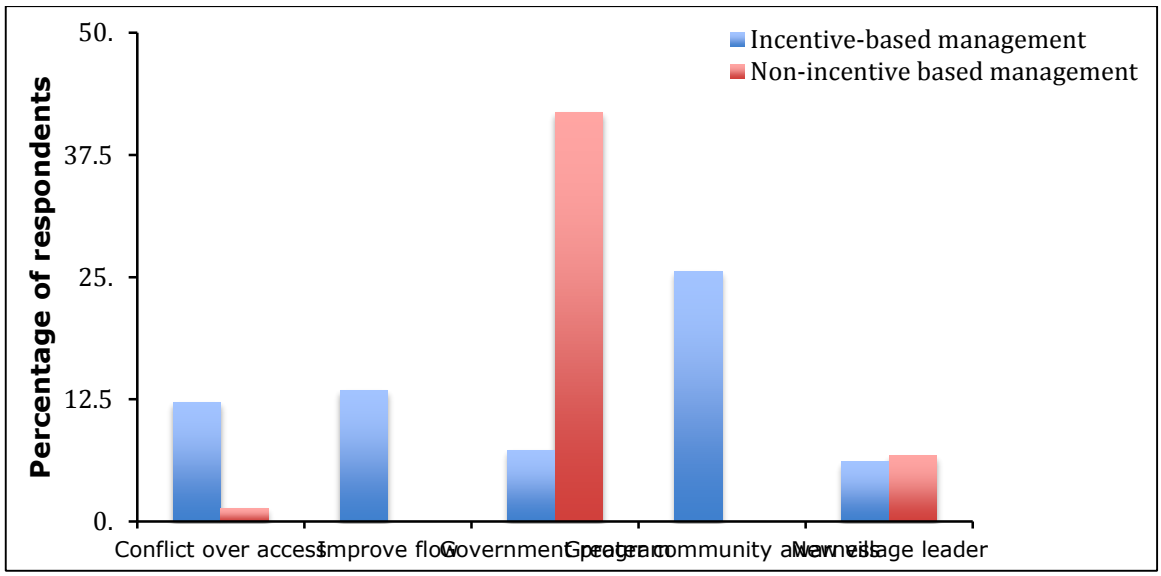

Figure 5.2. Respondent explanation of drivers of natural resource governance (n= 171).

Incentive-based management communities appeared to have a higher awareness of environmental issues that affected their livelihoods. They also placed a greater value on non-use benefits associated with the environment. Incentivised management had developed to use this awareness and intrinsic value to influence positive environmental behaviours within the community. It should be noted that these responses might have been influenced by the nature of questions asked in the questionnaire. More than three quarters of respondents in all survey communities were aware of existing rules that managed resource use or controlled access, although this was significantly higher in incentive-based communities (ρ=4.097, n=164, p***). There was also a significant difference between incentive-based communities and control villages' perception of benefits from the natural resources; for Wellbeing (ρ =-0.1699, n=147, p*); Wildlife (ρ=-0.1699, n=147, p***); Water retention (ρ=-0.3086, n=147, p***); and, Recreation (ρ =-0.2977, n=147, p***). The non-economic benefits perceived from natural resources incentive-based communities may have led to a higher value overall placed on the environment. A higher value may also therefore have driven action to manage the environment more sustainably.

5.5.2 How do incentive-based institutions 'fit' social-ecological systems?

Elements of institutional 'fit' were developed from Table 5.1. These elements focused on mechanisms within institutions that indicated greater alignment. These were: Bridge organisations, Leadership, Focus of resource management, Timing of institution, and Adaptability. Institutional case studies were determined to indicate 'fit' or 'mis-fit' according to the presence or absence of these elements (Table 5.3).

Table 5.3. Elements of institutional 'fit' for each of the six case studies (incentive-based and control) in Lombok. (++ High level of fit, + Fit, - Mis-fit, -- High mis-fit, +/- Unclear, likely fit, -/+ Unclear, likely mis-fit). Based upon elements of fit in Table 5.1.

Fit Element	Case Studies					
	Incentive-based institutions			Control		
	1	2	3	1	2	3
Bridging organisations	--	++	++	--	--	+
Leadership	-	++	++	-/+	-/+	+/-
Resource management focus	-	+/-	+/-	-/+	-/+	+/-
Timing	+/-	+	+	-/+	-	+
Adaptability	-	+	++	-/+	-/+	+/-

Bridging organisations between local actors and communities with other institutions

All communities had existing institutions and institutional arrangements that managed natural resources, enabled societal norms, and created an adhesive community social system. Many respondents were involved in multiple institutions. These ranged from farmer groups and community youth groups to the adherence to traditional beliefs and active religious practice. Village institutions encompassed a number of different types of associations such as youth groups and women's groups. Religious institutional involvement was understood to be the active practice of religious activities. Farmer institutions were active groups of individuals that supported agricultural production. Traditional institutions were denoted as adhering to aspects of *awiq-awiq*, the traditional Sasak culture. As such, respondents' involvement in these institutions varied according to their occupation, i.e. farmers within farming groups, etc.

Involvement in institutions did not necessarily denote high participation in decision-making. For the purpose of this study, participation was defined as being a member of

an institutional group (village or farming), or adhering to the belief system and norms of an institution (religious and traditional). Institutional involvement generated community networks and indicated involvement in cooperative activities. Within the three incentive-based institution communities, participation in institutional activities was significantly higher across all existing institutional groups than within the control communities (χ^2=12.58, d.f.4, p**). Higher involvement in institutional activities, especially in institutions that drove incentives, may have enabled a great 'fit' of incentive-based management. By building on existing institutions that played a strong role in community activities and creating local values, incentive-based management enabled closer alignment of institutional management and social norms.

Religious institutions dominated many of the institutions, which was reflective of Lombok's strong religious heritage. Respondent participation in religious institutions was highest in IB2. This is indicative of the strength of religious belief in this community, and the influential role of the local mosque. The use of the mosque to motivate compliance to protect the environment built on the strength of Islamic social norms in the community, "*We do not want to be bad Muslims,"* respondent, men's focus group IB2. The incorporation of social norms into incentive-based management built trust for the institution. The involvement in religious institutions was far greater in this community compared with neighbouring community C2. In C2, focus group respondents spoke of a lack of overall water management, of individuals 'stealing water' from the reservoir in IB2 to sell in C2, and of poor water quality as, "*Other villages have better management than here*," questionnaire respondent C2. No respondent in C2 spoke of the role of the mosque in water management. This suggests that the use of religion to provide incentives for water conservation in IB2 is highly specific to that community.

Traditional socio-cultural norms, specifically Sasak *awiq-awiq*, existed across all the communities. For some communities, like IB3 and C3, the influence of *awiq-awiq* on community and individual behaviours was more evident. "*It's our whole system of life,"* respondent, focus group C3. *"Awiq-awiq has been here a long time, since our ancestors. It isn't written down, but only* [those] *within our community take notice,"* village head, IB3. The incorporation of socio-cultural norms into incentives, or the development of incentives from socio-cultural norms, motivated cooperation for collective behaviours towards the forest and water systems. This included the protection of a 50m forest radius around the spring, the refusal to participate in illegal logging, and the maintenance of the local pipe infrastructure. Socio-culturally-driven incentives appeared to enable greater community participation in decision-making, particularly in IB3. In this village, regular community gatherings were held to determine rules about how the environment was to be managed. High levels of participation in decision-making through *awiq-awiq* mechanisms in both IB3 and C3 provided strategies that bridged management institutions and the local communities and actors, and enabled the management of their social interaction.

When incentive-based management was developed from, or connected to, existing institutions, bridging was higher. There was a greater awareness of the institution, increased participation in decision-making, a higher level of trust, and a broader understanding of community requirements to meet compliance. This was evident in both IB2 and IB3, but less so IB1. In this village, bridging between incentive-based initiatives and the community was weak. There was little awareness, trust, or use of the economic incentives to motivate behaviours. Respondents in IB1 who received payments did not always link incentives with environmental behaviours. They believed the payments either were aimed: *"To increase my income,"* and that *"There are no major changes,"* questionnaire respondents IB1*.* Only a small group within the community received payments. The economic-incentivized institution appeared to be considered quite separate to the community, "*We have no interest or pay attention to them* [IMP stakeholder group]*. "We are busy with our own work," respondent,* women's focus group. "*I haven't met the government or even know about the government," "What we have here* [in IB1] *is enough," respondents, men's focus group*. Other small, community-led informal institutions to protect the production forest and water sources were in existence in IB1. However, the overall economic-incentive based institution appeared to be misaligned with local objectives and needs.

Leadership

High levels of community cohesion and strong leadership – through village heads or local imams – played a key role in generating community trust in, and driving development of, incentive-based institutions. This was observed in all incentive-based institutions in the three surveyed communities. Key individuals created links between local actors and institutions, and generated trust and understanding between community members. IB2 and IB3 had strong leaders that were trusted by their communities. These leaders (an imam, the head of PAMDES, and a village leader) were relied on by the community to resolve conflict and make decisions, "*He is a respected commander,"* focus group respondent describing IB3 village head. They also facilitated the flow of communication between incentive-based institutions and the community. This generated high public awareness of the institutions. The connection between leaders, communities, and institutions was particularly evident with the transparent nature of the institution in IB3, where information was dispersed via the imam.

In IB1, there was a respected village head, but the leadership was not linked to the incentive-based program. Instead, it was connected to the encouragement of collective activities. Self-organized collective activities were seen throughout the communities. This was done through group maintenance of pipe infrastructure, clearing of irrigation channels to reduce pollution, and planting seedlings in forest areas around springs. In C3, there were strong individuals who encouraged environmental governance, but conflict between them led to community distrust. "*If there is not drinking water, the*

village head would not care or help," respondent C3. A lack of transparency in governance and village finance also generated anger. "*Where is the money going?"* respondent C3. This situation eventually led to the head of water governance being driven out of the village at the peak of the dry season in September, 2012. Leadership in both C1 and C2 was not strong in relation to environmental institutions. This was likely due to their newly-established status as villages, as they separated from larger villages in 2011 as part of regional government policy.

Resource management focus

The scale of an institution is fundamental to the issue of its 'fit.' All institutions within this study were implemented on a small, localised scale. This small scale generated difficulties in ascertaining environmental outcomes of governance beyond the availability of local resources such as water. For example, it would be difficult to determine the impact of institutions on wider ecosystem services on Lombok from these studies sites. The research showed that institutions in IB2 and IB3 'fit' their local ecosystems. The institutions in these communities enabled greater access to, and availability of, water for household use without too narrow controls over specific resources. For all control villages, 'mis-fit' was evident. Continued conflict over access to, and limited availability of, water resources indicated that environmental governance was insufficient to address mechanisms driving resource use. In IB1, despite incentives, the institution was focused on restoring only a small area of forest within the community as part of a wider watershed-wide reforestation programme. The specific control of this resource did not address the social and ecological drivers of localised resource use.

Timing

Institutional implementation varied across the survey communities. For the incentive-based institutions in IB2 and IB3, the timing of governance was in response to conflict over natural resources. IB2's incentive-based institution was established in 1993 at the height of intra-village water conflict. The long-term solution to develop infrastructure for household water provision had enabled households' greater access to water resources. Resource governance had since been responsive to social and ecological drivers. It met water needs, and protected forest around the spring. In IB3, implementation of an incentive-based institution to manage water resources had enabled ecosystem services governance. Since the development of pipe infrastructure in the 1980s, this governance had established greater household water access, and motivated the protection of the forest ecosystem.

Governance was not always able to respond within a time frame to manage ecosystem services. Conflict remained with villages downstream, particularly with C3. IB3 had control over the entire upstream pipe infrastructure. This impacted downstream

communities' water supply. "*Gangga* [IB3] *think they own the pipes;"* and, "*They* [IB3] *are selfish*," respondents C3. Deforestation had mostly been conducted by outsiders and occurred following the government's decentralisation policies. Since then, deforestation activities had slowed in the region. Institutional governance was also not fully aligned with the social and ecological drivers of ecosystem change.

For IB1, an incentive-based institution was implemented to respond to deforestation, but was short-term in approach and objective. Economic incentives were only given to a small group within the community in 2011. This focused on replantation of specific deforested areas and economic compensation for opportunity costs. Payments were only made for one year. The time span of this response was slow in affecting ecosystem changes and, once replantation had occurred, it was limited to providing incentives for social conservation responses.

Adaptability

For the purpose of this study, an institution's adaptability was interpreted as its capacity to adapt to both abrupt and slow environmental and social changes. It also had to resolve conflict. Incentive-based institutions in both IB2 and IB3 had feedback mechanisms, through which response to changes in both social dynamics and environmental shocks (e.g. droughts or floods) could be made. In IB3, management was continually adapted according to social and environmental needs. For example, during times of low water availability, community discussions would be held to determine a schedule to allow all households to obtain some water at set times during the day. This allowed households equal access to limited water supplies. If damage to pipe infrastructure had occurred, which often happened following flooding, the community was gathered to delegate teams to clear pipes, and to resolve water access issues. In IB2, high transparency in how water resources were governed encouraged a continual review of institutional management. For example, population growth in the community has increased demand on water resources. In response, the incentive-based institution is in the process of building a second *embung,* or reservoir. The Head of BUMDES, the incentive-based institution, also said that, "*We need to find another spring if the* [current] *reservoir is not enough.*" This capacity to respond to social and environmental changes has enabled this institution to adapt with the dynamic SES.

The short-term nature of the incentive-based institution in IB1 limited its adaptability. The distance between beneficiaries (downstream water users) and providers (IB1) heightened respondents' detachment to the institution. Despite the presence of IMP, the intermediary stakeholder group, there was limited capacity to adapt to localised environmental and social changes. The watershed scale of the institution, and the short time frame of payments (one year), gave few opportunities to respond, or adapt to, feedbacks within the SES.

5.5.3 What is the relationship between the 'fit' of incentive-based institutions and environmental behaviours?

Incentive-based institutions had a varied impact on environmental behaviours across the case studies. Most respondents felt that incentives were necessary to motivate positive environmental behaviours within their community, although this was stronger in incentive-based management communities (z=2.554, n=171, p**). Many felt that it should be "*an earning source for extra income,*" (both incentive-based management and control village respondents). Others felt that it served as compensation for "*damage in the future*" (IB1 and IB2). Some were concerned that those who received monetary payments would become "*corrupt*" (IB3) and that payments had the potential to "*make the community lazy,*" (IB3) when they "*should have the motivation to conserve the environment already,*" (C1, IB1, and IB2). The extent of institutions' effect on attitudes to, and perceptions of, their environment was also observed. Respondents in incentive-based management villages had a higher perception of how their activities benefited people outside of the community (z=-4.495, n=152, p***).

Collective action was strongest in incentive-based managed communities. It was often linked to existing institutions, which were underpinned by social norms and cultural values – "*It is something we have always done,"* questionnaire respondent IB3. Across all of the incentive-based institution villages and in C3, collective activities, such as maintaining pipes, clearing irrigation channels, and planting trees, took place. "*If pipes are above ground, everyone has to protect them. If deforestation occurs around the spring, we are all obliged to plant* [trees]*,"* village head, IB3. Collective activities were driven by strong leaders, such as an imam or village head, but were conducted on the basis of intrinsic motivation for cooperation.

'Crowding in' (i.e., the use of incentives that built upon intrinsic existing motivation such as religious, cultural, and traditional norms) was evident in the incentive-based institutions. The use of existing motivations, such as *awiq-awiq* in IB3 and the attendance of the mosque in IB2, to encourage cooperation with positive environmental behaviours led to greater participation as many did not "*want to be bad Muslims"* (respondent, IB2). In IB1, a lack of interest in wider community support of economic incentives ("*We do not need to get paid to protect the environment,*" respondents IB1) may be reflective of the community's limited participation in the scheme's implementation. Payments were made following a group's application to IMP, although the criteria for payments were unclear. The community had little involvement (except through wider village representatives in IMP) in making decisions about how payments and seedlings were used. Despite these limitations, other underlying motivations for positive environmental behaviours and collective action remained. This was observed in the collective work to protect piping infrastructure and the forest around the spring. For many people in IB1, it was

felt that their community was strong and cohesive, and there was an assumed notion to work together to protect village from "*outsiders stealing resources*" such as timber and crops. Many felt that "*To protect what we need does not require an incentive;"* "*To maintain the environment gives me comfort* [sense of wellbeing];" and, *"Why do we need any reward to guard our own needs?"* respondents, IB1. That suggested that IMP's economic incentives had not 'crowded out' these social norms.

Low community cohesion also was observed in both C1 and C3. These were newly-established villages, which had been recently separated in 2011 from larger villages as part of regional government policy. As a result, their capacity to self-organise and the overall level of cohesion appeared to be still developing. In C3, there were low levels of trust between the village administration and the community, despite the presence of an environmental management regime. As such, some respondents said there was a lack of transparency in how community activities were carried out.

5.6 Discussion

The incentive-based institutions used in this study illustrated a variety of approaches to govern ecosystem services. Not all of these institutions aligned with the SES in which they functioned. Key to community compliance and participation in both decision-making and implementation was whether the institution was driven by the community themselves, or had been imposed by external organisations, such as NGOs. Incentives had less impact on behaviours when they had been imposed by organisations external to the community, as observed in IB1. In IB1, little importance was placed on the incentive-based institution due to the irregular nature of the payments and the small group of beneficiaries. Land-use behaviours were more likely to be the result of other existing institutions. Greater 'fit' of incentive-based institutions was illustrated in IB2 and IB3, where incentives emerged within a localised context and built on existing social norms.

All of the communities within this study were influenced by the wider political, economic, cultural, social, and biophysical contexts of Lombok and Indonesia. Interplay with other institutions in these contexts was important to determine institutional 'fit'. Greater interplay, and ability for institutions to adapt to local contexts, also generated greater resilience to changes in SES interactions. For IB1, lower interplay of the incentive-based institution within the local context was reflected of the limited impact of the economic incentives on sustainable land-use behaviours, and low participation and involvement in decision-making. This was likely a result of a lack of connections between the incentive-based institutions and existing formal and informal institutions. Despite the lack of institutional interdependence in IB1, gaps in governance were not apparent as these existing institutions functioned through collective action, *awiq-awiq*, and local legislation.

5.6.1 Do incentives 'crowd in' or 'crowd out' motivation?

Two of the incentive-based institutions in this study (IB2 and IB3) used incentives that built on the communities' ability to self-organise and cooperate, as well as social norms that motivated communal behaviours. This reinforced intrinsic motivations for collective behaviours (i.e. crowded in), and therefore 'interplayed' with existing institutions and underlying social values. In contrast, economic incentives used in IB1 did not appear to have significant effect on land-use behaviours. As such, they could neither be defined as 'crowding in' or 'crowding out' existing local motivations. Monetary incentives did not undermine intrinsic motivators, but nor did they necessarily complement them (van Noordwijk et al. 2012, Bowles 2008, Rode, Gomez-Baggethun, and Krause 2013). This observation may be a reflection of only a small group within the IB1 community benefited from financial incentives. Where benefits are unequal, a focus on community-centred objectives was difficult, as individuals focused on short-term economic gains. Further research would be required to confirm the impact of these economic incentives on underlying motivations within IB1.

In all case studies, it was apparent that respondents were aware of a need to protect the environment, and to create rules to regulate its use. All of the case studies had experienced issues over access to, and availability of, water resources. In control villages, these were recognised to have been, or were in the process of being, addressed by government programmes. In incentive-based institution villages, there was a significant recognition of the community's responsibility to resolve environmental issues. This awareness appeared to drive social motivation for environmental behaviours that promoted collective action across the case studies. In particular, IB2 and IB3 appeared to have harnessed individuals' motivation for specific conservation needs. This suggested a 'crowding in' of intrinsic social norms, which highlighted the significance of existing social meanings to enable 'fit' of incentive-based institutions. There was no evidence to indicate that incentive-based mechanisms were crowding out social norms (although that this did not confirm that the phenomenon had not occurred). That was true even in the case of IB1, where the incentives were implemented by an outside organisation. This study suggests, however, that designing incentives that are built on underlying, existing motivations may enable 'crowding in,' (i.e. reinforcement) of pro-conservation behaviours and improve compliance.

It should be noted that this analysis was conducted without baseline data, which may have identified further implications of this form of governance. Communities without clear incentive-based mechanisms also exhibited similar social norms and community morals to communities with incentive-based mechanisms. Community activities in control villages were often conducted for social benefit, although these were not used specifically to provide incentives for behaviours that protected the environment. Control communities also appeared to lack strong leadership and the ability to self-

organise cooperative action. Yet the communities' mere existence could provide a strong platform on which to build future incentive-based management schemes to govern natural resources.

