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Governing Landscape Transitions in Cambodia



Rebecca Anne Riggs

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Ethics Statement

This PhD research was performed under James Cook University Human Research Ethics Committee
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Statement on the Contribution of Others

Chapter No.	Details of publications on which chapter is based	Nature and extent of the intellectual input of each author, including the candidate
1	Riggs, RA, Langston, JD, Sayer, J, (2018), <i>Incorporating governance into forest transition frameworks to understand and influence Cambodia's forest landscapes</i> , Forest Policy and Economics 96:19-27	The authors co-developed the research question. Riggs collected and analysed the data. Riggs wrote the first draft which was revised with editorial input from Langston and Sayer.
2	Riggs, RA, Langston, JD, Beauchamp, E, Travers, H, Sereyrotha, K, Margules, C (In Press) <i>Examining trajectories of change for prosperous forest landscapes in Cambodia</i> , Environmental Management	Riggs, Langston, and Margules co-developed the research question. Riggs and Langston collected the data. Riggs analysed the data. Riggs wrote the first draft of the paper which was revised with conceptual and editorial input from Langston, Margules, Beauchamp, Travers, and Sereyrotha.
3	Riggs, RA., Langston, JD., Sayer, J, Sloan, S, & Laurance, WF (2020). <i>Learning from Local Perceptions for Strategic Road Development in Cambodia's Protected Forest</i> , Tropical Conservation Science, 13	Riggs developed the research question. Riggs collected and analysed the data. Riggs wrote the first draft of the paper with conceptual and editorial input from Sayer, Langston, Sloan and Laurance.
4	Riggs RA, Langston JD, Phann S (submitted), <i>Actor network analysis to leverage improvements in conservation and development outcomes in Cambodia</i> , Ecology and Society	Riggs and Langston co-developed the research question. Riggs collected and analysed the data. Phann facilitated field activities. Riggs wrote the first draft of the paper with conceptual direction from Langston. Phann and Langston provided editorial input on subsequent drafts.

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Abstract

Achieving sustainable development in tropical forest landscapes is inherently challenging. Entwined issues of poverty and natural resource degradation provoke international attention, and the diversity of complex situations means there will not be one solution. In recognition of this, attempts to influence development trajectories focus on landscapes; geographical spaces, delimited by a set of locally identified problems, where decision-making unfolds. Understanding the unique, complex drivers of change occurring in different landscapes, and how change might be nurtured to improve existing systems, is fundamental to efforts seeking inclusive, locally desired, and environmentally-sound development pathways.

In Cambodia, communities, government, and non-government organizations hold diverse and conflicting visions exist over the future of rapidly changing rural forest landscapes. Current production and consumption systems drive inequality and environmental degradation. Protected areas exist to retain habitat for globally significant biodiversity but compete for land against rural people seeking to improve their well-being. Institutions, processes, and structures that govern inherent conservation and development trade-offs are not delivering the desired outcomes for people and nature.

In this thesis, I examine two changing forest landscapes in Cambodia to determine how local governance can enable better environmental and social outcomes. I ask (I) what are the trajectories of change for rural landscapes in Cambodia, and (II) how can institutions nurture change for sustainable development? Using place-based sustainability science, I engaged with the Wildlife Conservation Society and government and non-government organizations involved in conservation and development at the landscape scale. I gathered information through interviews, group discussions, questionnaires, and built upon previous studies that took place in the landscapes. I focused my analysis on local perspectives of conservation and development and the institutional arrangements and leverage points for managing landscape transitions.

I find that forest landscapes in Cambodia are transitioning at a rapid pace. Proliferating infrastructure and agricultural expansion drive wealth accumulation. These conditions enable rural prosperity which allows households to increase off-farm income; well-being improves with each generation. Households that are locked out of increasing their assets, through hard or soft infrastructural isolation, remain in a poverty trap. Local agencies responsible for managing conservation and development trade-offs lack technical capacity and resources, and rent seeking is entrenched in decision-making. As a result, conservation agencies struggle to prevent deforestation and environmental degradation.

Opportunities for nurturing landscape transitions in Cambodia lie within existing decision-making networks between government, non-government, and local actors. Local agencies must be willing to solve problems, and external actors must engage with local institutional processes, targeting resources to improve their capacity for governing change. Conservation agencies must accept trade-offs that arise from improving well-being in rural areas and consider long term realistic scenarios for the future of Cambodia's forests.

In tropical forest landscapes, efforts to nurture sustainability must be embedded in the social-political context, including decision-making and drivers of change at multiple temporal and hierarchical scales. The degree to which landscapes deliver sustainable inclusive development will depend on the institutions that govern them.