5.6.2 Implications for PES theory - Incentives for collective action

Pirard (2012), from his own studies on Lombok, notes that perhaps a specific type of PES may be emerging from the original "beneficiary pays principle." Certainly no community in this study fulfilled the criteria for compensatory conservation interventions (Table 5.4) (Wunder 2006a, b). Village management of resources was neither all incentive-based, nor completely non-incentive-based. While Lombok illustrates a number of key characteristics of PES schemes, none of the communities fulfil all of the definitions described in literature.

Table 5.4. Five PES Criterion and degree of compliance for each of the three incentive-based institutions case studies in Lombok (++ High compliance, + Compliant, - Non-compliant, -- High non-compliance, -/+ Unclear, likely non-compliant, +/- Unclear, likely compliant).

PES Criterion	**Incentive-based Institution Case Studies**		
	(IB1) Lebah Suren	**(IB2) Ledang Nangka**	**(IB3) Gangga**
1. Existence of voluntary contracts	+	--	--
2. User pays principle	+/-	-/+	-/+
3. Conditionality	+	--	--
4. Directness	+	-	-
5. Additionality	-	--	--

The incentive-based institutions within this study do appear to be focused on conservation of ecosystems and greater equity in access to, and availability of, resources. It is misleading to label these 'incentive-based' in the traditional PES context. Muradian's (2012) argument that incentives are determined by their social value, and are conditional on the culture and context, may be a more applicable approach in this instance. These social values and norms underpinned cultural and religious activities in IB2 and IB3 (and to an extent IB1, although not directly related to the incentive-based institution). They also provided a degree of incentives for cooperative behaviours (Mosse 1997). This builds on earlier arguments in Chapter 4, that social norms drive collective action.

What does this mean for future definitions of PES and their relation to collective action? While definitions of, and criteria for, PES and PES-like mechanisms are important for their wider implementation, it is unlikely that all of these criteria will be met when applied in the realities of local contexts (Muradian and Rival 2012, Muradian 2013). It may therefore be more appropriate to understand and/or implement PES or PES-like incentives as incentives for collective action that are built on existing institutions and social norms.

There was a low level of commodification of ecosystem services within these incentive-based schemes, even in IB1's monetised scheme. Rewards appeared instead to give social recognition and acceptance, and became moral norms that induced other users to follow similar practices. This suggests that strong intrinsic motivations can drive behaviours, which are not dependent on external stimuli (Muradian and Rival 2012, McAfee 2012). The schemes that appeared to be better aligned to their communities in IB2 and IB3 had emerged from within the communities themselves, rather than driven by external organisation. These schemes built on the strength of existing institutions, and 'crowded in' intrinsic motivations to strengthen collective activities.

While some may argue that these case studies fulfil few, if any, of the PES criteria as documented by Wunder (2005, 2006, 2008), they do provide insights into the role of incentives and rewards in managing ecosystem services. The incentives presented in the research have social meaning and conveyed different information between beneficiaries and users (Muradian and Rival 2012). IB2 and IB3 relied on intrinsic motivation to drive behaviours, and demonstrated low commoditisation and additionality of ecosystem services. In contrast, the case study of IB1 was driven by external stimuli, which included outside beneficiaries, high additionality, and significant degrees of commoditisation.

5.7 Conclusion

How can institutional 'fit' be incorporated into incentive-based approaches to conservation?

The findings in this paper are very specific to the context of Lombok. Nonetheless, they add to the wider debate about incentive-based institutions influence on communal behaviours and collective action, and the reality of their practical implementation. It is evident that the 'fit' and 'interplay' of institutions are necessary and important factors to consider when implementing incentive-based management of ecosystem services. The provision of incentives that strengthen natural resource governance, and create benefits for and empower local communities is valuable for conservation. However, this study highlights the importance of understanding local

social, cultural, economic, and political contexts that influence individual and communal behaviours. In particular, the inclusion of socio-cultural dimensions in ecosystem valuation and development of incentives is essential to enable 'fit' and strong 'interplay' between existing institutions and social norms. This may prevent underlying social motivation to be 'crowded out.' On Lombok, individual perceptions and values of the environment were highly dependent on their socio-cultural backgrounds, rather than financial outcomes. Social and cultural values should therefore be considered as important as economic values when creating incentive-based management approaches.

Closer alignment of incentives, and institutional function, with these local socio-cultural values is essential for any mechanism that seeks to alter human behaviours. A more holistic understanding of values is paramount to determine the true value of ecosystem services. It can therefore reflect the perceived benefits and implicit desires of individuals, and their contribution to the wider community through collective action. SES resilience is likely to be strengthened by greater interplay between a community's socio-cultural dynamics and collective action, and the wider institutional context. Stronger institutions based on this approach are more likely to be able to adapt to shocks and slow rates of change.

One management institution does not 'fit' all contexts. The implementation of more hybrid governance structures may be more appropriate when they incorporate social norms, values, and dynamics, which are themselves culturally determined. When considering these local contexts and dynamics, it is suggestive that the application of strict incentive-based criteria is unlikely to be met. A focus on fulfilling this specific criteria and emphasis of only economic environmental values may reduce the likelihood of institutional 'fit.' The implementation of incentive-based institutions with greater 'fit' can, therefore, be fostered when societal values that promote collective behaviours for sustainable natural resources use are also incorporated.

5.8 References

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6 Efficiency and equity implications of changes to the Brazilian Forest Code, *Código Floresta,* for landowners and ecosystem service provision in the Amazon frontier, Mato Grosso, Brazil

6.1 Abstract

Complex processes drive changes in land use, which are governed by institutions that influence landowners' decisions about their environment. The regulation of land use within private properties in Brazil under the country's Forest Code has been subject to recent reform. Although these changes aim to balance forest protection with opportunities for agricultural expansion, the efficiency and equity outcomes of the reformed legislation remain unpredictable. This study analysed the impact of Forest Code reform on compliance, land-use decisions, and ecosystem services within Alta Floresta, Mato Grosso. Spatial analysis of changes in land use and land cover was conducted to examine to what degree properties of different sizes complied with requirements after the policy revisions. Levels of deforestation in the region between 2002 and 2011 were extremely high, and compliance with the Forest Code was low. The vast majority (95.7%) of deforestation has taken place on large properties. Yet the reformed Forest Code has offered an amnesty to abate 'environmental debt,' which has generated disproportionate benefits for large landholders. To reach compliance under the revised Forest Code, significant restoration of deforested areas, or the uptake of Environmental Reserve Quotas, must occur. Large landowners with the capacity to purchase these offsets may benefit from the more lenient requirements of the reformed forest legislation compared with small landowners. This unequal outcome can lead large landowners to believe that further legislative changes will lead to increased amnesty for future illegal deforestation. More stringent enforcement is therefore required to fully implement to Brazil's Forest Code.

6.2 Introduction

The use of regulation by governments can have a direct impact on landowners by helping to create incentive structures needed to manage land-use change. The effects of legislation, however, are unpredictable (de Koning 2014). Complex political,

social, economic, and ecological issues influence individuals' decisions about agricultural land use. To understand these interlinked relationships, it is important to monitor the practical implementation of regulation when assessing land-use outcomes. It also is paramount to understand the elements – political, social, and economic - that determine land-use decisions. This study contributes to the existing discourse around these issues by analysing the impact of Brazilian forest regulation reform on landowner compliance, land-use decisions, and ecosystem services. It also contributes to the wider discourse around the relationship between natural resource management policy and the reality of its practical implementation.

The Brazilian Amazon's highly biodiverse ecosystem plays an important role in providing and maintaining essential ecosystem services at local, regional, and global scales (de Souza, Miziara, and Junior 2013). The protection of native vegetation, however, must be weighed with the competition from pressure to convert land for agricultural expansion. The total extent of deforestation in the southern and eastern region of the Amazon has created an "arc of deforestation" in what is currently the world's most prolific land use frontier (Morton et al. 2006). The conflict between human land use and efforts to protect the ecosystem influences the ecosystem's resilience to disturbance, forest fragmentation, carbon storage, hydrological services, biodiversity and soil resources, and regional and global climate patterns (Portela and Rademacher 2001, Sparovek et al. 2010). Deforestation similarly has significant implications for policy controls, landowners' decisions, and ecosystem services function.

The ability of policy to reconcile agricultural demands for land with efforts to halt forest loss is fraught with difficulty. Many policies in Brazil have focused on conserving forests within protected areas. Yet with approximately 53% of Brazil's native vegetation located on private properties, policies also must provide incentives for forest protection that are focused towards private landowners (Soares-Filho et al. 2014, Stickler et al. 2013). To meet these challenges, policy approaches in Brazil have attempted to regulate land conversion and conserve forests within private lands through the Brazilian Forest Code (FC). The regulation's effectiveness to govern landowner's decisions and to reduce deforestation, however, remains limited (Stickler et al. 2013, Munroe and Muller 2007).

Deforestation in the Amazon is fundamentally linked to rural land-use systems. It is driven by complex social, ecological, political, and economic processes and interactions. These rural land-use systems and the historical patterns of agricultural settlement and conversion determine the rates of forest protection or extraction from the Amazon region (Michalski, Metzger, and Peres 2010). Government land settlement programs in the 1970s encouraged agricultural development in the Amazon. Over the subsequent 40 years, many small-scale properties have consolidated into large-scale mono-croplands and cattle ranches (Morton et al. 2006).

Currently, large-scale properties represent just 10% of all properties, but account for nearly 75% of the total agricultural land (Lapola et al. 2014).

The conversion of land to meet growing agricultural demands has led to high regional variability in deforestation rates (Rosa, Souza, and Ewers 2012, Rudel 2005b, Lapola et al. 2014, Bowman et al. 2012). Economic objectives aimed at maximizing profits have influenced deforestation behaviour. As a result, deforestation is highly spatially correlated with human population, roads, and rainfall seasonality across the Amazon (Michalski, Metzger, and Peres 2010). Within the "arc of deforestation," pressure on forest areas for cattle ranching and monoculture cropland expansion is relatively high (Aguiar, Camara, and Escada 2007, Fearnside 2005, Laurance et al. 2002, Michalski, Metzger, and Peres 2010). Since 2004, however, the overall annual average deforestation in the Amazon region has almost halved from ~18,000km^2 (1990-2004) to ~10,000km^2 (2005-2012) (Lapola et al. 2014, Boucher, Roquemore, and Fitzhugh 2013). The decline in annual deforestation is partly due to the impact of the global economic recession on agricultural markets, and more stringent Brazilian government regulation (Rosa, Souza, and Ewers 2012).

Studies by Michalski et al (2010) and Oliveira-Filho and Metzger (2006) suggest that property size is the main driver of deforestation in Alta Floresta within the 'arc of deforestation,' where this study was conducted. Different deforestation spatial patterns also have been created depending on the 'deforestation agent:' small landholders versus large agricultural businesses (Rosa, Souza, and Ewers 2012). Property level financial returns play a significant role in determining land-use activities (Vosti et al. 2003). Due to limited land area and financial capital, small landholders (defined by the Brazilian government as farms ranging in size up to 200 ha) often adopt diversified production systems of shifting cultivation and cattle ranching for subsistence and income (Pacheco 2009). In contrast, large landholders have access to larger amounts of capital, agro-industry subsidies, and greater livelihood security. This ensures higher agricultural productivity, which allows large landholders to out-compete small-scale farm productivity. A gradual increase in the number and total area of large-scale farms reinforces this inequality in land ownership and related environmental benefits (Lapola et al. 2014).

Livelihood options are limited for small-scale farmers, as nearly 40% of them lack secure property titles. They also receive less financial and institutional support compared to large landholders. This lack of financial and institutional support increases small-scale farmers' susceptibility to changes in governance and in the wider economy. To meet subsistence needs, small-scale farms often enter a cycle of deforestation, and opt for short-term economic benefits over long-term ecological sustainability (de Souza, Miziara, and Junior 2013, Godar, Tizado, and Pokorny 2012). Land clearing from small-scale farmers, for example, accounted for 73% of total deforestation in 2009 (an increase from 30% in 2002) in Mato Grosso, compared to 2.5% from large landowners (a decrease from 17% in 2002) over the same period

(Rosa, Souza, and Ewers 2012). The increase in overall annual deforestation within small-scale properties also suggests that they, not large landholders, may bear the burden of forest policy reform. The impact of reform, therefore, could further constrain their livelihoods and aggravate opportunity costs.

Deforestation creates fragmented forest patches (Skole and Tucker 1993, de Filho and Metzger 2006). This fragmentation has multiple impacts on ecosystem services for both global and local stakeholders. Loss of forest accounts for an estimated 20% of global carbon emissions (Trivedi et al. 2009), biodiversity loss (Fearnside 2005, Summers 2008), reduced productivity through soil erosion and nutrient depletion (Foley et al. 2005, Calder 2005), and unknown impacts on the provision of water for both agriculture and human consumption (Sweeney et al. 2004, Mann et al. 2012).

As productive areas for agriculture, riparian habitats are facing increased pressure from agricultural expansion (Sparovek et al. 2010). The deforestation of riparian forests, including buffering stream and river channels, reduces the overall habitat for biodiversity. It similarly has a direct impact on watershed structure and functionality (Sweeney et al. 2004). Loss of riparian habitats also can compromise ecosystem function and the ability of that ecosystem to process water pollutants. The loss can subsequently impede the downstream transport of pollutants and sediment (Sweeney et al. 2004, Summers 2008, Hayhoe et al. 2011). This change can affect hydrological cycles across multiple scales.

The effect of ecosystem services on water flow is complex and site specific. It results in misconceptions surrounding the links between ecosystem function and riparian forest cover (Wunscher, Engel, and Wunder 2008). In large-scale basins, such as the Amazon, multiple types of land use and vegetation can create difficulties in differentiating the hydrological impacts of land cover change (Costa, Botta, and Cardille 2003b). Studies of small-scale catchments indicate that modifications in land cover have significant implications for ground permeability, seasonal distribution of water, and soil nutrient cycles. They also can alter both abiotic and biotic properties (Hayhoe et al. 2011, Locatelli and Vignola 2009). After the conversion of tropical forest to pasture, the balance between infiltration, evaporation, and runoff of the area can be affected, which may impact the total water yield. Such changes can disrupt the hydrological cycle of drainage basins (Brando, Coe, Defries, and Avzevedo 2013).

The economic value of these ecosystem services is reflective through benefits to human welfare and wellbeing (Raudsepp-Hearne et al. 2010). The majority of ecosystem services, however, are non-marketable, public goods such as nutrient cycling, carbon sequestration, and watershed retention. Their economic value is often external to the market system, and can lead to inefficient resource allocation and extraction (MA 2005, Goulder and Kennedy 2011, Landell-Mills and Porras 2002). Sweeney et al (2004) argue that if the true value of riparian forests through the services they deliver relative to forest-derived products is acknowledged, individuals'

economic behaviour may change. They suggest that deforestation of riparian habitats for agricultural profit can be reduced through incentives. Effective incentives for landowners can encourage ecological management to avoid the potential costs of riparian forest ecosystem loss (Walker et al. 2013).

"Without compliance, however, rules are meaningless", (Keane et al. 2008).

Regulation of economic motives and rational choices over land-use decisions can not solely drive positive environmental behaviours to maximize utility and conservation. To achieve and maintain landholder compliance, punishment – and awareness of the risk of punishment – is vital (Andrighetto and Villatoro 2011).

Enforcement behaviour assumes that compliance with the norm is dependent on the probability of detection and the severity of any punishment. The effect of punishment is determined by: 1) Trade-offs between the potential economic benefit of non-compliance and following prescribed behaviours; 2) The cost imposed when caught; and, 3) The deterrence of future offences (Becker 1968). Individuals with a high dependence on resources often bear significant economic and social costs (Keane et al. 2008). To foster compliance, positive environmental behaviours should be more cost effective compared with potential rule breaking. Individuals must make trade-offs between the perception of likely detection, the severity of punishment, the enforcement of rules, and any immediate short-term gains of non-compliance (Keane et al. 2008, Leader-Williams and Milner-Gulland 1993).

Compliance creates varying trade-offs for different land users. Incentives to comply with land-use regulation, therefore, is highly contextual. It depends on landowners' socioeconomic status, livelihood, tenure, and land cover (Duchelle et al. 2013). Land-use regulations to shape landholder behaviour must be site specific, and are critical for the governance of forests (Stickler et al. 2013).

This paper seeks to understand the impacts of regulation reform on land-use outcomes in the Brazilian Amazon. This is important to understand the drivers of compliance, and how regulation can therefore achieve efficient and equitable forest conservation (Borner et al. 2014). Since the emergence of rapid deforestation in the Amazon in the early 1990s, the Brazilian government has implemented numerous conservation initiatives. These include protected area expansion and restricted access to credit in critical municipalities (aimed at reducing capital for deforestation activities). The initiatives also include regional legislation to combat deforestation, offset rapid agricultural expansion, and place pressure on large agribusinesses (Rosa, Souza, and Ewers 2012, Rudel 2005b). The Forest Code (FC) was introduced as the primary instrument to regulate deforestation within private landholdings. Significant policy changes were introduced in the policy in 2012 that have had large impacts on land use, forest cover, and the livelihoods of smallholders.

6.3 Brazilian forest protection legislation

6.3.1 Original Forest Code

The original 1965 Forest Code (FC), *Código Florestal,* legislation had become *de facto* environmental law by the 1990s (Soares-Filho et al. 2014). It was intended to extend the protection of natural forest cover beyond federal and state protected areas, and Indigenous Lands *(Terras Indígenas)* to include private agricultural lands. Approximately 68.34% of natural vegetation in Brazil remains in private landholdings. The FC aimed to protect these forests, and required landholders to set aside a proportion of their forested land as Legal Reserves (LR). They also had to set aside forests along riparian areas (streams, rivers, and headwaters) as Areas of Permanent Preservation (APPs) (Sparovek et al. 2010, Brannstrom et al. 2012, Stickler et al. 2013, Soares-Filho et al. 2013, 2014).

APPs include Riparian Preservation Areas (RPAs), steep slopes, and hilltops that protect hydrological functions and prevent soil erosion. Both APPs and LRs require private landowners to set aside a proportion of their property as forest. APPs are defined by their geographic location adjacent to headwaters and water bodies (RPAs) or at high elevation. By maintaining natural vegetation cover and preventing soil erosion along steep slopes, APPs aim to protect riparian habitats. For the purpose of this paper, only the riparian forest requirements of the APP legislation were included. Other APP provisions, including steep slope set-aside, are irrelevant in the Alta Floresta region due to the local topography. LRs have no geographic definition, but require a proportion (determined by biome and vegetation type; For Alta Floresta, this was 80%) of all private properties to be maintained as forest (Table 6.1). Some productive use is allowed under LR legislation, but clear cutting of primary forest is not permitted.

6.3.2 Why change the Forest Code?

FC restrictions on land have led to significant opportunity costs for farmers. They often perceive the legislation as a barrier to agricultural development (Sparovek et al. 2010, Stickler et al. 2013, Soares-Filho et al. 2013, 2014). The enforcement of legislation, however, has proven difficult. Remote landholdings, variation in regional requirements, and confusion over FC implementation have led to non-compliance by large and small landholders. The result of this non-compliance is a large legal deficit of forest areas (Sparovek et al. 2010). The FC has therefore been ineffective in conserving natural vegetation.

The achievement of full compliance under the 1965 FC would "require radical changes" in agricultural practices (Sparovek et al. 2010). The high costs of these agricultural changes were estimated to have considerable social and economic consequences. Heavy legislative restrictions on land use resulting from any reforms

may encourage deforestation in other locations. This 'leakage' could occur to satisfy the economic pressure to convert primary forest for agriculture and timber production. It also could help compensate for lost agricultural revenue due to the restoration of existing deforested land. A lack of clear tenure of large, legally-unprotected areas in regions such as the "arc of deforestation" may also increase land vulnerability to agricultural expansion (Sparovek et al. 2010). The risk of 'leakage,' therefore, may undermine any environmental benefits that arise from enforcing compliance.

An influential lobby (including small- and large-scale farmers) has driven efforts to reduce the legal requirements of the FC. The campaign has focused, largely, on the perception that compliance would invoke a significant economic burden on cattle ranches and large mono-croplands. The ecological benefits, such as increased connectivity, carbon storage, and improved hydrological services, of maintaining the forest to meet compliance have been side-lined for the perceived economic benefits from forest conversion for crops and livestock, i.e. non-compliance under existing FC rules (Stickler et al. 2013).