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Introduction

Research Statement

Navigating the challenges of sustainable development is one of the defining issues of the Anthropocene. Globally, governments have agreed upon ambitious targets for conserving the earth's resources for future generations. Governments, civil society, and the private sector contribute vast resources to initiatives such as the Sustainable Development Goals and the Paris Agreement on climate change, advocating for development pathways conducive to natural resource conservation. Sustainable development is widely recognised as an integrated initiative, demanding involvement of social, economic, and environmental governing systems. Yet many of the world's challenges converge in landscapes. Forest landscapes are increasingly central to the focus of international sustainability concerns. Forests are essential to climate change mitigation and the maintenance of terrestrial biodiversity. Forests provide important nature-based contributions to society: they provide goods and services important for health, energy, and income, contributing to economic growth and human wellbeing (Myers, 1996). Forests and the biodiversity they harbour are also declining (FAO, 2018; IPBES, 2019). Population growth, economic development, and food production drive forest degradation and deforestation. Habitat loss, unsustainable hunting, introduced invasive species, and other factors contribute to biodiversity loss (Geist & Lambin, 2002). Many of these challenges are most acute in tropical forest landscapes.

By 2050, more than half of the global population will be living in the tropics. Underlying issues of food security, poverty, natural resource degradation, and energy influence social, economic, and environmental policies in tropical countries (Nambiar, 2019). Rising development aspirations, combined with ambitious economic development programs, are transforming forests. Tropical deforestation accounts for the majority of global deforestation (Seymour & Busch, 2016), seventy-three percent of which is due to conversion of forest to agriculture (FAO, 2016). Infrastructure expansion to meet transport and energy requirements are key component of national and regional development strategies (Huang, 2016). In many cases, infrastructure is developed in ways that threaten areas of cultural and ecological significance, polarising views on conservation and development (Laurance & Arrea, 2017; Sloan et al., 2018).

In support of environmental sustainability, scientists frequently implore decision-makers to safeguard tropical forest ecosystems and confront the 'tropical biodiversity crisis' (Barlow et al., 2016; Laurance, 2007). Tropical forests encompass 15 of the 25 global priority biodiversity conservation hotspots (Myers et al., 2000). Protected forest areas in the tropics have increased from 12% in 1990 to

26.3% in 2015 (Morales-Hidalgo et al., 2015)¹. Despite the extent of protected forests exceeding Aichi Biodiversity Targets, the recent movement to give half the surface of the earth back to nature suggests moving beyond existing conservation goals (Wilson, 2016). But what does this mean for the 650 million people living in extreme poverty (World Bank, 2018), many of whom live in tropical developing countries?

Finding sustainable development pathways in tropical forest landscapes is inherently difficult. Extreme poverty and biodiversity hotspots frequently intersect (Fisher & Christopher, 2007). While people are living in poverty, they will continue to exert pressure on local natural resources (Sandker et al., 2012; Sunderlin et al., 2005). Conservation efforts can inhibit development pathways and fail in areas where poverty persists (Adams et al., 2004; Colchester, 1994; Norton-Griffiths & Southey, 1995; Pimbert & Ghimire, 1997). Local behaviours affecting forest landscapes often do not match global values, resulting in incoherent policies and management strategies (Boedhihartono et al., 2018; Bull et al., 2018). Recently, interest has grown in initiatives that support ‘working landscapes’, in which land is managed for biodiversity and human needs (Kremen & Merenlender, 2018). Many of these initiatives require strong regulatory authorities, market instruments, and tenure systems that do not exist in poor, rural areas.

Challenging situations in tropical forest landscapes are not static. Across Africa, Latin America and Asia, the availability of new agricultural technologies and modern farming inputs have transformed rural economies (Haggblade et al., 2010). Globalization enabled industrialization and modernization; advancing societies from agriculture-based economies into services and manufacturing. In some cases, long term development patterns lead to positive environmental impacts, such as the revival of forest cover and ecosystem services (Bhattarai & Hammig, 2004; Chazdon et al., 2016; Mather, 2007). But not all rural landscapes follow the described pattern of development. Without economic opportunities, population growth increases pressure on land, natural resources degrade, and low productivity livelihoods mean households are stuck in a poverty trap (Barrett et al., 2019; Gallup & Sachs, 2000). Development opportunities are rarely equally accessible, and some exacerbate social and economic inequality (Easterly, 2007).

As rural tropical landscapes evolve, meeting goals of conservation and development will depend on the institutions, processes, and structures that govern change. Governance - the way decisions are made and implemented - determines the allocation of and access to resources, the availability of goods and services, incentives, and policies for sustainable landscapes (Graham et al., 2003). Governance influences power and equity in development – who benefits now, and who will benefit in

¹ Protected area extent does not equate to effective protection (Bruner et al., 2001; Chape et al., 2005)

the future. In many tropical forest landscapes, governance is not delivering the desired outcomes for sustainable development (Barrett, 2016; Wiczczyk, 2018). Strategic engagement focused on building capacity for governing landscape transitions is needed to strengthen pathways for sustainable development. My research seeks to contribute to this process.

Transitions to sustainable development

As a global objective, sustainable development responds to society's desire to reach development goals and maintain environmental integrity. The Brundtland report states that sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). The United Nation Sustainable Development Goals (SDGs) explicitly seek to promote environmental protection, economic growth, and social equity. But in reality, sustainable development is an open-ended concept (Robert et al., 2005). The needs of the present and the needs of future generations change continuously through cultural, ecological, and economic interactions (Frantzeskaki et al., 2012). It is both integrative and exclusive, recognising that social-ecological processes are linked, and meeting objectives requires trade-offs. Discourses on sustainable development often contradict; shaped by concern for either social equity or environmental protection (Banerjee, 2003; Hopwood et al., 2005). The more pertinent, practical questions converge on building a common vision for the future: what is to be sustained, what is to be developed, and for whom?

Pathways for sustainable development must be explored on the ground, where change happens. When people have a voice in deciding their future needs, they steer institutions to evolve to meet those needs (Fraser et al., 2006; Kemp et al., 2007; Mog, 2004). For this reason, scientists and practitioners seeking to improve sustainability operate at the landscape scale (Reed et al., 2017). Landscapes are geographical spaces, delimited by a set of locally identified problems. Conceptually, landscapes are a combination of the social, political, and biophysical components of a system (Sayer et al., 2007). Landscapes are where decision-making unfolds; where bottom up and top down approaches meet. Approaching sustainable development challenges at the landscape scale does not mean problems and solutions are limited to a geographic space, but it situates people, institutions, and natural resources within the landscape at the centre of analysis.

There are endless examples of failed attempts at sustainable development in landscapes (Chambers, 1997). Externally imposed solutions rarely meet desired goals of conservation or community development. A large body of work is emerging, demonstrating the diverse ways to nurture transitions to sustainable development in a localised setting. Described as 'sustainability transitions', many of these initiatives focus on driving change through socio-technical innovations (Markard et al., 2012).

Examples include water management, energy supply, and the transportation sector (Wieczorek, 2018). While various analytical approaches exist, a core element in each approach is the institutional changes that take place throughout sustainability transition (Turnheim et al., 2015). Institutions are the formal and informal rules (laws, policies, norms) that shape decision-making and behaviour. Emphasising the role of institutions in sustainability attempts to deal with problems created by politics, power imbalances, and elite capture of wealth (Avelino & Wittmayer, 2016). But institutions on their own are insufficient to deal with complex trade-offs that arise with social and environmental change.

Sustainability transitions often arise from a combination of social, economic, and political forces. Changing societal values, global commodity markets, diplomatic relations, and a myriad of other factors influence institutional practices. Understanding what is driving change in landscapes, and how these changes unfold, requires a multi-level systems approach; examining both internal and external processes that shape outcomes (Turnheim et al., 2015). Analyses of local values, practices, decision-making structures, and processes can help to identify future trajectories of change and the actions that could better deliver on social, economic, and environmental objectives. As collaborative and adaptive processes, analyses can promote dialogue and build capacity for governing change (Armitage & Plummer, 2010). Emphasis may therefore be on the process of change towards a desirable future, rather than a normative understanding of sustainable development. Some see the solution as a radical transformation – changing the political and cultural structures that underpin society. Others do not see an urgent problem; global markets will first bring people out of poverty, then lifestyle choices and technology will provide for environmental sustainability (Hopwood et al., 2005). The answer lies somewhere in between.

My thesis argues that sustainable development pathways are embedded in the cultural, economic, political, and environmental interactions that exist within landscapes. Landscape transitions for sustainable development are therefore not about controlling for a fixed outcome, but navigating and nurturing changes to improve existing systems. In this light, sustainable development is broadly defined; appropriate to local aspirations, needs, and bio-physical attributes of the landscape. The methods, tools, and actors necessary to bring about change depend on the local context – what is considered to be unsustainable, and what is the vision for the future generations (Wilkinson & Cary, 2002). Nurturing landscape transitions aligns with place-based specific strategies for sustainable land use (DeFries & Rosenzweig, 2010) and bottom-up approaches to development (Chambers, 1997). Long-term engagement, deep knowledge of the system, and a thorough understanding of actor networks underpin these approaches, described in detail by Langston et al. (2019c).

The chapters in this thesis explore how tropical forest landscapes are changing and the ways research might contribute to nurturing favourable landscape transitions. The landscapes of focus are located in

rural Cambodia, where local institutions struggle to find a balance between biodiversity conservation and livelihoods. As a tropical developing country, Cambodia faces the common challenge of meeting the development aspirations of the current population while conserving resources for future generations. Political, cultural, economic, and environmental conditions influence how Cambodian landscapes are changing, and how inclusive and environmentally sustainable those changes are.

Rural forest landscapes in Cambodia

Cambodia sits at the base of the lower Mekong in Southeast Asia. With a population of 15.5 million and geographic area of 181,000 km², the country is small by global comparisons. Cambodia is mostly known for its pernicious history, namely, the Khmer Rouge genocide that took place between 1975 and 1979. But in the forty years since then, Cambodia has emerged into a rapidly growing economy. Thriving tourism and garment industries make Cambodia one of the fastest growing economies in the world (World Bank, 2019).