6.3.3 A revised Forest Code for Brazil – Who benefits from a deforestation amnesty?

Despite this political reality, "controversial revisions" to the FC were implemented in October, 2012 (Soares-Filho et al. 2014). A reduction in set-aside requirements for LRs and APPs, and an introduction of CRAs (*Cota de Reserva Ambiental*, or Environmental Reserve Quota, Article 66), have created an "amnesty" for small- and large-scale farmers (Table 6.1). The amnesty includes a lower legal requirement for set-aside forest on properties that has enabled a pardoning of historical illegal deforestation prior to 2008 (Arima et al. 2014). This action has reduced overall environmental debt – i.e. non-compliance – for all private properties across Brazil.

The revised FC differentiates between conservation requirements (LR and APPs) and restoration. The reforestation requirements for deforested land are key to determine the new levels of compliance under the new FC. Properties may be compliant with their own set-aside forest cover, but land deforested prior to 2008 may still require reforestation to become fully compliant. APP restoration is mandatory in narrower buffers, and cannot be compensated for through forest restoration in other locations.

LR restoration of deforested land, however, may be conducted on the property or through CRAs. CRAs are legal titles to land with intact native vegetation that can be traded to offset LR environmental debt on one property for surplus forest on another (Soares-Filho et al. 2014). The creation of an economic value for native vegetation is aimed at creating a market that, according to estimates, could abate 56% of all of Brazil's LR debt (Bonell and Bruijnzeel 2004, Soares-Filho et al. 2014).

Table 6.1. Changes in Forest Code requirements for Areas of Permanent Preservation and Legal Reserve protection of natural forest vegetation for landholders in Brazilian Amazonia. Proportion of property area set aside land applies to most of Legal Amazonia, including Alta Floresta. Some regions may have different requirements, depending on biome type and county economic profile.

	Property size	Original Forest Code	New Forest Code*
Forest Protection			
APP - Headwaters	All	50m	15m
APP – Rivers/ Streams	</= 100ha	30-50m	5m
	>100ha-200ha		8m
	>200ha-400ha		15m
	>400ha		20m
APP – Large rivers >50m wide	All	50-500m	200m
LR	>400ha	80%	50%** (80%)
	<400ha	80%	100% of 2008 forest cover
*** Narrower buffers apply to land converted before 2008 only – if conversion did not occur, riparian forest remnants remain protected up to 500m, depending on river width.** ****For properties where deforestation occurred after 2008, LR requirements under the new FC remain 80% off property size**			
LR reforestation			
Deforested land before 2002	All	Restore or compensate	Amnesty if at least 50% was preserved
Deforested land 2002-2008	<400ha		Amnesty
Deforested land 2002-2008	>400ha		Restore or compensate
Deforested land 2008-2011	All		Restore to 2008 levels or compensate

There are multiple implications of the reformed FC for both large and small properties. To regulate land use, legislation is dependent on its clarity, the perceived

cost of compliance, the strength of enforcement, and the values placed on the environment. The variation of requirements for different property sizes and in deforestation histories in Brazil has created ambiguity in what is required from individual landowners: The timing of historical deforestation and size of property, for example, determines restoration requirements.

From an economic perspective, a proportional forest set-aside, in terms of LRs and APPs under the new FC, will incur an opportunity cost for all properties. Yet, the policy is likely to have greater implications for smaller properties, which are limited by factors such as land type, a lack of CRA offset land, alternative livelihood opportunities, and financial capital. To reduce these limitations, the cost of maintaining riparian areas through APPs should be largely incurred by large-holdings, which contain a greater number of riparian habitats. The FC reforms therefore lower the opportunity cost of environmental requirements. By relaxing set-aside requirements, the reforms can reduce many of those previously technically non-compliant large properties.

FC reforms also have had environmental impacts. The reduction of forest set-aside requirements exposes a larger extent of forest to legal clearance. It also increases the likelihood of habitat fragmentation, which is expected to be more severe within small properties because of their lack of ecological and financial resources. Studies by Prist, Michalski, and Metzger (2012) suggest that fragmented forest landscapes affect habitat species richness and increase edge effects. The loss of forest also impacts the provision of ecosystem services, including reduced forest carbon storage in biomass, increased run-off from lower evapotranspiration, and changes in regional climate patterns (Lima et al. 2013, Foley et al. 2007).

The political lobbying to drive changes and reforms in the FC has been significant. Many of the lobby perceived earlier the FC legislation to be a barrier to agricultural development. Their influence to reduce FC requirements also may have spread the understanding within landowners that future law amendments could further dilute compliance, or at least compliance deadlines may be extended in the future. There also is a belief that future legislation may be even more lenient, therefore weakening landholder incentives to comply with the new FC (de Souza, Miziara, and Junior 2013).

6.4 Research questions

1: How have the changes in the Forest Code policy affected land-use decisions of small and large properties?

6: Efficiency and equity implications of changes to the Brazilian Forest Code

2: What impact have the property-scale levels of deforestation during the period 2001-2011 had on compliance levels from the 2012 Forest Code legislation changes?

3: What are some of the impacts of the reforestation requirements of 2012 Forest Code legislation on the land-use decisions of large and small landowners? How can Environmental Reserve Quotas be used to address these legal requirements?

6.5 Methods

6.5.1 Study Region

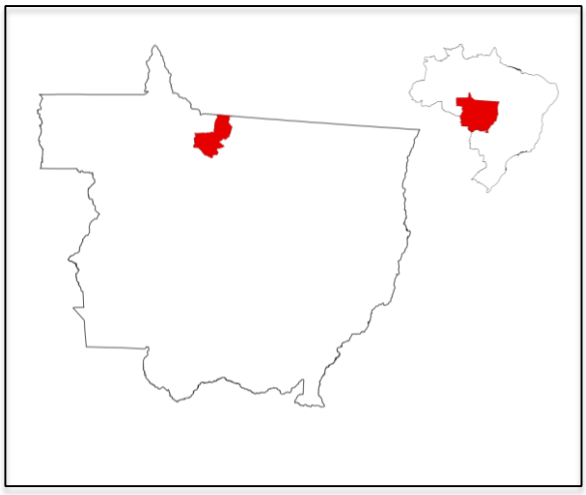

Figure 6.1 Map locating Alta Floresta municipal district in Mato Grosso State, Brazil.

The study region focused on the municipal district of Alta Floresta, in Northern Mato Grosso, Brazil (Figure 6.1). Alta Floresta was chosen as a model landscape where the relationship between environmental compliance costs and property size could be examined. The area comprised of 897,292 ha, in which 2767 rural properties were examined, that ranged in size from 0.90 to 33,519 ha. Landscape configuration in this area of the Amazon included small properties that were uniformly situated close to the main town. The region also included extensive cattle ranches that still retained large forest patches (Oliveira-Filho and Metzger 2006, Peres and Michalski 2006). Fire has been used extensively to maintain pastures and agricultural plots. Large-scale deforestation in the area began in the early 1980s after the Brazilian Federal Government started programs to develop roads and agricultural resettlements (Oliveira-Filho and Metzger 2006, Peres and Michalski 2006). The current spatial distribution of primary forest between properties in the municipal county was unlikely to be the result of pre-existing differences in land cover, but instead related directly to historical and current land-use strategies.

A set of eight cloudless QuickBird images with a 10m resolution from 2008 were used in the study, with all data projected on UTM 21S (datum SAD69). Band 3 (0.63-0.69µm), band 4 (0.76-0.90 µm), and band 5 (1.55-1.75 µm) were used to classify the images using IDRISI as forest, pasture, scrubland, bare ground, and water. Visual distinction between land cover categories was facilitated by the image's high-resolution.

Ground-truthing of property boundaries was conducted by the municipal administration of Alta Floresta in 2008-2011 to determine property polygon size and geographic position. Spatial analysis of actual and expected land cover was conducted to determine the extent and patterns of forest set-aside compliance for all properties across the entire size spectrum. Expected forest set-asides that were identified as pasture, scrubland, or bare ground were considered to be non-compliant, and the area was calculated as environmental debt. Total LR and APP compliance was then calculated from the extent of environmental for all properties to determine the impact of FC changes.

The time period of deforestation is an important element to determine APP and LR requirements under the new FC. The Brazilian Space Agency's PRODES project (www.obt.inpe.br/prodes) provides a yearly inventory of deforestation across the Brazilian Amazon with a pixel-size resolution of 60m. Deforestation polygons from PRODES for the period 2002-2008 and 2008-2011 were overlaid on the Quickbird land cover mapping to calculate the area of deforestation. This additional data served as ancillary data to the time of deforestation in the monotemporal, high-resolution images. There are limitations and greater margins of error when using images from different satellite sources with different resolutions. For the purpose of this study, however, it was important to identify properties where active deforestation had occurred both after 2001, and after 2008. This analysis enabled FC requirements to be determined under both the old and new FC legislation. It also allowed for the cost of reforestation to meet compliance under the new FC to be estimated.

6.5.2 Wealth proxy

Alta Floresta holds one of the largest municipal scale bovine stocks in Brazil (~920,000 head of cattle in 2012), and cattle ranching accounts for more than 95% of the total land-use revenue in the region. This study used cattle herd size, predicted from active pasture area within each property, as a proxy for property wealth. This was based on interview data obtained from 114 geo-referenced properties across the Alta Floresta county. Total pasture area was both estimated from Quickbird images and verified *in situ* by local landowners. Despite some variance in pasture quality, pasture area explained 86.7% of local cattle herd size. Cattle stocking densities at these properties also were consistent with the mean density across the entire county (2.07 head per hectare of pasture: M. Medeiros, unpublished data). Cattle herd size-

per-property was used to estimate the property-scale economic implications of the costs and benefits of managing ecosystem services, fulfilling FC obligations, and generating revenue.

6.5.3 Calculating reforestation costs

Property-scale reforestation costs estimated in the study, in terms of erecting fences along riparian buffer strips or actively planting tree seedlings, are not necessarily mandatory. Landowners may choose to reforest or simply allow natural vegetation succession to take place. This paper used reforestation costs to provide an indication of landowners' cost-benefit behavioural choices under the FC requirements. Economic information from property-scale interview data by UNEMAT (2008) was used to calculate the total cost of full reforestation to meet compliance. This included the costs of reforestation labour (USD $2,499.25 per ha) and erecting fencing around riparian strips (USD $3,475.19 per km of stream) to prevent cattle overgrazing and trampling.

6.5.4 Data analysis

A spatially-explicit General Linear Mixed Model (GLMM) was used to model level of legal compliance within properties. This multivariate analysis tested the relationship of both fixed and random effects on landowners' compliance responses. Where necessary, data was log-transformed to control for non-normal distribution (Osbourne 2002). The explanatory variables considered were property size, a proxy of wealth (predicted number of cattle per property), and distance to Alta Floresta. Environmental variables considered included forest cover, stream length, and headwater density. To avoid pseudo-replication, forest area, stream length, and headwater density were modelled as random effects, and property size, wealth and distance to Alta Floresta were modelled as fixed effects (Bolker et al. 2009). This spatially-hierarchical model was deemed most suitable to analyse properties within hydrological basins and to control for pseudo replication All GLMMs were undertaken in Stata 12.0. Coefficients from the GLMM indicated the significance and direction of each independent variable on compliance outcomes (Armsworth et al. 2009, Bolker et al. 2009). This significance was measured by two-tailed z-statistical tests with a probability value of 0.05.

6.6 Results

For the purpose of this study, private properties less than 400 ha were considered to be small landholdings. These properties made up 93.60% of landholdings examined within the study, covering 123,195.65 ha. In contrast, large landholdings (greater than 400 ha) covered 370,567.79 ha, in total. As of 2012, the municipal county of Alta Floresta consisted of 505,553.5 ha (56.3 %) of forest cover, 52.2 % of which

(263,955.7 ha) was within the private landholdings that were examined in this study (14.35 % within small properties and 85.65% within large properties). For riparian areas, 54.87 % of the total stream length (6.692.6 km) and 59.58 % (4,930) of headwaters in Alta Floresta were located in the properties within this study. This geographical data has had significant implications for understanding riparian forest habitat protection requirements under the FC for these properties. Levels of compliance were analysed for properties under both the original and reformed FC. Deforestation rates between 2002 and 2011 were then included, and levels of compliance under the reformed FC recalculated to determine the impact of deforestation on policy outcomes.

6.6.1 Amnesty – How significant are the changes in the Forest Code?

Compliance under the original FC was low for both APPs and LRs (Table 6.2, Figure 6.2, and Figure 6.4), with a mean compliance of 52.10 % and 31.93 %, respectively. The lack of compliance created a high 'environmental debt' of deforested land across Alta Floresta, particularly within small properties. Under the new FC, with reduced requirements for legal set-asides and riparian buffers, significant increases in compliance have occurred across the municipal county and property sizes.

Table 6.2. Requirements and compliance under the old and new Forest Code for Area of Permanent Preservation and Legal Reserves on private properties. All areas in hectares (ha) (n=2766).

	Requirement	Actual Cover	% Compliance		Debt	Surplus
			Overall	Mean		
APP						
Old FC	38,766.88	26,213.44	67.62	52.08	12,550.85	0.00
New FC	23285.98	18,717.29	80.38	58.15	4,568.69	5,375.28
LR						
Old FC	396,631.83	132,676.12	66.55	31.93	132,676.12	12,802.22
New FC	223,163.74	263,955.71	100.00	99.13	-17,373.52	55,906.15

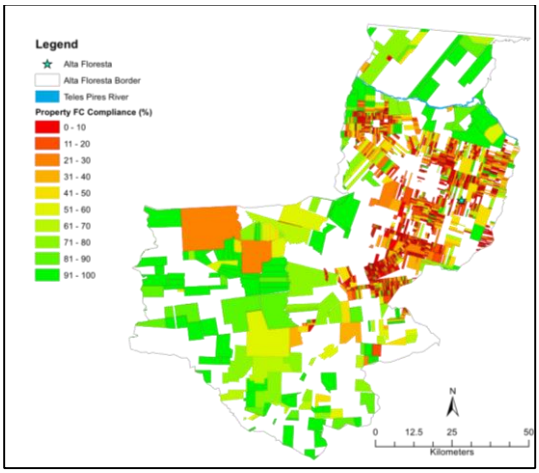

Figure 6.2. Property compliance (%) under the old Forest Code for Legal Reserve requirements.

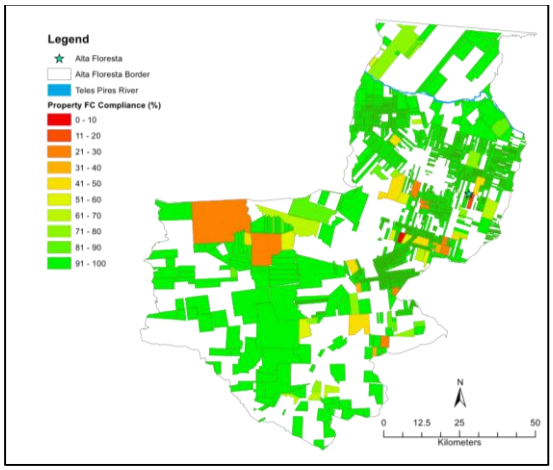

Figure 6.3. Property compliance (%) under the new Forest Code for Legal Reserve requirements.

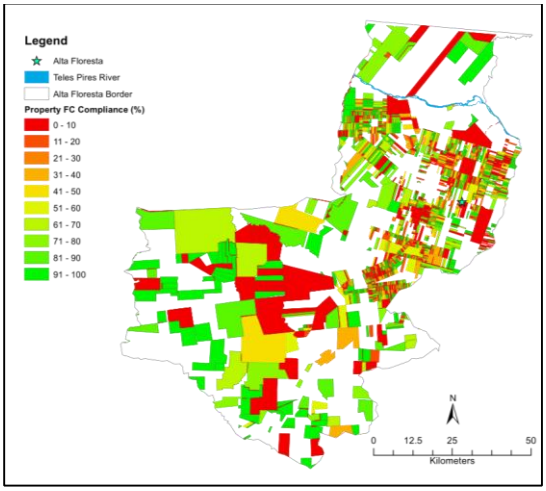

Figure 6.4. Property compliance (%) under the old Forest Code for Areas of Permanent Preservation requirements.

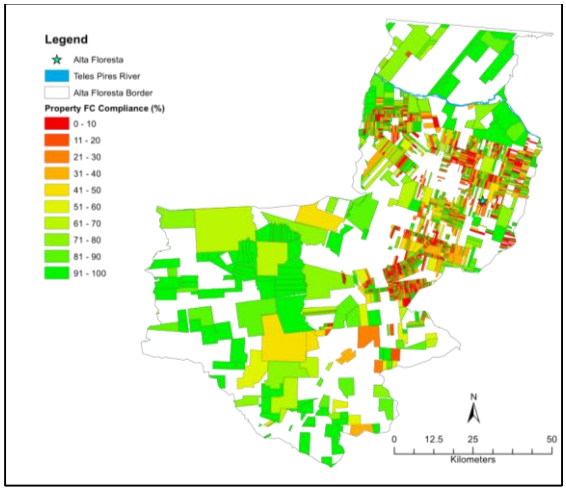

Figure 6.5. Property compliance (%) under the new Forest Code for Areas of Permanent Preservation requirements.

Under the new FC, there was a complete compliance for LR (Figure 6.3), and an increase to 80.38 % compliance for APPs (Figure 6.5) within Alta Floresta,. It should be noted, however, that overall compliance includes surplus forest areas and that some properties are still yet to reach full LR compliance. Nonetheless, this increased compliance has reduced overall environmental debt for both LR and APPs. It also has increased forest 'surplus' – forest land that exceeds set-aside requirement areas -- that can be legally deforested within LRs under the new FC.

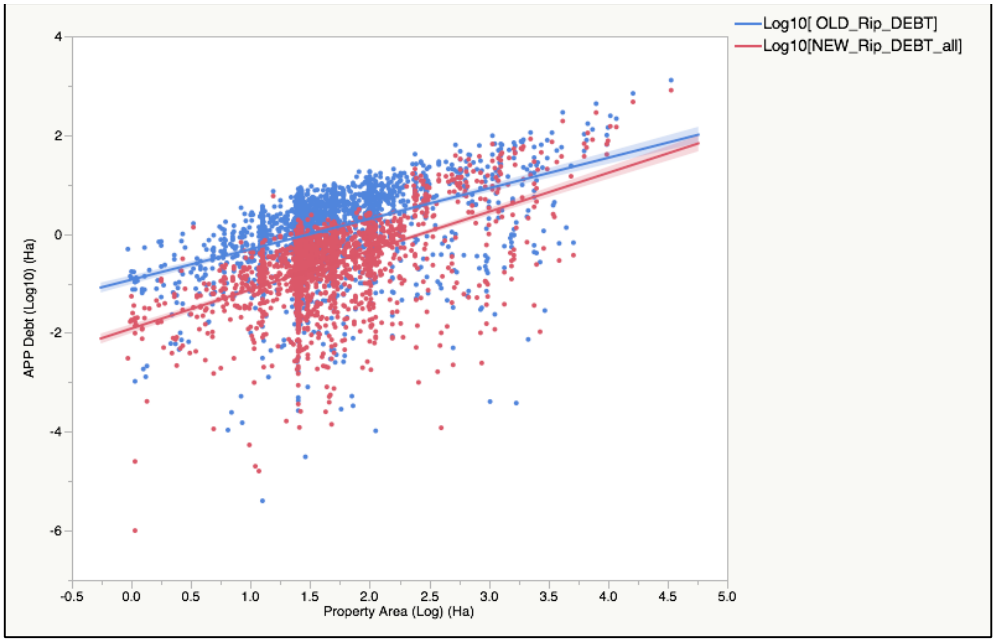

Figure 6.6. Area of Permanent Preservation 'environmental debt' across property sizes under the old and new Forest Code (n=2766).

Under the new FC, there is a significant reduction in environmental debt for APPs from 33.38 % to 19.62 % (Figure 6.6). Yet, the proportion of debt reduction under the new APP requirements decreases as property sizes increases. Properties less than 400 ha have seen an 81.35 % reduction in APP debt. For properties greater than 400 ha, this debt has only been reduced by 48.82 %.