Rapid economic growth does not capture the full story of rural Cambodia. Some 77% of the population still reside in rural areas, and agriculture accounts for more than 30% of employment (World Bank, 2019). Farmers, struggling to increase their incomes in the rice paddies of the lowland central plains, migrate north where there is land available in forested areas. Households are predominantly dependent on paddy rice but some diversify into cash crops, primarily cassava, clearing forest for land (Jiao et al., 2017). Agricultural expansion is not an isolated driver of deforestation. Infrastructure expansion, migration, boom and bust markets, and an array of political and institutional factors contribute to smallholder forest conversion (Mahanty & Milne, 2015). Industrial concessions comprise 2.1 million ha of land in Cambodia, contributing to deforestation, community displacement, elite capture of resources and land conflict (Beauchamp et al., 2018b; LIDACHO, 2019; Neef et al., 2013). Cambodia allocates 41% of land to protected areas². Of that 41%, the area allocated for strict protection is much lower; zoning is incomplete and continuously under political negotiation.

Rural forest landscapes in Cambodia are not on a trajectory towards sustainable development. Different actors compete for economic advantage, which conflicts with biodiversity conservation. Smallholder farmers feel threatened by industrial claims to land and seek to expand their landholdings for livelihood security (Scheidel et al., 2013). Indigenous communities are trying to maintain their ancestral lands but lack power in negotiations (Travers et al., 2015). Conservation agencies

² The percentage of land under protection changes annually due to the addition and removal of protected areas. Figures quoted in chapters may differ.

continually contest illegal logging and hunting, and the expansion of infrastructure, mining, and industrial agriculture. Despite these challenges, rural Cambodia is far from what it once was. Life improves with each generation. Remote villages have increasing access to health, education, and markets, and the institutional framework for environmental protection is progressing (Beauchamp et al., 2018a). Consistent with observations in other tropical forest landscapes, changes in rural Cambodia generate winners and losers, and trade-offs between human well-being and biodiversity (McShane et al., 2011).

Opportunities for nurturing landscape transitions in Cambodia exist within the governance systems that can enable better social and environmental outcomes. Local government institutions lack technical capacity for navigating complex trade-offs that arise vertically and horizontally in decision-making networks (Sokhem & Sunada, 2006). For example, rural community needs often do not match top-down directives, and development agencies conflict with conservation agencies. Corruption and lack of transparency hinders trust between local communities and government actors. Non-government efforts to improve livelihoods do not match social-economic realities and are limited by short term funding and externally set targets (Beauchamp et al., 2018b). The political landscape in Cambodia means government and non-government actors must operate within boundaries set by the national government. Leaders at the village and commune level have the impossible task of managing diverse and conflicting expectations at multiple scales. Many of these people are poor farmers themselves.

Two landscapes form the focus of this thesis; the Keo Seima Wildlife Sanctuary in Mondulkiri province and the Northern Plains landscape in Preah Vihear. Each landscape offers a unique geographic setting to explore the tension between conservation and development in rural Cambodia. The Keo Seima Wildlife Sanctuary is a 292,690 hectare protected area located in eastern Cambodia. It is the ancestral homeland for the ethnic Bunong people and exists in a mosaic landscape of rubber concessions, smallholder agriculture, expanding settlement, and protected areas. The Northern Plains landscape consists of three protected areas; the Kulen Promtep Wildlife Sanctuary (KPWS), Preah Roka Wildlife Sanctuary (PRWS) and Chhep Wildlife Sanctuary (CWS), collectively encompassing 535,000 hectares. Despite a more remote location, the protected area network in the Northern Plains is interspersed with large scale industrial agricultural concessions and a growing population dependent on expanding agriculture to meet their needs. All four protected areas are managed by the Ministry of Environment with technical support from the Wildlife Conservation Society. The challenges facing Cambodia offer insights into the complex localised trade-offs that arise as rural tropical forests change and the challenges confronting institutions seeking to manage change.

Aim and overarching questions

The aim of this thesis is to determine the conditions that enable better environmental and social outcomes of forest landscape transitions in rural Cambodia. By understanding these conditions and making them explicit to the governing systems in the landscapes of focus, I hope to nurture trajectories for sustainable development. This research is one of several PhD projects working collaboratively between James Cook University and University of British Columbia, focused on building capacity for strategic scientific engagement in landscapes to understand and influence sustainability. Research was conducted in partnership with the Wildlife Conservation Society Cambodia program to support integrated landscape initiatives in rural Cambodia.

The overarching questions of this research are:

- i. What are the historic and future trajectories of landscape change in Cambodia?
- ii. What strategies might nurture landscape transitions for better social and environmental management decisions at the landscape scale?
- iii. How can institutional arrangements be leveraged to achieve better landscapes outcomes?

Research Approach

There are various ways to approach complex sustainability problems. In recognition of this, I began this research as purposefully ill-disciplined³, receptive to different ways of knowing, and open-minded about the way forward. Living in the wet tropics of Australia and working in Indonesia, I became inspired by the concept of place, and the value of systems thinking. *Place* is about the political, cultural, economic, and environmental interactions that occur within a space, and how these interactions shape identity, worldviews and actions (Cheng et al., 2003; Williams & Stewart, 1998). Place-based sustainability science focuses on these interactions, collaboratively problem solving to meet the needs of people living in that place (Clark & Dickson, 2003; Kates et al., 2001). Systems thinking is the process of understanding how different components in a system are linked and influence each other over time (Richmond et al., 1987). Together, these concepts require a holistic, bottom-up collaborative approach to problem solving, without fixed boundaries of scale or subject.

As different actors involved in conservation and development have different epistemologies and ontologies, thinking in terms of systems and place can help to break down disciplinary and sectoral silos. Concepts such as action-research and transdisciplinarity, described below, are interwoven in this approach. Systems thinking and place do not only guide diagnosis and problem-solving, but the way

³ Inspired by the undisciplined Robert Chambers (2014), ill-disciplined describes an active dissociation from disciplines.

researchers personally engage and reflect when attempting to understand, analyse, and address complex governance challenges at the landscape scale. I describe my approach through the analytical framework outlined below.

Analytical Framework

A number of frameworks conceptualise and analyse social-ecological relationships in the context of environmental stewardship. Well known concepts include panarchy (Gunderson, 2001), Ostrom's frameworks for analysing social-ecological systems and institutions (Ostrom, 1999, 2009), livelihood perspectives (Scoones, 2009) and social network analysis (Scott, 2017). These frameworks inform the way in which researchers organise their studies, and how practitioners diagnose and manage social-ecological challenges. Examples include sustainable livelihoods in integrated conservation and development projects (Chambers & Conway, 1992; Scoones, 1998) and more recently the landscape approach (Sayer et al., 2013). Drawing from theoretical and empirical work, these approaches demonstrate the diversity of perspectives in conceptualizing and solving sustainability problems. Yet they converge in their purpose to integrate and apply interdisciplinary knowledge to understand and analyse systems.

Over the course of my research, I developed an analytical framework, describing the elements that influence landscape transitions and the process for nurturing change. I use the analytical framework to illustrate the approach and concepts I see as pertinent to understanding and influencing sustainable development. The analytical framework links past scholarship on understanding complex systems with ways in which place based sustainability science can help to improve systems (Berkes et al., 2008; Canter, 1977; Folke et al., 2005; Sayer et al., 2016). The schematic (Figure 1) is conceptually vague (Strunz, 2012) to allow for the diversity of terms and approaches that arise through 'ill-disciplined' research. The analytical framework provides a way of understanding and approaching sustainable development challenges, but it does not define or limit the problems or actions taken to resolve them. It allows for the delineation of questions refined throughout this research to explore topics in depth as they emerge. This approach adheres to grounded theory (Corbin & Strauss, 1990), in which knowledge generation informs the direction of research, with continuous reflection and analysis.

The analytical framework describes how drivers of change are inextricably linked to complexities within landscapes, which must be understood to nurture the system towards sustainability. At the centre of the analysis is the landscape, depicted as a highly dynamic, complex social-ecological system. As action researchers, it is often easier to gather data on sub-components of a system. But reductionist thinking fails to capture the realities of real-world problems (Baumgartner & Korhonen,

2010; Robinson, 2006). Understanding and influencing complex systems requires deep knowledge of past, present and future social and biophysical processes, political and market forces, local behaviour, needs and aspirations, and the impact of variables at different temporal and hierarchical scales. It requires acknowledging the different knowledge systems that exist and understanding how social relationships, power, institutions, and behaviours shape change (Cornell et al., 2013). With this knowledge, researchers can engage in a process of identifying leverage points for change within the system. Leverage points may be shallow or deep, characterised by their ability to create system-wide changes (Abson et al., 2017). Platforms to initiate change are supported by decision-making tools, which help to develop the appropriate intervention (Boedhihartono, 2012; Travers et al., 2016; van Noordwijk, 2017). Interventions intend to nurture or ‘nudge’ the system for positive outcomes, which feed back into the system as a continual adaptive process (Thaler & Sunstein, 2009). The analytical framework describes a process of knowledge uptake which influence sustainability trajectories at all stages of engagement. Principles of place-based transdisciplinary research can guide these actions.