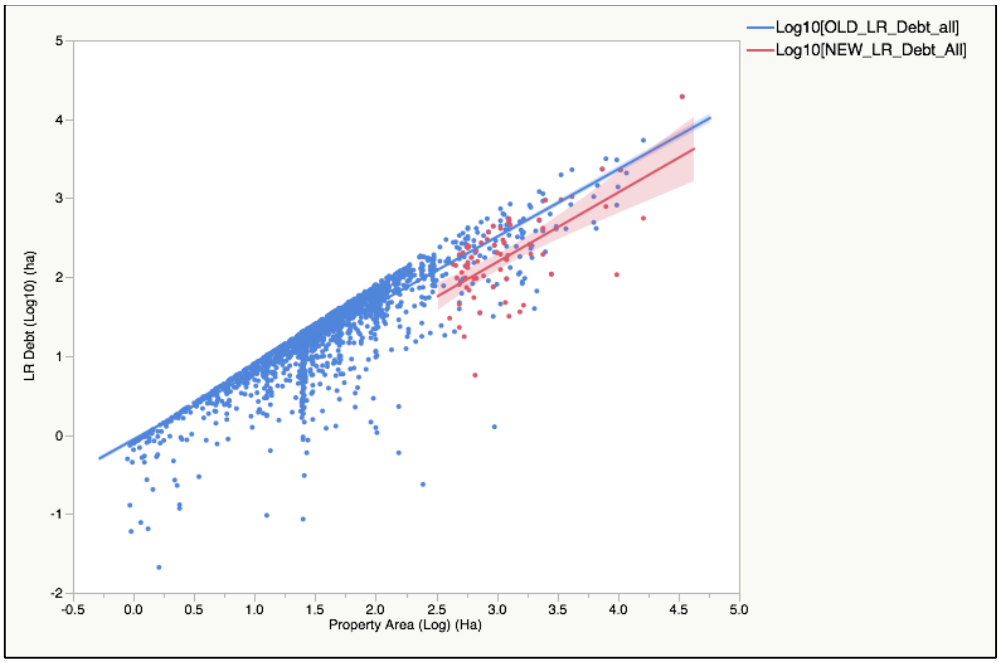

Figure 6.7. Legal Reserve 'environmental debt' across property sizes under the old and new Forest Code (n=2766).

Environmental debt for LR under the new FC also has reduced significantly (Table 6.2 and Figure 6.7). For small properties below 400 ha (excluding one property that

deforested land after 2008), LR environmental debt is virtually zero. This is reflective of the new LR amnesty for all farms under 400 ha, which are only required to retain forest that was left standing after 2008. Any deforestation that occurred on these farms prior to 2008 was not required to be reforested, as it did not count as part of individual properties' environmental debt. All farms over 400 ha have stricter requirements to retain 50 % of forest cover, or 80 % if they continued to deforest after 2008.

Table 6.3. GLMM to determine factors influencing environmental debt under the old and new Forest Code. Z value in brackets (n=2766).

Variable	Debt under Old FC		Debt under New FC	
	APP	LR	APP	LR
Property size (ha)	>0.05 (0.48)	*** (4.66)	*** (-4.63)	*** (-6.89)
Forest (ha)	*** (-4.89)	*** (-94.52)	*** (-4.47)	*** (-75.55)
Bovine density	*** (30.40)	*** (215.63)	*** (24.41)	*** (40.86)
Distance to Alta Floresta	*** (-2.81)	*** (3.83)	*** (2.55)	*** (5.18)
Stream length	*** (6.99)	*** (5.48)	>0.05 (1.44)	*** (14.01)
Headwater density	*** (3.63)	>0.05 (0.35)	>0.05 (1.29)	*** (-1.40)

Critical probability values quoted are represented as follows: '***'=p<0.001, '**'=p=<0.01, '*'p=<0.05, and '>0.05'= Non-significant (p=≥0.05) (Fowler, Cohen, and Jarvis 1998).

For both APPs and LR set-asides, 'environmental debts' have decreased significantly under the new FC. Property size, forest area, and wealth (bovine density) are significant determinants of APP and LR environmental debt (Table 6.3). Stream length and headwater density are, however, not significant in determining APP environmental debt. For APPs, environmental debt under the new FC shows greater association with bovine density than stream length or headwater density. Smaller properties, in particular, have increased their compliance following a reduced set-aside forest requirement. The influence of bovine density on environmental debt also is strongly associated with LR debt.

6.6.2 Amnesty levels under the revised Forest Code

Changes under the new FC have enabled an amnesty of environmental debt for certain properties. Previous environmental debt under the old FC, which is now met through lower set-aside requirements, has absolved some areas of historical deforestation. The changes have enabled an amnesty of 63,514.42 ha (100 % of old LR debt) for properties less than 400 ha. They also have allowed for an amnesty of 43,411.75 ha (61.68 % of old LR debt) for properties greater than 400 ha (Table 6.4 and Figure 6.7). Larger properties with forest areas that exceeded LR requirements can therefore legally deforest a surplus of 55,906.15 ha. Consequently, for larger properties, the total amnesty area for LR environmental debt is much greater than that for APP environmental debt (48.82 %). In contrast, there is no surplus of LR land for smaller landholders.

Table 6.4. GLMM to determine amnesty of environmental debt under the new Forest Code. Z values in brackets (n=2766).

Variable	APP	LR
Property size (ha)	*** (6.71)	*** (15.15)
Bovine density	*** (13.48)	*** (5.28)
Distance to Alta Floresta	*** (-7.36)	>0.05 (0.65)
Stream length	*** (10.82)	>0.05 (0.86)
Headwater density	*** (3.18)	>0.05 (0.46)

Critical probability values quoted are represented as follows: '***'=p<0.001, '**'=p=<0.01, '*'p=<0.05, and '>0.05'= Non-significant (p=≥0.05) (Fowler, Cohen, and Jarvis 1998).

For both small- and large-scale properties, overall amnesty for previous LR environmental debt under the old FC was 106,926.17 ha, and 7,938.34 ha for historical APP debt. Amnesty for LR debt was positively associated with property size and bovine density, and therefore wealth (Table 6.4). The proportion of amnesty was greatest overall for properties less than 400 ha (61.68 % for LR and 81.35 % for APP). There was a high number of these small properties (2589 farms, 93.60 % of properties within the study), and the total amnesty area for all of these properties was significantly smaller (1.77 ha for APP and 24.53 ha for LR), compared with larger properties, which held more overall land.

Landholders closer to Alta Floresta town were significantly smaller, and amnesty increased for these properties closer. Properties larger than 400 ha had a mean amnesty of 18.96 ha for APP debt, and a mean amnesty of 245.26 ha for LR debt. Small properties, less than 400ha, had a mean amnesty of 1.77 ha for APP debt, and a mean amnesty of 24.53 ha for LR debt. This association suggests that large properties, with high wealth opportunities compared to small properties, have benefited greatly from an overall amnesty effect of reduced FC requirements They have received a greater immunity from historical non-compliance, and surplus LR area within these larger properties also has enabled further legal deforestation.

6.6.3 Amnesty in the context of deforestation

Since 2002, deforestation has continued rapidly in Alta Floresta, particularly within large properties. This has had implications for FC compliance. Between 2002-2008, 162,592.97 ha of forest within the municipal county was deforested. A further 15,810.94 ha was felled between 2008-2011, although at a slower rate. Combined, this deforestation accounts for a loss of 67.59 % of Alta Floresta's forest during the nine-year period (Figure 6.8).

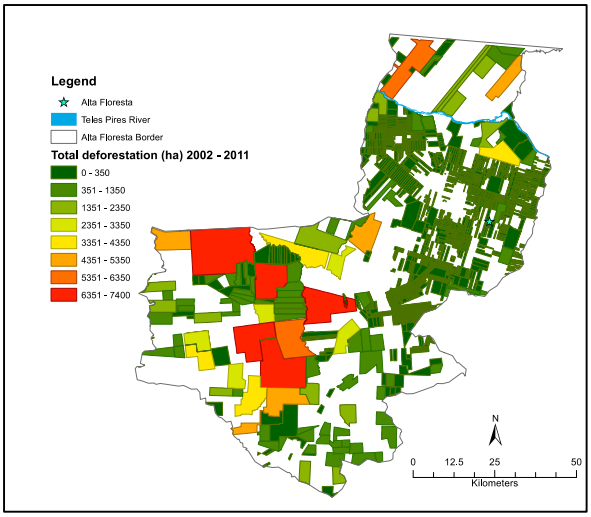

Figure 6.8. Area (ha) of deforestation across properties in Alta Floresta between 2002-2011 (n=2766).

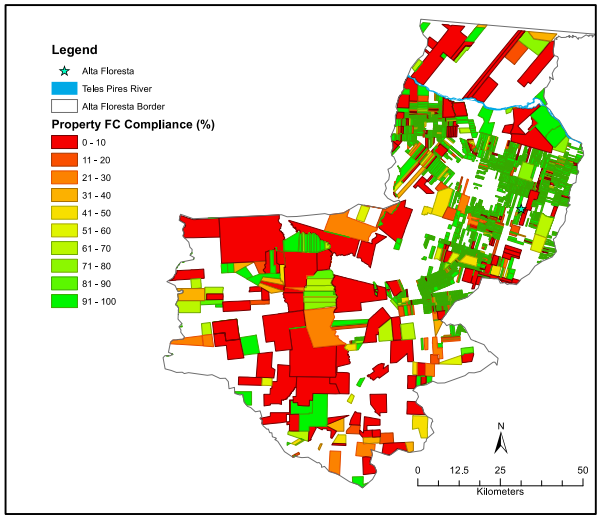

Figure 6.9. Property compliance (%) to Legal Reserve requirements under the new Forest Code, after deforestation between 2002-2011 (n=2766).

While the new FC regulations led to a widespread amnesty for both large- and small-scale landholders, overall deforestation rates must be considered when discussing the implications of compliance under the new FC regulations. Compliance may appear to be significantly greater under the new requirements. Yet when the compliance associated with previous deforestation is included, the significant loss of overall forest provides a clear indication that the FC has had negative impact on private properties forest retention.

Deforestation of 178,403.91 ha between 2002-2011 reduced overall compliance significantly from 100.00 % to 34.69 %, with a mean compliance of 86.80 % (Figure 6.9), and an overall amnesty of 99,593.19 ha. Reforestation to meet LR compliance has only been 38,532.63 ha. Yet reforestation to restore lands deforested between 2002-2011 accounts for 170,715.96 ha, and is required under the new FC. This is likely to have implications for the potential uptake of CRAs. Reforestation of such large areas of forest is likely to be unfeasible. CRAs may therefore be a more cost-effective means to reach compliance.

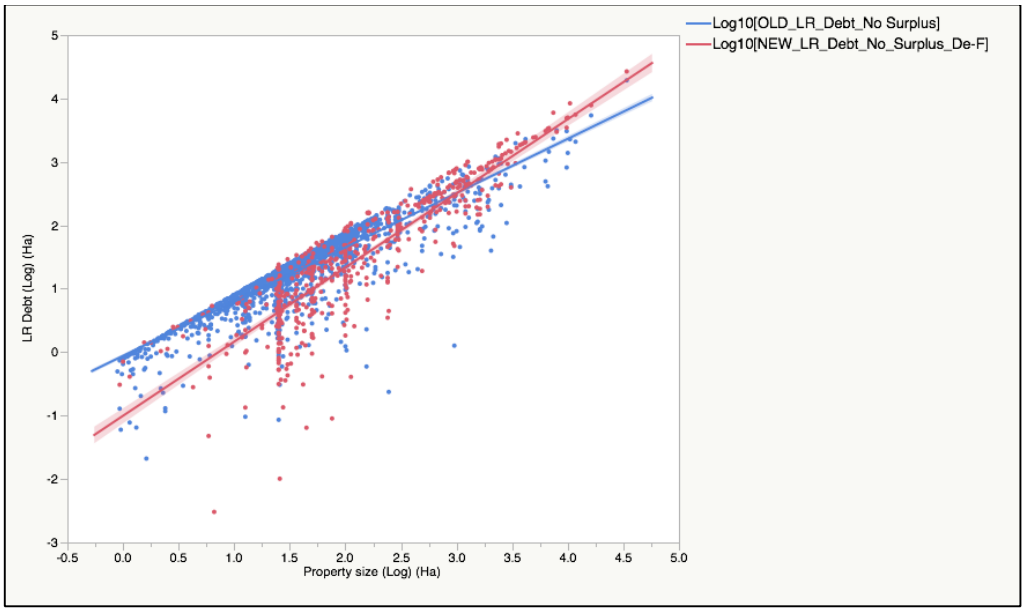

Figure 6.10. Legal Reserve 'environmental debt' across property sizes under the old and new Forest Code after deforestation is included (n=2766).

The high levels of deforestation that occurred during 2002-2011 are significantly correlated with larger properties greater than 400 ha (r2=0.2127, d.f.11, p***) (Figure 6.10). During this period, large properties felled 170,715.96 ha of forest (48.07 % of their total property area). The impact of deforestation levels within these larger properties is evident in Figure 6.8 When deforestation is included under the new FC, environmental debt for properties greater than 1,059.97 ha began to exceed these landholdings' previous debt under the old FC.

Despite higher deforestation levels that generated larger environmental debts, large properties have gained a significant amnesty under the new FC LR requirements (Figure 6.11 and Figure 6.12). In contrast, smaller properties experienced lower levels of deforestation in the run up to the FC reforms. Properties of less than 400 ha felled only 7,687.95 ha (6.14 % of their total property area). But there has also been a large reduction in debt under the FC LR requirements, which generated a widespread amnesty. That includes a complete pardon for deforestation before 2008 for smaller properties.

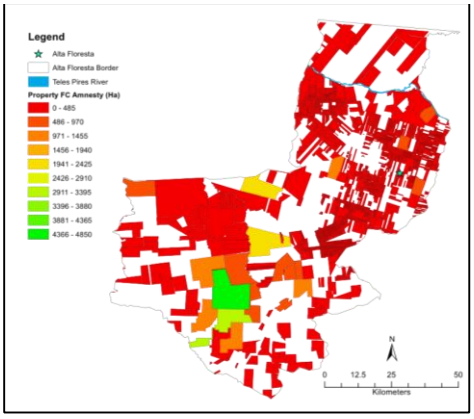

Figure 6.11. Amnesty area (ha) for environmental 'debt' on properties under the new FC LR requirements (n=2766).

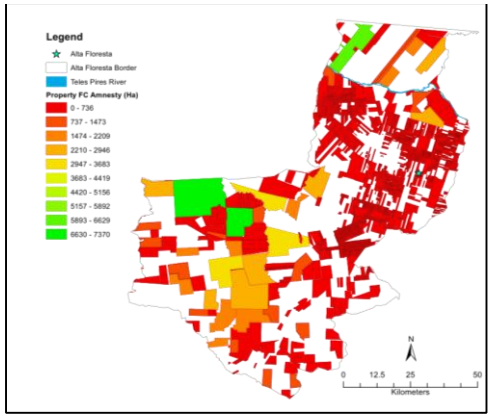

Figure 6.12. Amnesty area (ha) for environmental 'debt' on properties under the new FC LR requirements, with deforestation included (n=2766).

6.6.4 Reforestation costs versus cattle revenue – Capacity for compliance

The reforestation requirement to meet compliance for both LR and APPs is an important part of the new FC legislation. Because of more lenient FC requirements, a reduction in 'environmental debt' is evident across all properties. However, substantial deforestation between 2002-2011 means that landowners either have to restore forested lands to 2008 levels at their own expense, or utilize CRAs. This excludes deforestation on small properties (less than 400 ha) before 2008, which is pardoned under the new legislation. All deforestation after 2008, however, must be

restored across all property sizes. The relative capacity of landowners to address reforestation costs to meet compliance compared to their ability to obtain revenue from the deforested land for cattle grazing is determined by property size (Figure 6.13).

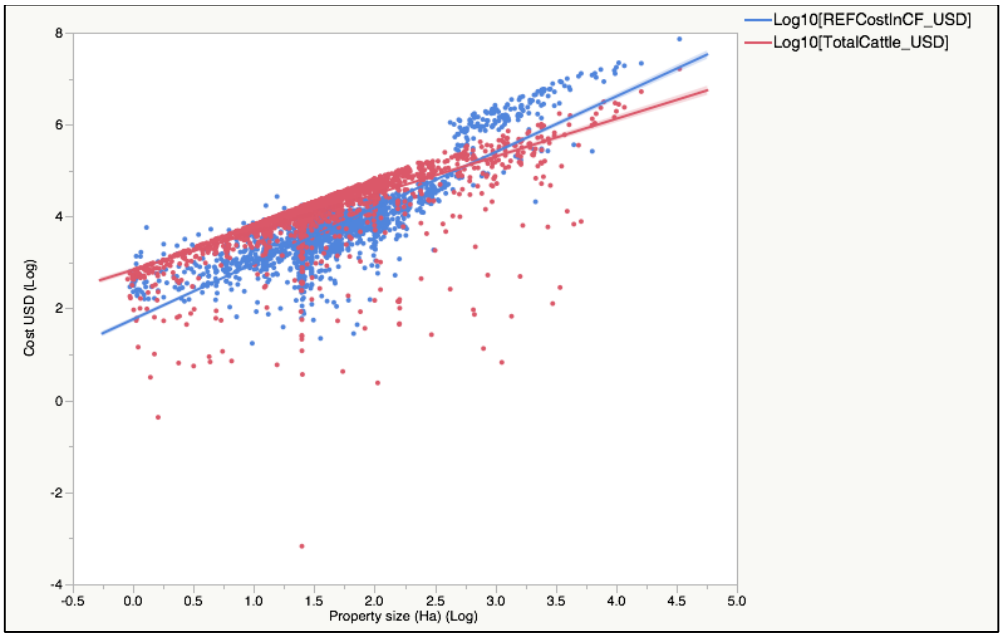

Figure 6.13. Reforestation costs versus total cattle revenue across property sizes (n=2766).

Across the properties examined in this study, the total cost of reforestation to meet full compliance under the new FC is USD $579,704,624.19. This includes both costs for reforestation and fence erection to protect riparian forest habitat from cattle trampling and grazing. For small properties, the expense of reforestation (USD $14,617,512.74) is more than three times less than that of potential annual cattle revenue (USD $54,387,831.32). This difference implies that small property owners have the financial capacity to reforest land, and therefore are likely to become compliant through forest restoration. For large properties greater than 550 ha, reforestation costs begin to exceed annual cattle revenue. These increased costs may reduce the financial capacity and incentive for these properties to be meet restoration requirements. The likelihood of larger properties (greater than 400 ha) to restore forest may also be reduced due to the significant surplus of LR (10,941.82 ha) that is available for these properties. This excess forest land can either be legally deforested, or sold for CRA offsets.

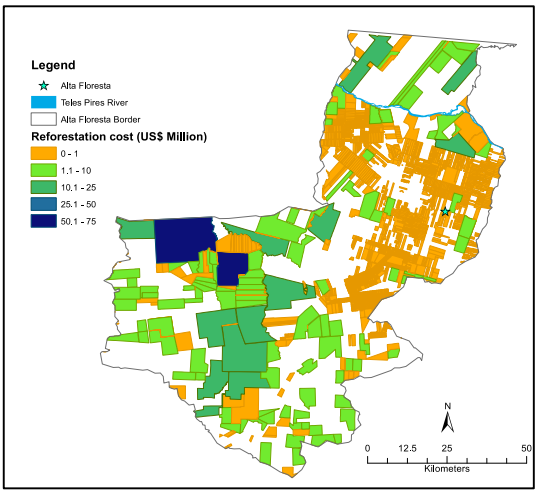

Figure 6.14. Reforestation costs for properties to meet compliance for restoration requirements under the new Forest Code (n=2766).

For larger properties, the difference between restoration and annual cattle revenue costs is likely to reduce the incentive to comply with the new FC's reforestation requirements (Figure 6.14). It may also increase the uptake of tradable CRAs as an economical option, which enables continued cattle grazing on deforested lands. Properties less than 400 ha, however, have a much smaller LR surplus (2,208.92 ha) than large properties, which reduces their opportunity for future legal deforestation or to sell CRA offsets

6.7 Discussion

6.7.1 Impact of changes in the Forest Code on land-use decisions

How have the changes in the Forest Code policy affected land-use decisions of small and large properties?

There are widespread implications from the changes in the new FC. The reformed FC requirements have significantly reduced APP and LR forest set-aside requirements for both small- and large-scale properties. This reduction has increased compliance by creating an amnesty for historical environmental debt. For APPs, the amnesty affected both small and large properties (creating a 48.82 % amnesty of previous debt), while there was a complete amnesty for small properties linked to LR debt. The increased compliance levels would suggest that the FC reform has altered the land-use decisions of both small and large properties. In one respect, it has increased the compliance of conservation of forests and riparian habitats by reducing the set-aside requirements for landowners.