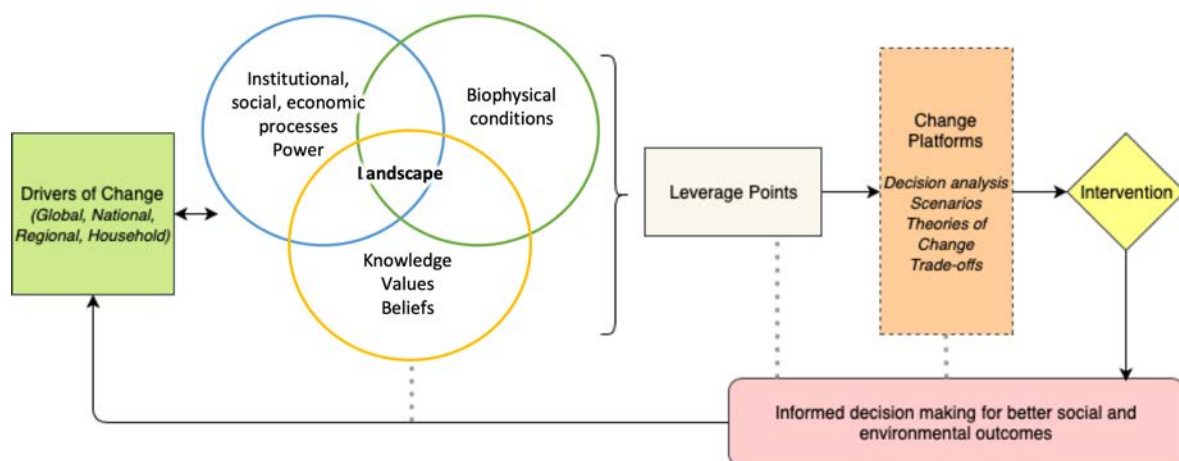


Figure 1: Analytical Framework for this research.

Transdisciplinary research describes a process of collaboration between scholars and non-scholars that transcends disciplinary boundaries; it explicitly acknowledges the contribution of different perspectives in solving real world problems (Haider et al., 2017; Roux et al., 2010; Walter et al., 2007). Transdisciplinary action research means generating knowledge in a democratic, participatory way, such that multiple actors engage in the identification of challenges and the pursuit of solutions (Reason & Bradbury, 2001; Torbert, 1981). As the actors that manage and allocate resources are cross-scale, interdisciplinary, and dynamic, efforts to drive change must strategically involve diverse actors and knowledge systems (Tengö et al., 2017). Processes that emphasize reflexivity can encourage critical assessment and mutual learning of values, assumptions, and narratives that support norms and practices (Langston et al., 2019a; Popa et al., 2015). Inclusive and transparent dialogue

supported by evidence can help to explicitly identify trade-offs and build consensus on credible pathways towards accepted landscape trajectories (Sayer et al., 2016). Partnerships can also strengthen capacity for change, matching the roles of actors to the needs of the system.

Each chapter of my thesis is underpinned by the analytical framework described above, emphasising deep knowledge of the system and local perspectives, an integrated transdisciplinary approach to problem solving, and collaborative partnerships for change. I aim to contribute to emerging fields that tie systems thinking with place-based sustainability science, most recently described as embedded science (Langston et al., 2019c).

Thesis Outline

Following this introduction, my thesis consists of four chapters, followed by a brief concluding discussion. In **Chapter 1**, I diagnose governance challenges in Cambodia in relation to forest cover change. I propose ways in which research can provide insights into the connectivity between governance and forest cover change for improved policy and decision making. In **Chapter 2**, I examine two rural forest landscapes in Cambodia to determine drivers of landscape transitions and sustainability challenges. I explore future scenarios for change and implications for conservation and development. In **Chapter 3**, I closely examine the trade-offs between conservation and development that arose in Chapter 2, focusing on road development as a driver of rural prosperity and deforestation. In **Chapter 4**, I use actor network analysis to investigate how decision-makers at the landscape scale can improve governance for sustainable development. The chapters in this thesis are organized as sequential, stand-alone publications. In the discussion, I synthesis their key findings and I reflect on the contributions of this research to local and global questions of sustainable development and identify directions for future research.