Riparian forest habitats are natural places that are under increased pressure in agricultural areas (Sparovek et al. 2010). This is evident in the Alta Floresta municipal county where agricultural expansion is forcing a choice between legal compliance, profit, and ecosystem function. The loss of forest to increase pasture areas appears to be more profitable than the preservation of forest and riparian habitats. The extent of deforestation during 2002 to 2011 indicates that the drivers of deforestation, particularly expanding agricultural development, remain in existence

(Keane et al. 2008, Leader-Williams and Milner-Gulland 1993, Rudel 2005b). While rates of deforestation slowed significantly after 2005 (comparing levels in the 1990s to 2005 levels), it is unclear whether the FC reforms will continue this reduction in deforestation, or completely reverse it (Schwartzman, Moutinho, and Hamburg 2012).

What impact have the property-scale levels of deforestation during the period 2001-2011 had on compliance levels from the 2012 Forest Code legislation changes?

There were significant differences in the level of deforestation between large and small properties during the period 2002-2011. This led to varying impacts of the reformed legislation on different property sizes. Small properties, for example, had a lower contribution to overall deforestation, and therefore environmental debt. In contrast, large-scale properties deforested 48.07 % of their total property area across Alta Floresta, which generated significant environmental debt. This historical deforestation, in particular within large-scale farms, has considerably reduced the compliance levels for these properties under the new FC. The reformed FC may be viewed as substantially lenient by some (Stickler et al. 2013). But it is clear that achieving complete compliance remains unlikely because the extensive loss of forest area will be unable to meet the new FC's forest set aside requirements. The ecosystem benefits of the FC's enforcement could therefore be seriously undermined by continued deforestation (Sparovek et al. 2010).

High deforestation rates are indicative of a low economic value placed on standing forest areas. The short-term economic benefits of deforestation have fostered the expansion of cattle pasture. They also have outweighed the environmental cost of compliance (Sweeney et al. 2004). This is evident with large properties' environmental debt. Despite more lenient requirements under the new FC, after deforestation is included, large landowners' debt exceeds that of the stricter original FC. The reformed FC is therefore weak in its ability to alter economic behaviours for large private landowners to manage, and not exhaust, forest tracts (Tollefson 2011, Walker et al. 2013).

The inclusion of deforestation in this analysis significantly lowers compliance levels across the properties. It also suggests that the reformed FC rules are ineffective for many landholders, and may drive further deforestation (Keane et al. 2008). This is emphasized by the significant amnesty of environmental debt for both APPs and LR under the new FC. Excluding deforestation, the amnesty is most significant for small properties. When deforestation is considered, however, in absolute terms, FC reforms enable a greater amnesty for properties larger than 400 ha, and those with higher bovine density and, therefore, greater wealth. This is because large-scale farms hold more overall land and, even with substantial deforestation, the reduced forest set-aside requirements pardon historic non-compliance. These large properties also have a greater surplus of forest land, which can legally be cleared or traded as CRAs. These

larger and wealthier properties benefit more from the FC change than smallholders, which do not have excess land to be either cleared or traded as CRAs.

Economic behaviours to maximize utility are evident in landowners' decisions to increase agricultural revenue through extensive deforestation (Angelsen 1999). This economic activity is, however, maximized at the expense of forest and hydrological ecosystem services. To enable environmental behaviours, compliance must be more cost effective than non-compliance. To deter future offences, enforcement measures and punishment must be more costly to landholders than their perceived benefits of deforestation (Leader-Williams and Milner-Gulland 1993). The effect of the political lobby in Brazil in campaigning Congress to reduce the original FC requirements was significant. The political campaigning also have given the perception to landowners that lobbyists can either drive future law changes, or that future legislation revisions will further reduce compliance requirements. Currently, positive environmental behaviours, i.e. compliance, are perceived to be of greater economic cost, particularly for large landowners, than non-compliant behaviours linked to agricultural expansion.

What are some of the impacts of the reforestation requirements of 2012 Forest Code legislation on the land-use decisions of large and small landowners? How can Environmental Reserve Quotas be used to address these legal requirements?

To enable environmental debts to meet compliance under the new FC when deforestation is considered, significant restoration of forest needs to occur, particularly among large landholders. A landowner's economic ability to deal with restoration requirements will largely determine the relative capacity and motivation to comply with regulations. For smallholders, forest restoration requirements are lower due to property size, lower deforestation levels, and the extent of LR amnesty. Consequently, the cost of restoration for small landowners is less than total annual cattle revenue for these properties, and therefore is financially viable.

For large-scale properties, the cost of reforestation exceeds that of total annual cattle revenue when the extent of deforestation between 2002-2011 is considered. The impact of these reforestation costs may encourage landowners to not comply, or to take up CRAs (either selling or buying) to abate LR debt. By developing a tradable market, CRAs can alter landowners' perceived economic value of forests (Soares-Filho et al. 2014, Bonell and Bruijnzeel 2004). CRAs can be used to offset LR environmental debt from one property to another. The compensation for forest loss in one location by protecting forest in another location, however, may not always be effective or appropriate. The use of CRAs may penalize small property owners with limited surplus forest and capital opportunities to enter the market. The very notion of offsetting environmental debt through CRAs also may develop a perception that regulations can be bypassed and the market abused, while deforestation and large agribusinesses continues to expand.

Despite their substantial deforestation levels, large properties appear to benefit from the significant amnesty in environmental debt. Lower forest set-aside requirements and optional offsetting to reach compliance allow large and wealthy properties to avoid punishment for environmental debts, while continuing to maximize agricultural profit. The use of CRAs to address compliance may prove to be more cost-effective for large landowners. Yet CRA offsets may increase the acceptance of deforestation activities, and give a perception that there are ways to avoid the new FC regulations. Protection of forests through regulation therefore requires greater equity in benefits and compliance for small-scale farmers. Nazareno (2012) argues that the FC reform would achieve neither forest conservation nor the sustainable development required to increase equality between small- and large-scale property owners. Nazareno's research also found that compared to large-scale properties, the FC reforms generated little opportunity for small-scale properties to benefit from reduced provisions for forest protection.

6.8 Conclusion

While this paper focused on the municipality of Alta Floresta in Mato Grosso state, it is indicative of the wider implications of the new FC for much of Brazil's forests and highlights the disparity between environmental policy and the reality of its practical implementation. While the amnesty, which followed a reduced LR and APP requirement for private property owners, is disproportionate across Brazil's biomes, the message that it delivers to landholders – given the current rates of deforestation – is clear: Compliance can be optional. The creation of an amnesty for historical deforestation and non-compliance benefits large landowners, many of whom were involved in driving the policy revisions. This inequality is due to large landowners – with their property size and capital resources – had greater opportunities for previous illegal forest clearances compared to small landowners.

Deforestation rates across Brazil prior to the FC reform may have slowed (in particular after 2005), but forest clearance nevertheless has continued. The extent of forest loss within Alta Floresta would suggest that, despite an overall decrease, the original FC was not successful in lowering deforestation rates within the region. The FC reforms attempt to increase the efficiency of land-use governance and to control deforestation behaviours. Yet, the reforms have increased the inequity of the policy with disproportionate benefits given to large landholders. These properties owners have obtained a significant amnesty and a greater financial capacity to buy or sell CRAs despite their deforestation activities before the FC reforms.

The new FC may still not provide effective carrot-and-stick motivation to protect forests on private properties because it is still more profitable to convert forest to

cattle pasture, particularly for large landholders**.** More recent studies by Godar et al. (2014) suggest that large landholders may be altering their behaviour to continue deforestation, but in patches that are within the detection limits of satellite-based forest clearing monitoring systems such as INPE's DETER (*Detecção de Desmatamento em Tempo Real* - Real-time System for Detection of Deforestation). The increased difficulties of detecting non-compliance and enforcing FC legislation under these circumstances may limit the effectiveness of the reformed policy and increase the marginal costs of reducing deforestation. Sufficient economic objectives that combine incentives for compliance, enhanced enforcement, and punishments for non-compliance are, therefore, required to motivate the management, not the exhaustion, of ecosystem services (Walker et al. 2013).

Significant changes in agricultural practices, and more effective enforcement procedures that provide incentives for positive environmental behaviours, are necessary to successfully implement the new FC (Sparovek et al. 2010). Greater transparency, communication, and trust of forest governance may also enable wider acceptance by all landowners**.**

This study shows that the governance decisions of the new FC are clear, but the policy's implementation to manage ecosystem services remains elusive. Unless the true value of forest and riparian habitats at local, regional, and even global scales are recognised, environmental externalities cannot be accounted for. Short-term economic behaviours also will continue to exhaust ecosystem services. The potential return to higher deforestation rates under the reformed FC has been described by some scientists as "*A recipe for Amazon dieback"* (Thomas Lovejoy, Heinz Centre, Washington DC (Tollefson 2011). This renewed deforestation could create ecosystem responses from the substantial conversion of forest to savannah and resultant changes in local climatic and rainfall patterns.

For the Amazon ecosystem, greater leniency in LR and APP requirements is likely to encourage further deforestation, create fragmented forest areas, and continue the transformation of riparian habitats into agricultural land. Without positive incentives and adequate punishments to encourage and reward compliance, coupled with greater equity in the treatment of those who have illegally cleared land, a "new wave" of deforestation is likely to occur (Tollefson 2011). This direct consequence of the policy reforms could compromise complex and dynamic ecosystem processes and functions (Sweeney et al. 2004), with, as yet, unknown impacts on biodiversity, carbon storage, and hydrological ecosystem services.

6.9 References

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7 Conclusion

Conservation interventions that use incentives to alter land-use behaviours have been heralded as an effective approach by which to control the use of natural resources. The outcomes of such approaches, however, are often unpredictable. There is a need to understand how these initiatives function in reality and whether they can be successfully implemented to promote both efficient conservation management and equitable resource distribution. This study applied a social-ecological (SES) approach to examine the ways in which incentives to manage ecosystem services can influence the equity and efficiency of natural resource use. It highlighted the difficulties of implementing mechanisms to motivate behaviours for the sustainable use of ecosystem services. This is particularly important when considering local contexts and dynamics, and the likelihood of non-compliance by actors.

A mixed-methods approach generated both qualitative and quantitative data. The analysis provided insights into water and forest resource use behaviours on Lombok, Indonesia. It focused on the impacts of access and availability of resources, the equity implications of incentive-based institutions to manage land-use decisions and collective action, and how the management of positive incentives 'fit' local contexts to alter environmental behaviours and generate collective action. A further case study in Alta Floresta, Mato Grosso, Brazil provided a separate analysis of how changes in policy, which created negative incentives for land-use decisions, influenced local environmental behaviours.

The use of conservation interventions, which alter incentives for land-user decisions and environmental behaviours, has been widely implemented in recent years. Incentives are, however, neither a 'Panacea or Pandora's box,' (Tomich et al. 1998). Their application as an efficient means to conserve resources and provide more equitable benefits has been promoted in both developing and developed countries. Despite this widespread use, there is a need to understand how the implementation of these incentives fulfil efficiency and equity objectives, and whether the application of incentive-based institutions are appropriate ways to alter land-use behaviours within the complex reality of the real world.

7.1 Concluding section structure

This section summarises the overall findings of the empirical research papers. The theoretical implications of these conclusions, particularly the use of an ecosystem services approach and the debate surrounding collective action versus economic rationale to provide incentives, are then considered. The consequences for policy implementation and, often, unpredictable outcomes, and the management of land-use behaviours for ecosystem services provision are also reviewed. Lastly, the limitations of this study and recommendations for future avenues of study are discussed.

7.2 Summary of results

The structure of this thesis entails that the main empirical findings are specific to each research paper. However, the respective chapters contribute to the wider argument regarding the relationship between incentives and pro-environmental behaviours within a SES context. The synthesis of the results therefore summarises the contribution of each paper in answering the main research questions, as set out in Chapter 1.

7.2.1 Implications of water stress on Lombok, Indonesia

There are multiple challenges in the governance of water resources. This is due to the extent, nature, and complexity of water-related conflict, security, and institutional cooperation. For island ecosystems like Lombok, sustainable water governance is vital to manage finite water resources. The access to, availability, and allocation of water are major constraints for agriculture, livelihoods, poverty, and wellbeing. It is therefore important to understand the dynamics of water resources and resource users for any management to be effective. Chapter 3 examined the biophysical, socio-economic, and institutional determinants of household water supply for communities across Lombok. Significant variation in water resource availability and access was observed, with an irregular distribution of water resources between seasons and villages. Large population densities, in particular, drove the demand for water resources, and which sectors of society competed for them. For rural communities, far from urban settlements, this resulted in limited domestic water infrastructure.

Water management on Lombok is currently supply-driven. This focused on improving infrastructure to increase the supply of and access to water resources. For marginal communities, the high cost of acquisition of, or connection to, household water infrastructure led to a societal scarcity of water resources. A more sustainable and equitable use and allocation of water resources may be developed, however, from a demand driven perspective through end-use efficiency. This is likely to improve access to water infrastructure for rural communities, and reduce the acquisition effort for household water supply. The findings from this chapter furthers our understanding

of the issues for the management of water resources on island ecosystems, and the barriers that biophysical and institutional settings, and infrastructure, pose to sustainable household water provision (Hophmayer-Tokich and Kadiman 2006). The findings also highlight the contextual and unpredictable nature of water scarcity. This has implications for the implementation of water management, which should be developed from an understanding of the 'messy' reality of communities and ecosystem functions on the ground, and should integrate their multiple and, often, competing goals.

This study suggests that inadequate access to water and relevant infrastructure can have significant implications on the time available for economic development and agricultural activities. Household water acquisition effort, however, may not be the single determinant of agricultural revenue. The agricultural sector on Lombok is a high consumer of water resources. Further research into the extent and impacts of agricultural water use would be useful to determine livelihood impacts of household and agricultural water resources (Rijsberman 2006).

7.2.2 Exploring the relationships between incentive-based management, collective action, and social equity: Protecting hydrological services on Lombok, Indonesia

Chapter 4 addressed how the local institutions, which control resource users and the resource system, are central to determining the condition of ecosystem services. All of the communities within this study were influenced by the wider political, economic, cultural, social, and biophysical contexts of Lombok and Indonesia. They highlighted the variation in, and trade-offs between, equity and efficiency that are central to incentive-based interventions. Institutional design, which matched local contexts and existing power relations, were important in determining equity in ecosystem services management.

Other studies (Vatn 2010b, Vatn 2010a, Gachter and Fehr 1999, Fehr and Falk 2002) have argued that economic rationale alone cannot predict environmental behaviours. The findings of this paper support this argument and further the understanding of the social drivers and communal institutions that affect environmental behaviours beyond merely maximising economic utility. On Lombok, communal local institutions based on social and cultural values, such as collective resource behaviours and customary laws, represented significant incentives to motivate pro-environmental behaviours. The findings of this paper suggest that incentive-based institutions had a more significant influence in altering land-use behaviours when built on existing social norms that motivated collective action. This supports theories of collective action by Mosse (1997, 2003) - that cooperative behaviours arise from moral conscience or social norms - and furthers the understanding of how collective action built on social norms can occur at local levels.

The communal local institutions that motivated pro-environmental cooperative behaviours generated greater autonomy over management procedures and the distribution of benefits. The risk of elite capture was evident across all case studies, and was reflective of the context-specific nature of institutional benefits and the political ecology of Indonesia. This emphasised the necessity for locally-driven and locally-targeted incentive-based institutions to enable the empowerment of local communities.

7.2.3 How well do incentive-based institutions 'fit' the societal values of ecosystems on Lombok, Indonesia

A variety of incentive approaches, including economic, religious beliefs, and customary laws, were examined in Chapter 5. They illustrated how different institutional signals were used to alter land-use behaviours. This paper examined elements of institutional 'fit' in relation to societal values in incentive-based institutional design. Key to the participation of communities in institutional decision-making and their compliance to pro-environmental behaviours was the autonomy of the incentive-based institution's development and management. Institutions that had higher community autonomy were, as a result, more closely aligned, and adapted to, social norms, cultural values, and existing institutional governance. Consequently, they had a greater impact on behaviours, and generated cooperation within communities for collective action.

The findings of this paper contribute to the wider debate about the importance of institutional alignment to SES contexts. Ultimately, it is only through context-specific studies that the 'fit' of incentive-based institutions can be observed. This suggests that a universal application of incentive-based institutions based on a Coasean approach will produce different outcomes when implemented in different contexts.

The case studies on Lombok illustrated the influence of these contexts and existing underlying institutions on collective action for communal pro-environmental behaviours. The inclusion of socio-cultural dimensions in ecosystem valuation and institutional development has critical implications for institutional 'fit.' For Lombok, socio-cultural backgrounds, rather than cost-efficiency outcomes, were significant in determining individual perceptions and values of ecosystem services. Incentives that were grounded within existing institutions and social norms were able to 'crowd in' intrinsic motivations for cooperation and pro-environmental behaviours.

No single policy can 'fit' all contexts. Consequently, interventions such as Payments for Ecosystem services (PES) rarely resemble their theoretical form in practical application. This is a consequence of the fact that incentives are often 'problem-based:' They are negotiated between various stakeholders, in the context of addressing specific problems for a specific SES. Outcomes are difficult to predict as

context determines the success of individual incentive-based mechanisms. The implementation and adaptive management of incentives that have closer alignment with existing institutions, contexts, and societal values is therefore essential for institutional signals to influence collective land-use behaviours.

7.2.4 Efficiency and equity implications of changes to the Brazilian Forest Code, *Código Florestal,* for landowners and ecosystem service provision in the Amazon frontier, Mato Grosso, Brazil

Chapter 6 addressed the impact of incentives to alter land-use behaviours, which are determined by the trade-offs of landowners between the perceived economic benefit, the likelihood of detection, and the severity of punishment of non-compliance. This paper highlighted the disparity between policy application and the reality of its implementation with the effect of changes in forest policy on institutional signals that influenced land-use decisions and the conservation of riparian ecosystem services.

The reduced requirements of the reformed Forest Code (FC) significantly lowered the forest protection requirements for landowners for both Legal Reserve and Areas of Permanent Preservation forest set-asides. This reduction has been viewed by some as substantially lenient (Stickler et al. 2013). Significant levels of deforestation between 2002-2011 across Alta Floresta changed the efficiency and equity outcomes of the reformed FC. When these deforestation levels are considered, the amnesty level remained substantial, but the overall compliance under the reformed FC is significantly lower than compliance under the original legislation.

Smaller, less wealthy landowners had a lower contribution to deforestation, yet the amnesty of their historic deforestation under the reformed FC was lower than larger, wealthier landowners. These larger landowners had a greater historic deforestation amnesty and surplus of forest, which they could legally clear or trade to offset non-compliance. The cost of compliance for these larger landowners was far greater than the benefits they obtained from continued deforestation. This paper supports McAfee (2012)'s argument that the 'incentive effect' of institutions may not always generate equitable outcomes. Inequity of landowner benefits from policy reform outcomes may also encourage the perception that compliance is not cost-effective, and therefore it may drive further deforestation and ecosystem degradation

The use of sanctions as incentives to motivate pro-environmental landowner behaviours did not in this case study appear to be sufficient to adequately explain land-use decisions. The implementation of the reformed policy to manage ecosystem services and reduce deforestation remains elusive. The findings suggest that environmental externalities have not been addressed and the degradation of ecosystem services imposed disproportional costs on the wider society. For Alta Floresta, weak incentives led to weak institutions. The 'incentive effect' of policy reform was

insufficient, both economically and in enforcement ability. This created an inefficient institution that appeared to be unable to motivate compliance, leading to a greater likelihood of further deforestation. Continued deforestation also could seriously undermine any ecosystem services benefits from the FC's enforcement.

7.3 Theoretical implications

In this section the contributions of the research findings to theoretical debates are discussed.

7.3.1. Valuation of ecosystem services

The Millennium Ecosystem Assessment (MA 2005) has driven considerable research into the economic values of ecosystem services. This conceptual approach is useful to identify ecosystem service function and benefits. It also can identify their economic values, which can be integrated into decision-making to develop pragmatic solutions for conservation (Goulder and Kennedy 2011, Daily et al. 2009). The acknowledgement of the value of ecosystem services is an important factor to determine land-use behaviours. Landowners seek short-term benefits through land conversion or unsustainable resource use. However, pure economic commodification of ecosystem services may exclude important drivers of land-use behaviours, which are often linked to underlying cultural values, social norms, customary laws, and the relationship between these values and other institutions (Hein et al. 2006, Oteros-Rozas et al. 2013).

This study highlights the benefits of using a SES framework (Ostrom 2009) to understand economic values of ecosystem services and the determinants of the processes that drive sustainable or harmful natural resource use. Multi-disciplinary approaches, such as SES, can examine relationships between social and ecological systems within the context of their social, political, and economic setting. This approach can reveal resource-user perspectives on ecosystem services and institutions that are used to govern their use. Consequently, a SES approach is beneficial to understand holistically the human responses to the dynamics of the SES context (Travers 2009). Incentives are, therefore, more likely to be accurately directed to alter these responses towards pro-environmental behaviours. Further research into the non-economic values of ecosystem services, such as intrinsic use and non-use values, and option and existence values, would be useful to infer social and cultural importance of ecosystem services, and their contribution to motivating pro-environmental behaviours.

7.3.2. Framing human behaviour towards the environment

Group behaviours do not always conform to theoretical or institutional arrangements, and outcomes are difficult to predict. Designing incentive-based institutions solely from theoretical perspectives may not provide the conservation and development outcomes that are sought. The findings from this thesis highlight the need to incorporate broader perspectives of human motivation to cooperate with communal environmental behaviours. Economic theory is often a key driver in the design of behavioural incentives. It is equally important, however, to include social, anthropological, and psychological theories to understand the foundations and social institutions behind behavioural motivation (Fehr and Falk 2002, Gachter and Fehr 1999).

7.3.3. The influence of collective action versus economic rationale on behavioural choices

The use of incentive-based mechanisms to control land-use behaviours is built on an economic rationale that individuals act to maximise individual benefit. In providing an incentive that is greater than the benefit from detrimental environmental activities, these mechanisms aim to fulfil both conservation and development objectives. Where individual action cannot achieve common goals alone, Wade (1987) argues that collective action is more efficient. This was partially supported by the findings of one of the case studies on Lombok, where the implementation of the incentive-based institution was motivated by a desire to obtain greater efficiency in the provision of water resources and hydroelectricity. Compliance and participation in the initiative, however, was weak and had limited impact on behavioural choices.

The findings from two case studies on Lombok, however, suggested that it was important to look beyond economic rationale when defining human motivation. These two case studies highlighted the implications of communal local institutions, such as *awiq-awiq*, religion, and social norms, to provide incentives for pro-environmental behaviours and collective action. Case studies in this context suggested that rationale choice alone could not predict or explain individual behaviours. This argument builds on Mosse's (1997, 2003) debates that collective action is motivated by social norms rather than economic efficiency. Cooperative solutions to manage common pool resources appeared to be driven by a common moral conscience or the wider social norms of these communities. Incentives appeared to show a greater 'fit,' higher levels of participation, and compliance when built on these underlying drivers of communal social behaviour (Ostrom 1990, 2000).

'Crowding in' and 'crowding out'

The findings from the case studies on Lombok highlight the importance of interplay of incentive-based institutions with existing local institutions and their 'fit' to local

social, economic, biophysical, and political contexts. The complex and dynamic nature of SESs and the case studies meant that it was difficult to clearly define whether incentives-based institutions 'crowded in' or 'crowded out' existing intrinsic motivations. Monetary incentives did not undermine intrinsic motivators, but nor did they necessarily complement them (van Noordwijk et al. 2012). The findings from two of the case studies on Lombok, however, suggest that building incentives on communities' existing social norms, and their ability to self-organise and cooperate, can reinforce intrinsic motivations for collective action, i.e. 'crowd-in.'

7.3.4. Methods to understand institutional theory and practical implementation

This thesis used a diverse array of methods to try to understand how the theory behind incentive-based institutions function in practice to alter behaviours towards the environment. In particular, the use of spatial analysis was useful to understand large-scale actor-specific implications of forest policy changes for small and large property owners in Alta Floresta. This method highlighted trade-offs between economic gain and conservation that could be examined under different policy designs. The use of this approach, however, may be limited due to the multiple factors involved in determining land use decisions by small and large landowners over such a large, heterogenetic landscape. Furthermore, recent studies suggest that large landowners, aware of the government's deforestation monitoring system through satellite imagery may be adapting their behaviour to continue deforestation activities, but at a scale that avoids detection (Godar et al. 2014). The use of the method in this study provides an example of how spatial analysis can be used to illustrate the disparity of policy and the theories behind governance systems, as well as the reality of its implementation on the ground.

7.4 Policy implications

The results of the case studies in Lombok and Alta Floresta highlighted the difficulties in predicting and determining conservation and development outcomes of incentive-based institutions. The findings of this research, however, also have clear relevance and implications for the design and implementation of policies that use incentives as mechanisms to alter land-use behaviours. Each case study highlighted the often divergent realities between policy design and the complex world in which initiatives are implemented. The inherent inter-relations within a SES imply that any management of ecosystem services will create trade-offs between resource users and the resource system (Rodriguez et al. 2006). The design of policies to manage ecosystem services with incentives will also reflect these trade-offs. An interdisciplinary approach to the implementation of incentive-based institutions is

therefore essential to quantify these trade-offs and understand the drivers of human decision-making (Milner-Gulland 2011).

7.4.1 Efficiency outcomes of incentive-based management

The basic principle underlying incentive-based institutions is to enable greater economic and environmental efficiency for a more sustainable use of natural resources (Jack, Kousky, and Sims 2008). Yet, optimising the provision of one ecosystem service, or for one group of resources users, will result in trade-offs for the provision of other ecosystem services and for other resource users. It is also difficult to measure efficiency, particularly due to the context-dependent nature of what is understood to be efficient, and the complex processes and functions of ecosystem services (Pascual et al. 2010). Efficiency is often focused on costs and gains, with a focus on ecosystem services values and a more sustainable use of resources. However, it is also argued that to manage resources efficiently, social equity and intrinsic values of natural resources must also be taken into account.

The findings of this study suggest that policy should look beyond economic efficiency goals in the application of incentive-based institutions. Efficiency outcomes of incentive-based management should not be confined to just short-term gains and cost-effectiveness (Kosoy and Corbera 2010, Martin et al. 2014). They also must promote long-term changes in land-use behaviours. At the local level, long-term behavioural changes may be achieved through communal incentives to control land-use choices, and promote greater cooperation and collective action. Sustainable and efficient outcomes may therefore be dependent on the development of incentive-based institutions that include socio-cultural values, and that are able to increase cooperation and equity among resource users.

7.4.2 Equity outcomes of incentive-based management

Incentive-based managements, which are efficient in their use of natural resources, are not automatically equitable (McAfee 2012). While economic efficiency is clearly important in the design and implementation of incentive-based institutions, environmental behaviours are also driven by concepts and perceptions of social justice for both governance procedures and resource distribution (Martin et al. 2014, Kollmuss and Agyeman 2002). Policy should therefore have a specific focus on understanding historical and existing power relations, and social perceptions of equity.

Multiple factors in the research's case studies were found to have an impact on the equity of the distribution of benefits under incentive-based management. For Alta Floresta, landowners with greater capital were able to obtain greater level of benefits from the weak enforcement of with weak compliance incentives. On Lombok, the

case studies that were led by local institutions had a greater focus on the equity of outcomes than those led by external organisations, which appeared to have a greater focus on efficiency outcomes. Case studies on Lombok highlighted the importance of equity in procedures that enabled participation in decision-making. However, there was significant disparity between different incentive-based institutions in the redistribution of benefits and the empowerment of local people.

The existence of social equity prior to incentive-based institution implementation was not determined to be a prerequisite for this management to function. On Lombok, existing social hierarchies showed an increased risk of the elite capture of benefits linked to incentive-based institutions. Yet when there was greater equity in decision-making and control of natural resource management, the distribution of natural resource benefits was higher and compliance through collective action was more likely.

Lower equity in procedural justice, such as through the implementation of external incentives, was found to weaken incentive-based institutions. Social equity in the Alta Floresta case study was adversely affected by institutional reforms of the local Forest Code. Landowner decisions to increase agricultural revenue through continued deforestation were illustrative of economic behaviours aimed at maximising utility (Angelsen 1999). In this case study, compliant behaviours were less cost effective than non-compliant behaviours. The negative 'incentive effect' of sanctions was also disproportionately felt by small landowners compared to large landowners. Consequently, the wealthier landowners captured greater benefits from their historical deforestation activities and the legislative reform because of their greater access to the financial benefits of non-compliance versus poorer subsistence farmers.

Further research into the justice implications of incentive-based institutions would be necessary to identify local perceptions of what is 'just' in relation to resource access and availability, and institutional governance; and, how these views impact environmental behaviours in response to incentives.

7.4.3 Institutional 'fit'

The findings of this research illustrate that the institutional effectiveness of incentive-based management is dependent on the SES context in which institutions function and on the environmental problem they wish to address. The ability of these institutions to 'fit' these contexts is key to their ability to alter land-use behaviour. It is therefore essential for policy to understand how incentive-based institutions align with local contexts and values, and interplay with existing institutions.

For Lombok, high community participation in decision-making, adaptive management of natural resources, high autonomy over incentive-based institutions,

and incentives that matched social norms and the resource, illustrated institutional 'fit.' Community-led institutions, such as in Ledang Nangka and Gangga, used existing institutions and social norms to motivate collective action for pro-environmental behaviours. These were more accepted by local communities and showed greater alignment with the local SES context than in communities where this approach was not taken. Incentives were grounded in underlying intrinsic motivations, such as religious beliefs and customary laws, and were used to 'crowd in' social norms.

In contrast, institutional 'mis-fit' was illustrated in Lebah Suren and Alta Floresta, and proved to be ineffective in managing ecosystem services. In Lebah Suren, the implementation of incentives by an external organisation reduced interplay with other local institutions, had a narrow resource management focus, little adaptability, and did not encourage community participation in, or cooperation with, the institution. Consequently, social acceptance and 'fit' of this institution was weak and short-term. For Alta Floresta, negative incentives through sanctions were insufficient to alter land-use behaviours. The implementation of the reformed FC after significant deforestation reduced the strength of incentives to be able to change behaviours.

Incentives to alter environmental behaviours need to be directly targeted at local providers within the context of a SES and resource management focus. Institutional structures that 'misfit' the resource and resource users that they aim to govern are unable to provide sufficient incentives to alter land-use behaviours. The implementation of external institutional structures may be inappropriate and insufficient in addressing environmental issues and local land-user needs. It is crucial to understand the context in which incentives aim to function so that appropriate policies can direct land use towards social goals, which also reduce environmental degradation.

7.4.4 The 'messy middle'

The findings from these case studies illustrate some of the reality of how incentive-based institutions can function in practice. They highlight that the 'messy' world in which they are implemented makes it difficult to clearly attribute outcomes to the theoretical assumptions on which incentive-based institutions are designed. Human behaviour and ecological systems are determined by multiple and dynamic factors. Their management is typified by multiple and often competing goals.

The 'optimal design' of policy should, therefore, be developed within the context in which it functions, taking into account the different perceptions, cultural backgrounds, social norms, and ecological dynamics of each SES. None of the case studies used in this thesis clearly adhered to Wunder's (2005) PES criteria. Nonetheless, these findings are relevant for PES and incentive-based design. They move PES beyond its theoretical application to meet the realities of the complex world that is the

application of incentives. The use of these criteria and theoretical approaches such as political ecology and SES, can be useful in guiding understanding of SES dynamics. They can also help with the development of incentive-based institutions that are more likely to align with specific case study contexts. The application of incentive-based institutions, which are able to incorporate and adapt to the 'messy middle' and create a problem-centred approach may, therefore enable a greater 'fit' to the chaotic, unpredictable, and, often, poorly understood reality.

7.5 Study limitations

As with all research, there were a number of limitations that influenced the scope of this study, which need to be considered. These included potential methodological weaknesses when applying matching, cultural misunderstanding, and time constraints for surveys conducted on Lombok; and, margins of error in spatial analysis applied for both Lombok and Alta Floresta. The use of matching to select control villages in Lombok was a useful tool to create comparative case studies in which to analyse conservation and development intervention (Pattanayak 2009, Ravallion 2005). However, for the researcher to accurately match case study communities that were similar in every context except the intervention, a significant understanding of the SES was required (Clements 2012). In reality, this was not always possible or feasible within the limitations of the fieldwork and research time-scales. Consequently, matched variables could have been selected on a more practical basis rather than qualitative assessment. This may have limited the compatibility of control villages with the incentive-based institution case studies.

In Lombok, due to time constraints, particularly during the month of Ramadan (July-August 2012), respondents were often difficult to find and indicated frustration when responding to questions. It was decided that questionnaires would be conducted in the early evening, after *iftar*, the breaking of the fast. This ensured respondents could be located, were happier to answer questions in a more free manner, and that the research assistant could also observe Ramadan practices.

The findings from the case studies in Lombok may also not necessarily be representative of the wider island population. Data was collected from households within a short time scale, which could limit the qualitative understanding of the complexities of SES and drivers of environmental behaviours. The findings may also have not considered the long-term impacts of such behaviours and system dynamics. A larger sample of populations in other villages would have helped to identify and calculate more generalised motivations for pro-environmental behaviours and collective action across the island.

On Lombok, interviews and questionnaires were conducted in Bahasa Indonesian, and translations into Sasak were made where necessary. Where possible, the influence of the researcher's own perspectives and cultural differences on data was minimised. Some cultural understanding and influence, however, was unavoidable, and likely to have influenced the questions asked, the direction and theme of discussions, and the responses given. Gender issues and the impact of power relations were significant factors in obtaining responses. It was recognised that presence of a male research assistant and local power hierarchies were likely to have generated more conservative answers, in particular from female respondents. Some information and colloquial understanding may also have been lost in translation.

Spatial analysis generated limitations for both the Alta Floresta and Lombok case studies. For Alta Floresta, the use of two differently sourced satellite images (QuickBird and LANDSAT-5/TM) with different resolutions and from different years increased the margins of error in the spatial analysis. For the purpose of identifying land-use behaviours in relation to deforestation rates, however, it was important to include both of these images. While images were classified using the same bandwidth, and projected on UTM 21S (datum SAD69), some margins of error were unavoidable. While ground-truthing to determine property boundaries had been conducted by the municipal administration of Alta Floresta, due to the number of properties surveyed (nearly 3,000), some overlap was also unavoidable. Due to the high resolution of the QuickBird image, classification of land cover was a complex and lengthy process, requiring multiple classifications. Some detail in forest type, such as the quality of forest, in particular along forest edges, may have been lost during this classification.

A lack of baseline biophysical data and the small-scale nature of the Lombok case studies meant that it was beyond the scope of this research to determine whether outcomes, particularly those linked to the local environment, were specifically attributable to incentive-based institutions or other factors (Ferraro 2009). For Lombok, limited sources of available biophysical data did allow some spatially analysis. However, further collation and collection of this data would have been beneficial to obtain a more detailed understanding of the biophysical characteristics of natural resource distribution in relation to incentive-based institutions. While the findings of this study may be influenced by these limitations, nonetheless, it provides an important insight into the use of both positive and negative incentives to manage land-use behaviour, and will prove useful in future studies.

7.6 Conclusion

Rapidly growing populations, increased demands on limited natural resources, and climate change are driving a global loss of ecosystem services. Countries such as

7: Conclusion

Brazil and Indonesia are particularly vulnerable to the loss and degradation of forest and water ecosystem services due to the extensive conversion of natural forests into agricultural land. This has significant implications, in particular for the rural poor who are dependent on natural resources for their livelihood strategies. Complex social, economic, political, and biophysical processes influence natural resource-use decisions and land-use change. The creation of institutional incentive structures can therefore be used to govern resources required to directly impact land-use choices.

Conservation interventions, which use incentives to alter behaviours that are currently detrimental to the continued provision of environmental services, have been perceived to be a 'win-win' for both conservation and rural development outcomes. These initiatives aim to reconcile the economic efficiency considerations of implementing conservation programs with the equity concerns of access to, and allocation of, benefits from natural resources. It is essential to understand how these institutions align to the SES in which they function, and how they influence the land-use decisions that they aim to change.

The findings in this study support the idea that SES's context – the biophysical, social, economic, and political dynamics – is highly significant in influencing environmental and institutional perceptions, and in determining land-use behaviours. Landowners are more likely to be compliant on the basis of these predictors within their SES context. In the real world, however, it is difficult to predict individual and communal behaviours from theoretical or institutional arrangements. This has implications for wider conservation outcomes, and the implementation of incentive-based institutions in developing and developed countries. When designing and implementing incentive-based management of ecosystem services, it is important to understand the context of the SES in which the institution will act. These contexts will constrain or influence the institutional signals of mechanisms that determine the costs and benefits of different environmental behaviours for both individual and collective action.

Appropriate incentives to control or alter these behaviours need to be built on these specific contexts. They must take into account social norms, economic rationale, and existing institutions. This study emphasises the need to consider non-economic values such as social and cultural norms, as well as underlying customs, if incentive-based institutions are to promote pro-environmental behaviours and local development goals. The identification of behavioural drivers beyond black-and-white economic rationale is important when incentives are aimed at altering behaviours for sustainable natural resource use. Inappropriate and misaligned incentives may have negative effects on environmental behaviours, create imbalances in power structures linked to resources, or further damage already vulnerable ecosystems. Local contexts, and the localised nature of drivers for collective behavioural change, should therefore be identified and incorporated into an incentive-based approach to ecosystem services management.

The type of incentives used to drive pro-environmental behavioural change is also important. This study examined the impacts of the 'incentive effects' of legislative sanctions, economic motivations, religious beliefs, and traditional customs on land-use decisions. Due to the complexities and dynamics of SES, the universal application of incentive-based institutions, such as Payments for Ecosystem Services (PES) criteria, is unlikely to be successful. The application of a 'one-size-fits-all' management intervention may be inappropriate in many local contexts. Incentives must be tailored specifically to the ecological resource, resource system, and local resource users. This will increase community participation, the social and overall 'fit' of an institution, as well as enable compliance to be perceived as a more cost effective (socially and economically) environmental behaviour. Local actors must consider these incentives to be more beneficial than non-compliant land-use behaviours that can be detrimental to ecosystem service provision. These factors are strong predictors of pro-environmental behaviours and institutional 'fit.'

Ultimately, there is a need to balance the conservation of ecosystem services with the complexities of rural development and agricultural land use. Conservation interventions that seek to reconcile these often-divergent aims with the use of incentives are more likely to succeed if the underlying drivers of resource-use behaviours are fully understood, and the institutions to manage behaviours are aligned with the social and economic objectives of local resource users. Intrinsic motivation and localised priorities are paramount. This approach can incite greater 'incentive effects' that motivate pro-environmental behaviours, and increase the capacity of local actors to work collectively to sustainably use and manage their natural resources. "Incentives [do] matter" (Gneezy, Meier, and Rey-Biel 2011), but their application in the real world needs to be designed to incorporate the complexities of the realities of practical natural resource management to the theories behind them.

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Appendix I - Lombok-Wide Household Questionnaire

INFORMATION TO BE EXPLAINED TO RESPONDENTS BEFORE THE INTERVIEW STARTS

1. The purpose of this questionnaire is to independently understand livelihood conditions, and water use across Lombok, and to learn whether they are different across the island.

2. Your participation in this study is optional; you do not have to participate if you do not want to. If you do agree to participate, you will have the right to refuse to answer any question that you do not want to discuss, and you can stop the interview at any time. Should you wish to withdraw your responses, you can do so up to 3 months after the interview.

3. You name or any facts that could be used to identify you or your family will not appear in any documents resulting from this study. All of your answers will be held in strict confidence and cannot be traced back to you, your children or other household members.

4. The information that you give may help guide the formation of policy that ensures both people and the environment are protected and managed. Once completed, the results from this study will be shared with you.