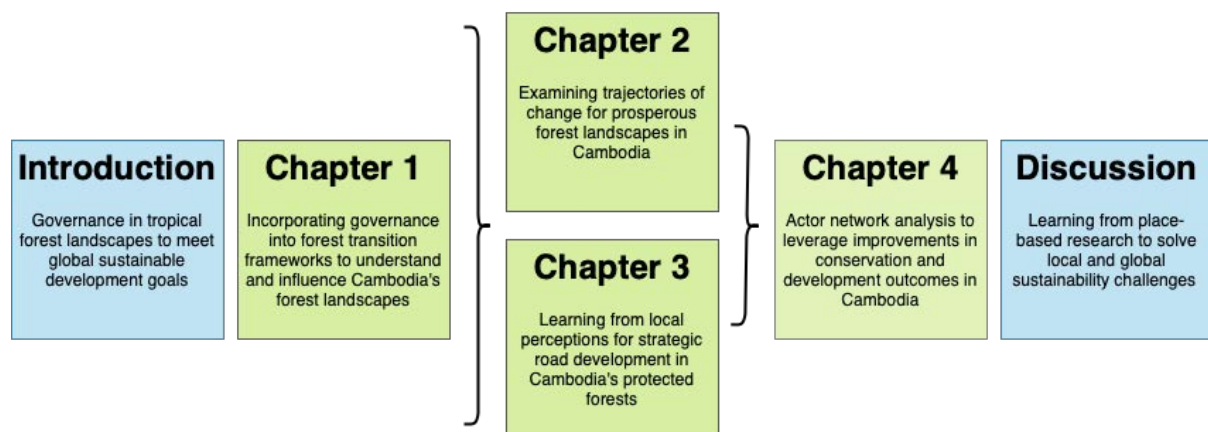


Figure 2: Thesis Structure

Research publications

- Chapter 1: Riggs, RA, Langston, JD, Sayer, J, (2018), *Incorporating governance into forest transition frameworks to understand and influence Cambodia's forest landscapes*, Forest Policy and Economics 96:19-27
- Chapter 2: Riggs, RA, Langston, JD, Beauchamp, E, Travers, H, Sereyrotha, K, Margules, C (In Press) *Examining trajectories of change for prosperous forest landscapes in Cambodia*, Environmental Management
- Chapter 3: Riggs, RA., Langston, JD., Sayer, J, Sloan, S, & Laurance, WF (2020). *Learning from Local Perceptions for Strategic Road Development in Cambodia's Protected Forests*. Tropical Conservation Science, 13
- Chapter 4: Riggs RA, Langston JD, Phann S (submitted), *Actor network analysis to leverage improvements in conservation and development outcomes in Cambodia*, Ecology and Society

Over the course of my doctoral studies I have had the fortunate opportunity of working with a number of colleagues interested in solving sustainability problems. I have contributed to the following publications, which have helped to inspire and inform this thesis:

- Sayer, J., Sheil, D., Galloway, G., **Riggs, R. A.**, Mewett, G., MacDicken, K. G., Arts, B., Boedhihartono, A. K., Edwards, D. P., & Langston, J. D. (2019). *Life on land - The Central Role of Forests in Sustainable Development*. In Sustainable Development Goals: Their Impacts on Forests and People: Cambridge University Press.
- Weng, L, Sayer, J. A., Langston, J. D., **Riggs, R. A.**, (submitted), People centred approaches are key to the success or failure of China's 'Belt and Road Initiative' *World Development Perspectives*
- Sayer, J. A., Sari, D.A, Boedhihartono, A. K Langston, J. D., **Riggs, R. A.**, (accepted) New institutional arrangements needed to foster forest landscape restoration in Indonesia, *Land use Policy*
- Langston, J. D., **Riggs, R. A.**, Boedhihartono, A. K., Kastanya, A., Sayer, J. A., (accepted) Conservation and development pressures intensify on one of Indonesia's least developed large islands, Seram, *Singapore Journal of Tropical Geography*
- Langston, J. D., **Riggs, R. A.**, Kastanya, A., Sayer, J. A., Margules, C., & Boedhihartono, A. K. (2019). Science embedded in local forest landscape management improves benefit flows to society. *Frontiers in Forests and Global Change*, 2, 3.
- Bull, G. Q., Boedhihartono, A. K., Bueno, G., Cashore, B., Elliott, C., Langston, J. D., **Riggs, R. A.**, Sayer, J. (2018). Global forest discourses must connect with local forest realities. *International Forestry Review*, 20(2), 160-166(167)

- **Riggs, R. A.**, Langston, J. D., Margules, C., Boedhihartono, A. K., Lim, H.S., Sari, D.A., Sururi, Y., Sayer, J., (2018). Governance Challenges in an Eastern Indonesian Forest Landscape, *Sustainability* 10(1), 169.
- **Riggs, R. A.**, (2017). Review of ‘Governing Cambodia’s Forests’ by Andrew Cock. *International Forestry Review* 19(2):245-246.
- Sayer, J., Margules, C., Boedhihartono, A. K., Sunderland, T., Langston, J. D., Reed, J., **Riggs, R.**, Buck, L., Campbell, B., Kusters, K., Elliot, C., Minang, P., Dale, A., Purnomo, H., Stevenson, J., Gunarso, P., Purnomo, A (2016). Measuring the effectiveness of landscape approaches to conservation and development. *Sustainability Science*, 1-12.
- Langston, J.D. & **Riggs, R. A.**, (2017). Improving Infrastructure Governance: The Sentinel Landscape Approach. Case Study in *State of The Tropics 2017: Sustainable Infrastructure for the Tropics*

Chapter 1: Incorporating governance into forest transition frameworks to understand and influence Cambodia's forest landscapes

Abstract

Academic inquiry into forest transitions has produced a rich body of literature examining the shift from net deforestation to net reforestation at multiple land use scales. However, researchers, practitioners, and policy analysts question the utility of current forest transition theory. Does it accurately describe and provide insight into strategies to influence patterns of forest change in countries where forest cover continues to decline? Forest transition theory has provided important insights into the ‘necessary but not sufficient’ conditions for countries shifting from net deforestation to net reforestation. To advance forest transition theory, scholars should recognize forests as complex and dynamic social-ecological systems and use analytical methods that accommodate that complexity. Transdisciplinary research that incorporates a broader range of qualitative and quantitative methods and tools is required. We analysed the historical, social, and political factors influencing forest transition pathways in Cambodia. Cambodia exhibits similar economic pre-conditions to its neighbours, which have passed through a forest transition, yet deforestation rates remain high with no indication of slowing. We found that complex governance arrangements at multiple scales negatively influences Cambodia's forest cover and development trajectory. Attempts to nurture Cambodia's forest transition will require strengthening governance and institutions across all of the natural resource sectors. Further research that incorporates governance into forest transition frameworks is required to improve policy responses for post-transition forest outcomes.