ENNUMERATORS PLEASE NOTE:
Questionnaire no:_____
Interviewer Name:_____

A	Date of Interview	
B	Village GPS Coordinates (DD MM SS)	
C	HH ID [Ennumerator initials/Number]	
D	Village	
E	Sub-village	

VERIFICATION OF THE QUESTIONNAIRE
Supervisor Name : Lucy Garrett Date :_____
Follow-up with ennumerator :_____
Interviewer initials (Date) Supervisor initials (date)

THE FOLLOWING ARE STANDARD CODES TO BE USED THROUGHOUT THE QUESTIONNAIRE :
IF A RESPONDENT REFUSES TO ANSWER A QUESTION, PLEASE USE '999'
IF THE QUESTION IS NOT APPLICABLE, PLEASE USE '888'
IF THE RESPONDENT ANSWERS 'I DON'T KNOW', PLEASE USE '777'
IF THERE IS ANOTHER RESPONSE NOT LISTED, PLEASE USE '666' FOR OTHER

Appendix I: Lombok-wide household questionnaire

Section A : Part 1 : Area Identification

A.1.1.How many rooms does the house have?		
A.1.2.Location of Household in village	1=In or around the village centre	2=Isolated Household

Section A : Part 2 : Household Characteristics

A.2.1. Name of respondent		
A.2.1.Is the head of household answering the questions?		1=Yes 2=No
A.2.2.Sex:	1=Male 2= Female	
A.2.3.Age:		
A.2.4.Occupation:		
A.2.5.Number of years in education:		
A.2.6.Marital status:	1=Never married 2=Married 3=Divorced 4=Divorced and remarried 5=Widowed 6=Widowed and remarried	
A.2.7.What is the main religion/ belief system of the household?	1=Islam 2=Hindu 3=Traditional 4=Other	
A.2.8.What ethnicity does the household class themselves as?	1=Sasak 2=Balinese 2=Sumbawa 4=Other (Specify)_____	
A.2.9.How many years has the household lived in this village (even if seasonally)	1=Less than 1 2=1-5 years 3=5-10 years 4=Over 10 years 5=Always	
A.2.10.How many people live in this household?	1=Men 2=Women 3=Children <16 years	

Section A : Part 3 : Assets

A.3.1. Do you own this house?		1=Yes 2=No
A.3.2.If **NO** Who does this house belong to?		
A.3.3. If **NO** Do you pay them rent?		1=Yes 2=No
A.3.4. Tick all that apply to this house:	1=Grass/woven walls 2=Mud brick walls 3=Fired brick walls 4=Earth floor 5=Cement floor 6=Tiled floor 7=Grass/woven roof 8=Zinc/ iron roof 9=Tiled roof	
A.3.5.Please indicate the number of implements and other large household items that are owned by the household:		No. Units owned
	1=Car/ truck	
	2=Motorbike	
	3=Bicycle	
	4=Buffalo	
	5=Cows	
	6=Goats	
	7=Horses	
	8=Chicken/ducks	
	9=HP Cell phone	
	10=Fishing boat and boat engine	
	11=Fish pond	
	12=Cart	
	13=Plough	
	14=Water tank	
	15=Generator	
	16=TV	
	17=Radio	

	18=Other (specify)	
	19=Other (specify)	

Section A : Part 4 : Livelihoods

A.4.1. Of the following, which are the 3 most important sources of subsistence and cash for your household?		
1=Own farm activities 2=Labour (farm and non-farm) 3=Fishing (sea and fish ponds) 4=Trader/ Merchant/ Sales 5=Transport 6=Tourism 7=Construction 8=Factory worker 9=Educational professional/admin 10=Health professional/admin 11=Other professional 12=Restaurant/bar/hotel 13=Skilled trader 14=Other source (specify) 15=No other source 16=No source	A.4.1.Subsistence and cash sources	
	1.	
	2.	
	3.	
A.4.2.Does this change during the wet and dry season?		1=Yes 2=No
A.4.3. If **YES**, What are the 3 most important sources of both subsistence and cash during the wet season?	1.	
	2.	
	3.	
A.4.4. If **YES**, What are the 3 most important sources of both subsistence and cash during the dry season?	1.	
	2.	
	3.	
A.4.5. Have your sources of subsistence and cash changed over the last 5-10 years?		1=Yes 2=No
A.4.6. If **YES**, How?		

A.4.7.For how many months can your household survive on from your sources of subsistence and cash?		No. Months
A.4.8.What do you do in other times?		
A.4.9.What do you spend money on? (Tick all that apply) AND can you out of this spending, what proportion of money you spend on this? i.e. if you spent half of your income on electricity =50%		% of spending
	1=School fees 2=Food 3=Water 4=Electricity 5=Medical bills 6=Transport 7=Other (specify)	
A.4.10.When something unexpected happens and you need money for it (e.g. funeral, accident), how are you able to get the money you need?	1=Savings 2=Loan 3=Extra work 4=Selling an asset 5=Unable to fulfil the need 6=Rely on family 7=Other (specify)	

Section B : Part 1 : Land

B.1.1.Do you have land to farm?		1=Yes 2=No
B.1.2.Do you:	1=Own land 2=Rent land 3=Share land with family 4=Share land with others (not family 5=Other (specify) 6=Do not own/ rent/ share land	

B.1.3.What land type is it? (Tick all that apply)	1=Protected forest - HKm 2=Protected forest – Adat 3=Protected forest - HTI 4=Protected forest – Special purpose (specify) 5=Production forest – HKm 6=Production forest – Adat 7=Production forest – HTI 8=Production forest – Special purpose (specify 9=Non-forest irrigated cropland 10=Non-forest non-irrigated cropland 11=Other (specify)	
B.1.4. What agricultural practices/ crops do you grow? (Tick all that apply)	1=Irrigated Rice 2=Rain-fed rice 3=Tobacco 4=Agroforestry – Timber (specify) 5=Agroforestry – NTFP (specify) 6=Other crop (specify) 7=Fish pond 8=Inter-cropping 9=Livestock grazing 10=Other (Specify)	
B.1.5. How many harvests per year for these crops?	Crop:	No. Harvests/ year:
B.1.6.Has the number of harvests per year changed in the last 5-10 years?		1=Yes 2=No
B.1.7.If **YES**, how?		

Section B : Part 2 : Household Water

<table>
<tr><td>B.2.1 What are the sources of water for your household consumption? (Domestic activities)</td><td colspan="2">1=Collect from spring
2=Collect from community well
3=Collect from shared well within compound
4=Collect from personal well
5=Collect from reservoir
6=Collect from river
7=Piped water to household
8=Shared piped water with another household
9=Own tank
10=Community tank
11=Other (Specify)</td><td></td></tr>
<tr><td colspan="2">B.2.2.If your household is connected to a piped water supply, for how long have you been connected?</td><td colspan="2"></td></tr>
<tr><td colspan="2">B.2.3.If your household is connected to a piped water supply, how many metres of piping do you own?</td><td colspan="2">Metres</td></tr>
<tr><td colspan="2">B.2.4.If your household is NOT connected to piped water, how far away is the nearest piping?</td><td colspan="2">Metres</td></tr>
<tr><td rowspan="3">B.2.5.If you have to collect water from a source away from your house:</td><td colspan="2">B.2.6.How far do you have to collect it</td><td></td></tr>
<tr><td colspan="2">B.2.7.How many times per day do you collect it</td><td></td></tr>
<tr><td colspan="2">B.2.8.Who in the household collects it</td><td></td></tr>
<tr><td colspan="2">B.2.9.What is the quality of water for consumption?</td><td colspan="2">1=Very Good
2=Good
3=Moderate
4=Poor
5=Very poor</td></tr>
<tr><td colspan="3">B.2.10. Do you have to treat water (i.e.Boil, filter etc) prior to drinking?</td><td>1=Yes
2=No</td></tr>
<tr><td colspan="3">B.2.11.Do you have access to/ supply of water for household consumption all year round?</td><td>1=Yes
2=No</td></tr>
<tr><td>B.2.12.If NO, Why not?</td><td colspan="3"></td></tr>
<tr><td colspan="3">B.2.13.If NO,When this happens, how do you meet your Household water requirements?</td><td></td></tr>
<tr><td colspan="3">B.2.14.Has the availability of water for your household consumption changed over the last 5-10 years?</td><td>1=Yes
2=No</td></tr>
</table>

B.2.15.If **YES**, How?		
B.2.16.Do you pay for water for household consumption?		1=Yes 2=N0
B.2.17.If **YES**, how much do you pay on average per month?		Rp
B.2.18.If **YES**, Who do you pay?		
B.2.19.If **YES**, What do you pay for:	1=No. of Units used 2=Access to water resources 3=Both units used and access to water 4=Other (specify)	
B.2.20.What is your opinion on paying for water for household consumption?	1=Very good 2=Good 3=No opinion 4=Bad 5=Very Bad	
B.2.21.Why?		

Section B : Part 3 : Productive Activity Water Use

I am now going to ask you about your productive activities, this includes all your farming, livestock and business activities.

B.3.1 What are the sources of water for your household's productive activities? (non-domestic)	1=Collect from spring 2=Collect from community well 3=Collect from shared well within compound 4=Collect from personal well 5=Collect from reservoir 6=Collect from river 7=Irrigation 8=Rain-fed 9=Piped water 10=Own tank 11=Community tank 12=Other (Specify)	
B.3.2.If you have to collect water from a source away from your productive activities:	B.3.3.How far do you have to collect it	
	B.3.4.How many times per day do you collect it	

	B.3.5.Who in the household collects it	
B.3.6.Do you have access to/ supply of water for your productive activities all year round?		1=Yes 2=No
B.3.7.If **NO**, Why not?		
B.3.8.If, **NO**. When this happens, how do you meet your productive activity water requirements?		
B.3.9.If **NO**, If you are unable to meet the water requirements for productive activities what do you do?	1=Increased area of land farmed 2=Decrease area of land farmed 3=Switch to different crops 4=Construct water supply infrastructure (including digging wells, piped water sources) 5=Increase irrigation capacity 6=Other (specify)	
B.3.10.Has the availability of water for your productive activities changed over the last 5-10 years?		1=Yes 2=No
B.3.11.If **YES**, How?		
B.3.12.Do you pay for water for productive activities consumption?		1=Yes 2=No
B.3.13.If **YES**, how much do you pay on average per month?	Rp	
B.3.14.If **YES**, Who do you pay?		
B.3.15.If **YES**, What do you pay for:	1=Units used 2=Access to water resources 3=Both 4=Other (specify)	
B.3.16.What is your opinion on paying for water for productive activities?	1=Very good 2=Good 3=No opinion 4=Bad 5=Very Bad	
B.3.17.Why?		

Section C : Part 1 : Water Issues

I am now going to ask you some questions relating to how your household is affected by water.

C.1.1. What issues face your household relating to water (for both consumption and productive use? (Tick all that apply	1=Low water supply in all seasons 2=Low water supply in dry season only 3=Irregular flow in all seasons 4=Irregular flow in dry season only 5=Water quality 6=Pollution 7=Flooding 8=Erosion of soil 9=Conflict with other users in the village 10=Conflict with other users outside the village 11=Changes in rainfall patterns 12=Drought (unusual low water supply) 13=Landslide 14=No issues 15=Other (specify)	
C.1.2. Why do you think these occur?	Water issue (Link to Code from C.1.1.)	Reason for occurrence
C.1.3. How often do these issues occur? 1=Daily 2=Weekly 3=Monthly 4=Dry season only 5=Wet season only 6=Annually 7=Rarely 8=Never	Water issue (Link to Code from C.1.1.)	Frequency
C.1.4.How do these effect your household consumption of water?	Water issue (Link to Code from C.1.1.)	Effect on household

C.1.5.How do these affect your productive activities and use of land? 1=Grow different crops 2=Built flood defences 3=Built water infrastructure (irrigation, ground water well) 4=Reduced the different types of crop (e.g. if planted rice and tabacoo, now just plant rice) 5=Increased the different types of crop 6=No affect 7=Other (specify)	Water issue (Link to Code from C.1.1.)	Effect on productive activities and use of land

Section C : Part 2 : Village Water Issues

C.2.1. After rains, do streams:	1=Rise rapidly 2=Get low 3=Remain the same
C.2.2.During dry periods, do streams/rivers	1=Disappear 2=Get low 3=Remain the same
C.2.3.When was the last time flooding occurred in your village?	
C.2.4. When was the last time drought occurred in your village?	

Section D : Part 1 : Environmental management

D.1.1. Are you aware of any environmental management in your village?	1=Yes 2=No
D1.2.If **YES**, Is that management:	1=Traditional laws 2=Community management 3=NGO management 4=Local government management 5=Regional government management 6=Central government management 7=Other (specify)

D.1.3.If **YES**, is your household paid to protect the environment?		1=Yes 2=No
D.1.4.What do you think of schemes that pay households to protect the environment?	1=Very good idea 2=Good idea 3=No opinion 4=Bad idea 5=Very bad idea	
D.1.5. Why?		

Appendix II - Lombok Case Study Household Questionnaire

INFORMATION TO BE EXPLAINED TO RESPONDENTS BEFORE THE INTERVIEW STARTS

1. The purpose of this questionnaire is to independently understand livelihood conditions, and water use across Lombok, and to learn how different management affects these.

2. When I talk about your livelihoods (Penghidupan) this includes all the ways in which you get food, earn cash, get resources from the land and forest that you use for your household.

3. Your participation in this study is optional; you do not have to participate if you do not want to. If you do agree to participate, you will have the right to refuse to answer any question that you do not want to discuss, and you can stop the interview at any time. Should you wish to withdraw your responses, you can do so up to 3 months after the interview.

4. You name or any facts that could be used to identify you or your family will not appear in any documents resulting from this study. All of your answers will be held in strict confidence and cannot be traced back to you, your children or other household members.

5. The information that you give may help guide the formation of policy that ensures both people and the environment are protected and managed. Once completed, the results from this study will be shared with you.

ENNUMERATORS PLEASE NOTE:
Questionnaire no:_____
Interviewer Name:_____

A	Date of Interview	
B	HH GPS Coordinates (DD MM SS)	
C	HH ID [Ennumerator initials/Number]	
D	Village	
E	Sub-village	

VERIFICATION OF THE QUESTIONNAIRE
Supervisor Name : Lucy Garrett Date :_____
Interviewer initials (Date) Supervisor initials (date)

THE FOLLOWING ARE STANDARD CODES TO BE USED THROUGHOUT THE QUESTIONNAIRE :
IF A RESPONDENT REFUSES TO ANSWER A QUESTION, PLEASE USE '999'
IF THE QUESTION IS NOT APPLICABLE, PLEASE USE '888'
IF THE RESPONDENT ANSWERS 'I DON'T KNOW', PLEASE USE '777'
IF THERE IS ANOTHER RESPONSE NOT LISTED, PLEASE USE '666' FOR OTHER

Section A : Part 1 : Area Identification

A.1.1.Location of Household in village	1=In or around the village centre	2=Isolated Household

Section A : Part 2 : Household Characteristics

A.2.1. Name of respondent	
A.2.1.Is the head of household answering the questions?	1=Yes 2=No
A.2.2.Sex:	1=Male 2= Female
A.2.3.Age:	
A.2.4.Occupation:	
A.2.5.Number of years in education:	
A.2.6.Marital status:	1=Never married 2=Married 3=Divorced 4=Divorced and remarried 5=Widowed 6=Widowed and remarried
A.2.7.What is the main religion/ belief system of the household?	1=Islam 2=Hindu 3=Traditional 4=Christian 5=Other (specify)
A.2.8.What ethnicity does the household class themselves as?	1=Sasak 2=Balinese 2=Sumbawa 4=Other (Specify)_____
A.2.9.Does the household live in the village permanently or seasonally	1=Permanently 2=Seasonally

A.2.10.How many years has the household lived in this village (even if seasonally)	1=Less than 1 2=1-5 years 3=5-10 years 4=Over 10 years 5=Always	
A.2.11.How many people live in this household?	1=Men 2=Women 3=Children <16 years	

Section A : Part 3 : Assets

A.3.1. Do you own this house?	1=Yes 2=No	
A.3.2.If **NO** Who does this house belong to?	1=Family 2=Friend in village 3=Friend outside village 4=Other	
A.3.3. If **NO** Do you pay them rent?	1=Yes 2=No	
A.3.4. Tick all that apply to this house:	1=Grass/woven walls 2=Mud brick walls 3=Fired brick walls	
	4=Earth floor 5=Cement floor 6=Tiled floor	
	7=Grass/woven roof 8=Zinc/ iron roof 9=Tiled roof	
A.3.5.Please indicate the number of implements and other large household items that are owned by the household:		No. Units owned
	1=No. Rooms in house	
	2=Car/ truck	
	3=Motorbike	
	4=Bicycle	
	5=Buffalo	
	6=Cows	

	7=Goats	
	8=Horses	
	9=Chicken/ducks	
	10=HP Cell phone	
	11=Fishing boat	
	12=Boat engine	
	13=Fish pond	
	14=Cart	
	15=Plough	
	16=Water tank	
	17=Generator	
	18=TV	
	19=Radio	
	20=Other (specify)	
	21=Other (specify)	

Section A : Part 4 : Livelihoods

A.4.1. Of the following, which are the 3 most important sources of subsistence and cash for your household?	
1=None 2=Regular Salary (eg teacher) 3=Small business 4=Wage labour (non-agricultural) 5=Wage labour (agricultural) 6=Own farm crop/ livestock production 7=Harvesting natural products from the forest 8=Grants/ loans from government or other organisations 9=Remittances from abroad 10=Loans 11=Other (Specify)	A.4.1.Subsistence and cash sources
	1.
	2.
	3.
A.4.2.Does this change during the wet and dry season?	1=Yes 2=No

A.4.3. If **YES**, What are the 3 most important sources of both subsistence and cash during the **wet** season?	1.
	2.
	3.
A.4.4. If **YES**, What are the 3 most important sources of both subsistence and cash during the **dry** season?	1.
	2.
	3.

A.4.5. What proportion of your cash and subsistence do you get from the land/ forest/ water?	%

A.4.6. What are the 5 most important products that you obtain solely from the river, land and forest?

A.4.7. Can you rank these in importance for your health, your income, your food security and for your social cohesion with 0= not important to 5= very important.

A.4.6.Products	A.4.7. Ranking for			
	Health	Income	Food Security	Social cohesion/ strong community
1.				
2.				
3.				
4.				
5.				

A.4.8.Are there ever times when your sources of cash and subsistence are not enough to cover your basic needs (food, water etc)?	1=Yes 2=No
A.4.9.If **YES**, What do you when this happens?	

A.4.10.What do you spend money on? (Tick all that apply) AND can you out of this spending, what proportion of money you spend on this? i.e. if you spent half of your income on electricity =50%		% of spending
	1=School fees 2=Food 3=Water 4=Electricity 5=Medical bills 6=Transport 7=Savings 8=Other (specify)	
A.4.11.When something unexpected happens and you need money for it (e.g. funeral, accident), how are you able to get the money you need?	1=Savings 2=Loan 3=Extra work 4=Selling an asset 5=Rely on family 6=Other (specify) 7=Unable to fulfil the need	

Section B : Part 1 : Land

B.1.1. Do you have land to farm?		1=Yes 2=No
B.1.2. If **YES**, How much land do you farm?		Ha
B.1.2.Of this land farmed, what area is:	1=Land owned by respondent (with land title) 2=Rent land 3=Share land with family 4=Share land with others (not family 5=Other (specify) 6=Do not own/ rent/ share land	ha
B.1.3.If you own land did you	1=Buy it yourself 2=Inherit it from your family 3=Other (specify)	
B.1.3.What land type is it? (Tick all that apply)	1=Protected forest 2=Production forest 3=Irrigated cropland 4=Non-irrigated cropland 5=Other (specify)	

B.1.4. Is the land used for:	1=Mixed crops 2=One crop only – specify 3=Grazing/ fodder 4=Left idle 5=Rented by other households 6=Timber 7=Non-timber forest products (fruit, nuts etc) 8=Fish pond 9=Other (specify)

B.1.5. Which plant crops have you grown/ harvested from the forest in the last year?

B.1.5	B.1.6	B.1.7	B.1.8	B.1.9	B.1.10
Crop type/ forest resource	Proportion of land under this crop	Yield/ year	Income/ year	% Sold	% consumed in the household
(Name)	i.e. ¼, ½, ¾	KG	Rp		

B.1.11. Who cultivates and harvests the crops/ forest resources?		1=Family/ Members of household 2=Neighbour 3=Hired labour 4=Other (specify)
B.1.12. Are these?		1= Men 2=Women 3=Children 4=All

Section B : Part 2 : Household Water

<table>
<tr><td>B.2.1 What are the sources of water for your household consumption? (Domestic activities) This includes drinking, cooking and bathing and washing</td><td colspan="2">1=Collect from spring
2=Collect from community well
3=Collect from shared well within compound
4=Collect from personal well
5=Collect from reservoir/ dam
6=Collect from river
7=Piped water to household
8=Shared piped water to compound
9=Own tank
10=Community tank
11=Get water delivered
12=Other (Specify)</td><td></td></tr>
<tr><td colspan="2">B.2.2.If your household <u>is connected</u> to a piped water supply, for how long have you been connected?</td><td colspan="2"></td></tr>
<tr><td colspan="2">B.2.3.If your household <u>is connected</u> to a piped water supply, how many metres of piping do you own?</td><td colspan="2">Metres</td></tr>
<tr><td colspan="2">B.2.4.If your household <u>is NOT connected</u> to piped water, how far away is the nearest piping?</td><td colspan="2">Metres</td></tr>
<tr><td rowspan="3">B.2.5.If you have to collect water from a source away from your house:</td><td>B.2.6.How far do you have to collect it</td><td colspan="2"></td></tr>
<tr><td>B.2.7.How many times per day do you collect it</td><td colspan="2"></td></tr>
<tr><td>B.2.8.Who in the household collects it</td><td colspan="2"></td></tr>
<tr><td colspan="2">B.2.9.What is the quality of water for consumption?</td><td colspan="2">1=Very Good
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5=Very poor</td></tr>
<tr><td colspan="3">B.2.10. Do you have to treat water (i.e.Boil, filter etc) prior to drinking?</td><td>1=Yes
2=No</td></tr>
<tr><td colspan="3">B.2.11.Do you have access to/ supply of water for household consumption all year round?</td><td>1=Yes
2=No</td></tr>
<tr><td colspan="3">B.2.12.If NO, Why not?</td><td></td></tr>
</table>

B.2.13.If **NO**,When this happens, how do you meet your Household water requirements?	

B.2.14. 5-10 years ago, did you have access to/ supply of water for household consumption all year round??	1=Yes 2=No
B.2.15.If **No**, why not?	
B.2.16 How did you meet your household water consumption 5-10 years ago?	
B.2.17.Do you pay for water for household consumption?	1=Yes 2=No
B.2.18.If **YES**, how much do you pay on average per month?	Rp
B.2.19.If **YES**, Who do you pay?	
B.2.20.If **YES**, What do you pay for:	1=No. of Units used 2=Access to water resources 3=Both units used and access to water 4=Other (specify)
B.2.21.What is your opinion on paying for water?	1=Very good 2=Good 3=No opinion 4=Bad 5=Very Bad
B.2.22.Why?	

Section B : Part 3 : Productive Activity Water Use

I am now going to ask you some questions relating to water you use for all activities outside of your household. This includes farm activities, water for your livestock, for businesses.

<table>
<tr><td>B.3.1 What are the sources of water for your household's productive activities? (non-domestic)</td><td colspan="2">1=Collect from spring
2=Collect from community well
3=Collect from shared well within compound
4=Collect from personal well
5=Collect from reservoir/ dam
6=Collect from river
7=Irrigation
8=Rain-fed
9=Piped water
10=Own tank
11=Community tank
10=Other (Specify)</td></tr>
<tr><td rowspan="3">B.3.2.If you have to collect water from a source away from your productive activities:</td><td>B.3.3.How far do you have to collect it</td><td></td></tr>
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<tr><td>B.3.5.Who in the household collects it</td><td></td></tr>
<tr><td colspan="2">B.3.6.Do you have access to/ supply of water for your productive activities all year round?</td><td>1=Yes
2=No</td></tr>
<tr><td>B.3.7.If NO, Why not?</td><td colspan="2"></td></tr>
<tr><td colspan="2">B.3.8.If, NO. When this happens, how do you meet your productive activity water requirements?</td><td></td></tr>
<tr><td>B.3.9.If NO, If you are unable to meet the water requirements for productive activities what do you do?</td><td colspan="2">1=Increased area of land farmed
2=Decrease area of land farmed
3=Switch to different crops
4=Construct water supply infrastructure (including digging wells, piped water sources)
5=Increase irrigation capacity
6=Other (specify)</td></tr>
<tr><td colspan="2">B.3.10. 5-10 years ago, did you have access to/ supply of water for productive activities all year round??</td><td>1=Yes
2=No</td></tr>
<tr><td>B.3.11.If No, why not?</td><td colspan="2"></td></tr>
</table>

B.3.12.How did you meet your productive activities water requirements 5-10 years ago?	
B.3.13.Do you pay for water for productive activities consumption?	1=Yes 2=No
B.3.14.If **YES**, how much do you pay on average per month?	Rp
B.3.15.If **YES**, Who do you pay?	
B.3.16.If **YES**, What do you pay for:	1=Units used 2=Access to water resources 3=Both 4=Other (specify)
B.3.17.What is your opinion on paying for water?	1=Very good 2=Good 3=No opinion 4=Bad 5=Very Bad
B.3.18.Why?	

Section C : Part 1 : Values

C.1.2.Other than economic benefits, does the environment have any other importance?		1=Yes 2=No
C.1.3.If **YES**, what are these?		
C.1.4. What are the main direct and indirect benefits of the environment to your household? C.1.6. Can you rank these in importance? i.e. 1=Very important, 5 =Least important	C.1.5. Benefit	C.1.6.Ranked importance
	1=Income	
	2=Spiritual well-being	
	3=Wildlife	
	4=Water retention	
	5=comfort (How?)	
	6=Recreation	

	7=Food	
	8=Protection from natural disasters	
	9=Other (specify)	
C.1.7.Do you think the environment has any negative consequences for the people in your household?		1=Yes 2=No
C.1.8.If **YES**, What are these and why?		
C.1.9.Whose responsibility do you think it is to protect the environment – water resources, forests, non-forest land?		
C.1.10.Why?		

Section C : Part 2 : Environmental awareness

C.2.1 What is the greatest threat to the environment in your community?		
C.2.2. What currently is the most significant threat for:	Water supply	
	Comfort and wellbeing	
	Forest	
	Cash and subsistence	
C.2.3. Do you think your household and community are able to protect themselves from these threats?		1=Yes 2=No
C.2.4. How is your household and community able/ unable to protect themselves from these threats? E.g strong governance, diverse livelihoods, traditional knowledge		
C.2.5. Over the last 5-10 years what has been the most significant environmental change for your household?		
C.2.6. How has this affected your household?		
C.2.7.What do you think will be the biggest difficulty your household will face in the future?		

Section C : Part 3 : Social capital and networks

C.3.1.What are the existing institutions and community activities that exist in your community?	1=Village management 2=Religious 3=Farmer Groups 4=Traditional/ Adat/ Awig-Awig 5=Other (specify)

C.3.2.Which institution/ collective action are you a member of/ participate in?
C.3.3 What is your degree of participation?

Type of organisation or association		*C.3.2*	*C.3.3*
		Member? (✓)	**Degree of participation** (✓)
1	Village management	1=yes 2=No	1=Representative 2=Very Active 3=Somewhat active 4=Member but not active 5=Not a member/ do not participate
2	Religious	1=yes 2=No	1=Representative 2=Very Active 3=Somewhat active 4=Member but not active 5=Not a member/ do not participate
3	Farmer Group	1=yes 2=No	1=Representative 2=Very Active 3=Somewhat active 4=Member but not active 5=Not a member/ do not participate
4	Traditional/ ADat/ Awig-Awig	1=yes 2=No	1=Representative 2=Very Active 3=Somewhat active 4=Member but not active 5=Not a member/ do not participate
5	Other (specify) *e.g. farmer group*	1=yes 2=No	1=Representative 2=Very Active 3=Somewhat active 4=Member but not active 5=Not a member/ do not participate

C.3.2.Why did they emerge?	
C.3.4.If you are not a member/ do not participate, why not?	
C.3.7. Can you rank the organisations in order of importance to your household?	1
	2
	3

Section D : Part 1 : Water Issues

D.1.1. What issues face your household relating to water (for both consumption and productive use?

1=Low water supply, 2=Irregular flow , 3=Water quality, 4=Pollution, 5=Flooding, 6=Erosion of soil, 7=Conflict with other users in the village, 8=Conflict with other users outside the village, 10=Changes in rainfall patterns, 11=Drought (unusual low water supply), 12=Landslide, 13=No issues, 14=Other (specify)

D.1.2. Why do you think these occur?

D.1.3. How often do these issues occur?

1=Daily, 2=Weekly, 3=Monthly, 4=Dry season only, 5=Wet season only, 6=Annually, 7=Rarely, 8=Never

D.1.4. How do these effect your household consumption of water?

D.1.5. How do these effect your productive use/ non domestic use of water?

D.1.6. What does your household do to reduce these effects on both household consumption and productive activity use of water?

1=Planted different crops, 2=Built flood defences, 3=Built water infrastructure (irrigation, ground water well), 4=Reduced the different types of crop (e.g. if planted rice and tabacoo, now just plant rice), 5=Increased the different types of crop, 6=Let the soil rest,
7=Harvested less, 8=Nothing, 9=Other (specify)

Section D : Part 3 : Village Water Issues

D.3.3.When was the last time a flooding event occurred in your village?	
D.3.4.When this happened, what did your community do in response?	
D.3.5. When was the last time a drought event occurred in your village?	

D.3.6.When this happened, what did your community do in response?	

Section E : Part 1 : Environmental management

E.1.1. Are there rules about how you use water and the environment in this community?	1=Yes 2=No
E1.2.What are these? (Awig-Awig? Community Farmer Groups? Local government? NGOs? Protected areas? Limited harvesting of certain resources? Replanting trees?)	
E.1.3.Are there areas where you cannot use land or take out resources?	1=Yes 2=No
E.1.4. Where are these areas?	
E.1.5. Who decides how water and the environment is used in this community?	
E.1.6. What do you think about this?	1=Very good idea 2=Good idea 3=No opinion 4=Bad idea 5=Very bad idea
E.1.4.Do people check if the community members are obeying the rules?	1=Yes 2=No
E.1.5.If yes, who checks?	
E1.6.Before the current rules and management began, how was the environment managed?	
E.1.7.Why did the current rules and management begin (i.e. new Head of Village, Government law, new environmental problem (illegal logging) or big event such as severe flood or storm)?	

E.1.8.Do people in your community:	1= Voluntarily accept and participate/ adhere with these rules 2=Forcibly accept and participate/ adhere to these rules 3=Acknowledge but do not accept these rules, nor adhere to them 4=Ignore existing rules but are aware of them 5=Have no knowledge or awareness of these rules

E.1.9. If there is a sudden environmental problem, such as a landslide, storm or a severe drought, does the management of the environment change?	1=Yes 2=No
E.1.10. If **YES**, How does it change? Who changes it?	
E.1.11. If **NO,** Why not?	
E.1.11.Do you think the rules about the environment and water in this village mean that people outside of the village benefit?	1=Yes 2=No
E.1.12. If **YES**, How?	
E.1.13. Do you think it is necessary to provide an incentive/ reward to ensure that people protect and maintain resources?	1=Yes 2=No
E.1.14. Why?	
E.1.15.Are you/ is your household involved in any schemes that use incentives such as money or seedlings to protect the environment?	1=Yes 2=No
E.1.16. What do these schemes do	
E.1.17. What incentives or cash rewards do you receive?	
E.1.18. Who gives these incentives or cash rewards?	
E.1.16.What do you think of schemes that use incentives to protect the environment?	1=Very good idea 2=Good idea 3=No opinion 4=Bad idea 5=Very bad idea
E.1.17.Why?	

Section F : Part 1 : Wellbeing

F.1.1.With your current access to land and other resources, do you feel you are able to provide a good life with all the necessities for you and your family?	1=Very good life 2=Good life 3=Able to provide basic needs 4=Occasionally unable to provide basic needs 5=Regularly unable to provide even basic needs

F.1.4.In comparison to surrounding villages, how is the livelihood situation in this village?	1=Much better off 2=Slightly better off 3=Same as other villages 4=Slightly worse off 5=Much worse off
F.1.6.In comparison to other households, how is the livelihood situation here?	1=Much better off 2=Slightly better off 3=Same as other households 4=Slightly worse off 5=Much worse off

Appendix III - Lombok Environmental Data

Subvillage	Watershed	Area (km2)	Altitude (m)	Total population	Population Density	Distance to Mataram (km)	Springs and rivers				Area of ground water (km2)
							Distance to nearest spring (km)	No of springs	Spring density	Total river length (km)	
Gangga	Putih	85.74	1250	5782	67.44	4.45	2.12	2	0.02	97.70	85.74
Lokotumping	Putih	32.51	309	5200	159.95	5.27	12.58	0	0.00	30.04	32.51
Gunung Kosong	Jelatang	151.55	7	7782	51.35	2.15	1.45	24	0.16	72.30	151.55
Pelangan Tengah/Gubug Bali	Jelatang	184.45	21	6304	34.18	1.68	3.79	13	0.07	96.61	184.45
Putit	Dodokan	95.15	65	12477	131.13	10.29	4.11	2	0.02	25.21	95.15
Batu Cangku	Menanga	7.41	486	3939	531.23	1.71	1.91	1	0.13	24.27	7.41
Mapakin	Putih	93.19	1170	4529	48.60	10.15	10.64	1	0.01	33.68	79.97
Bagik Rempung	Dodokan	15.23	91	3347	219.71	3.28	0.38	2	0.13	23.94	15.23
Lancing	Jelatang	54.63	28	4402	80.58	5.00	7.59	2	0.04	28.64	54.63

Appendix III: Lombok environmental data

Kabol	Dodokan	25.25	68	3275	129.72	3.82	5.97	0	0.00	9.26	25.25
Sebowo	Jelatang	8.28	33	4057	489.71	4.15	7.34	2	0.24	11.41	8.28
Salut	Putih	66.15	850	3654	55.24	2.81	0.51	10	0.15	41.57	66.11
Tanak Petak Daya	Putih	9.83	750	4203	427.49	1.48	0.78	3	0.31	19.91	9.83
Ampanbelak	Menanga	25.81	49	10276	398.19	1.97	0.61	20	0.77	32.08	25.81
Orong	Menanga	16.58	107	9130	550.66	3.22	2.92	0	0.00	21.32	16.58
Lengkok	Menanga	5.04	48	3224	639.82	1.00	2.31	0	0.00	16.28	5.04
Lepak	Menanga	6.62	156	4793	724.43	1.24	0.85	0	0.00	0.52	6.62
Lebah Suren	Dodokan	16.01	650	2500	156.14	3.36	2.03	2	0.12	24.11	16.01
Medas	Dodokan	5.58	136	7203	1291.67	1.46	2.67	0	0.00	18.77	5.58
Kuranji Bangsal	Dodokan	5.90	775	3625	614.04	1.69	3.71	0	0.00	28.68	5.86
Malimbu	Putih	56.77	800	8155	143.64	7.90	4.37	0	0.00	30.34	56.77
Baga	Dodokan	5.17	300	4176	808.33	4.98	1.02	1	0.19	6.94	5.17
Gegekliko	Dodokan	15.74	488	4720	299.94	2.70	1.00	5	0.32	22.28	15.74
Embung	Dodokan	10.61	117	6667	628.66	1.43	6.33	0	0.00	25.40	10.61

Appendix III: Lombok environmental data

Lilin	Dodokan	19.91	41	9500	477.15	0.66	0.58	2	0.10	43.46	19.91
Kebon Baru	Dodokan	19.23	260	4979	258.92	5.15	2.99	2	0.10	37.73	19.23
Bagik	Dodokan	7.51	326	5415	720.81	0.94	3.33	0	0.00	15.67	7.51
Ledangnangka	Menanga	12.64	500	7319	579.02	3.20	0.81	2	0.16	33.45	12.64
Lajut	Dodokan	6.08	139	3743	615.70	2.36	2.58	0	0.00	16.66	6.08
Sondo	Dodokan	14.84	118	8300	559.35	1.89	6.37	11	0.74	37.15	14.84

Appendix III: Lombok environmental data

Subvillage	Land cover area (km2)							Distance (km) to Managed Forest	Managed Forest	%Managed Forest Cover	Length of irrigation channels (km)	% of paddy field
	Total Forest	Settlement	Agroforestry plantation	Paddy area	Farmland	Other	Total area					
Gangga	76.22	0.35	5.73	0.24	1.38	2.07	85.74	0.00	51.14	0.60	0.00	0.00
Lokotumping	29.25	0.35	2.49	0.78	0.42	0.00	32.51	0.67	5.23	0.16	0.00	0.02
Gunung Kosong	32.71			0.00	19.85	98.99	151.55	2.16	62.25	0.41	0.00	0.00
Pelangan Tengah/Gubug Bali	77.88	1.09	1.40	0.00	8.07	96.00	184.45	0.00	101.56	0.55	0.83	0.00
Putit	9.38			0.00	0.00	85.77	95.15	2.38	27.38	0.29	39.00	0.00
Batu Cangku	1.09	0.17	1.79	0.00	4.37	0.00	7.41	1.42		0.00	0.00	0.00
Mapakin	44.09	0.93		0.00	5.36	42.82	93.19	0.84	76.03	0.82	0.00	0.00
Bagik Rempung	0.14			7.55	13.10	1.99	15.23	11.18		0.00	10.95	0.50
Lancing	0.00			0.78	17.08	37.55	54.63	0.12	15.26	0.28	33.87	0.01
Kabol	1.57	0.99		0.00	11.04	11.64	25.25	0.33	8.29	0.33	0.00	0.00
Sebowo	0.00			0.00	1.67	6.61	8.28	10.56		0.00	0.00	0.00

Appendix III: Lombok environmental data

Salut	26.06	0.96	2.79	1.41	30.02	6.31	66.15	5.18	25.38	0.38	0.00	0.02
Tanak Petak Daya	0.00	0.45	0.68	4.53	4.82	3.88	9.83	8.80		0.00	0.00	0.46
Ampanbelak	0.00	0.82	6.19	1.92	11.14	7.65	25.81	6.60		0.00	0.00	0.07
Orong	0.00	0.65	10.98	5.80	3.37	1.58	16.58	12.84		0.00	0.00	0.35
Lengkok	0.00	0.21	1.87	0.00	0.00	2.96	5.04	17.61		0.00	0.00	0.00
Lepak	0.00			0.00	1.00	5.61	6.62	13.66		0.00	0.00	0.00
Lebah Suren	4.43		2.86	0.17	0.82	7.89	16.01	0.42	7.05	0.44	3.91	0.01
Medas	0.00	0.00	0.25	5.54	3.95	1.37	5.58	8.19		0.00	9.23	0.99
Kuranji Bangsal	0.00			3.74	5.14	0.76	5.90	8.39		0.00	34.45	0.63
Malimbu	27.71	0.11	1.70	0.30	9.00	18.25	56.77	1.22	24.10	0.42	0.00	0.01
Baga	0.00			4.50	2.75	2.41	5.17	12.81		0.00	48.84	0.87
Gegekliko	11.43			0.92	0.00	4.31	15.74	3.37	5.08	0.32	13.35	0.06
Embung	0.00	0.59		6.80	7.82	2.20	10.61	8.80		0.00	0.00	0.64
Lilin	4.23	0.63	1.63	6.36	11.00	2.41	19.91	0.82	2.20	0.11	51.32	0.32
Kebon Baru	17.58	0.07		0.32	1.57	0.01	19.23	2.03	5.75	0.30	8.33	0.02

Appendix III: Lombok environmental data

Bagik	0.00			7.51	0.17	7.34	7.51	14.83		0.00	0.00	1.00
Ledangnangka	0.00	0.11	7.08	0.02	0.00	5.45	12.64	7.26		0.00	0.00	0.00
Lajut	0.00			4.16	6.08	0.00	6.08	14.32		0.00	59.32	0.68
Sondo	0.00	0.10		14.80	14.74	0.00	14.84	12.31		0.00	46.67	1.00

Appendix III: Lombok environmental data

Subvillage	Rainfall			No of dry months	No. of wet months	Soil drainage types
	Min (mm)	Max (mm)	Average (mm)			
Gangga	400	3000	1700	4-9	0-7	3
Lokotumping	800	1200	1000	4-9	0-7	3
Gunung Kosong	400	3000	1700	4-10	0-7	3
Pelangan Tengah/Gubug Bali	400	3000	1700	4-10	0-4	1
Putit	500	3000	1750	3-9	0-7	3
Batu Cangku	1000	3500	2250	0-11	0-6	3
Mapakin	800	1200	1000	1-8	0-11	3
Bagik Rempung	500	3000	1750	3-9	0-7	3
Lancing	400	3000	1700	3-9	0-7	3
Kabol	400	3000	1700	3-9	0-7	3
Sebowo	400	3000	1700	3-9	0-7	3
Salut	800	1200	1000	0-11	0-11	3
Tanak Petak Daya	800	3000	1900	4-9	0-6	1
Ampanbelak	400	1000	700	4-9	0-6	2
Orong	400	2500	1450	3-9	0-7	2
Lengkok	400	2500	1450	3-9	0-7	2
Lepak	400	3000	1700	3-9	0-7	2
Lebah Suren	1000	2500	1750	3-8	0-6	2
Medas	1000	2500	1750	3-8	0-6	3
Kuranji Bangsal	400	1700	1050	6-10	0-4	1
Malimbu	800	1200	1000	4-9	0-11	3
Baga	400	3000	1700	3-9	0-7	2
Gegekliko	400	3000	1700	1-8	0-6	2
Embung	400	3000	1700	3-9	0-7	2
Lilin	400	4000	2200	6-10	0-4	1
Kebon Baru	400	1700	1050	0-9	0-10	3
Bagik	400	3000	1700	3-9	0-7	2
Ledangnangka	500	3000	1750	3-9	0-7	2
Lajut	500	3000	1750	3-9	0-7	3
Sondo	500	3000	1750	3-9	0-7	3