Introduction

Since 1990, economic growth in rural and urban Asia has reduced poverty and increased prosperity. Trade, technological innovation, and investment in health and education transformed Asia from a largely agrarian society to an urbanized, industrial powerhouse. As in Europe and the Americas, economic growth and industrialization has come at a cost. Income gaps are widening, leading to increased inequality (Zhuang et al., 2014). Large-scale agriculture, logging, mining, and infrastructure development drives widespread environmental degradation (Laurance et al., 2014b). However, the recent Food and Agriculture Organization Forest Resource Assessment states Asia experienced a net increase in forest stocks over the period 1990-2015 (FAO, 2015b). While there is large variation among the forty-eight nations examined, the net increase in forests associated with industrialization and urbanization represents a regional forest transition – defined here as a shift from net deforestation to net reforestation.

Forest transitions have been documented for a number of Asian countries, including Vietnam, India, China, Japan and South Korea (Youn et al., 2016). A recent special issue in *Forest Policy and Economics* (see de Jong et al., 2016) highlights this phenomenon, providing insights into the pre-conditions and pathways of forest transitions in nine Asian countries. Forest transitions in countries such as China (Zhang, 2000) and Vietnam (Meyfroidt & Lambin, 2008b; Minh et al., 2017) are well documented. However, fewer studies examine the processes lying behind the forest transition phenomenon in countries where transitions have not yet occurred, such as Indonesia, Laos, and Cambodia.

Cambodia is one of the least developed countries in Asia and deforestation rates are still high. According to current analysis (Liu et al., 2016), Cambodia meets the econometric pre-conditions, so is primed to move through a similar forest transition to that of other Asian nations. But deforestation rates have not decreased (FAO, 2014c). Analytical frameworks used to measure and explore forest transitions have mainly been quantitative (Ashraf et al., 2017; Meyfroidt & Lambin, 2008b). They have relied upon econometric measures, which are good for between country comparisons, but offer little insight into influences inside countries where forest cover continues to decline (de Jong et al., 2016). In other words, econometric models demonstrate the ‘necessary but not sufficient’ conditions to describe and influence a forest transition. Limitations of forest transition theory are increasingly recognized, prompting calls for interdisciplinary frameworks and heuristic models (Kull, 2017; Perz, 2007). Studies incorporating regression analysis with in-depth analysis of institutional and socio-economic factors are beginning to heed this call (Clement et al., 2009; Minh et al., 2017). Further insight is needed if decision makers want to use the knowledge on forest transitions already achieved to influence their trajectory in countries such as Cambodia, where forest cover continues to decline.

Given the extent of interest and academic enquiry into forest transitions, how can we increase the utility of forest transition theory for improving forest policy? The extent to which forest transitions can maintain desired environmental outcomes often depends on governance and management of multi-functional landscapes (Barbier & Tesfaw, 2015; Melo et al., 2013). However, good governance is inherently difficult to define and measure (Kaufmann et al., 2011). Forest transition frameworks might better describe and potentially nurture forest transitions if they consider forest transitions occurring in complex and dynamic social-ecological systems and use analytical models that accommodate this complexity (Kull, 2017). By including the social and political dimensions of forest transitions, such as governance and institutions, analytical models may better help us understand the barriers preventing forest transitions. This is especially relevant in countries such as Cambodia, where the econometric preconditions have been satisfied.

In this paper, we consider how more holistic analytical models of forest transitions could provide better insight into the processes by which development leads to transitions from deforestation to reforestation. Using the five forest transition pathways described by Mather (2007), we analyse the case of Cambodia, where governance is a barrier to a forest transition (Mahanty & Milne, 2015). We aim to demonstrate the decisive role of governance in forest transition outcomes, and the need to address governance challenges in efforts to nurture forest transitions. We argue that econometric frameworks fail to adequately consider the governance factors necessary to describe and influence forest transitions. We show how expanding frameworks to incorporate richer insights into governance and institutions could deliver a more holistic understanding of forest transitions and how the resulting knowledge might be used to influence the quality of natural capital as well as forest cover.

Forest transition frameworks: shy of their potential

Forest transition theory gained traction in the 1990s when Alexander Mather described the historical forest trends of a number of developed countries throughout the twentieth century (Mather, 1992). Mather found that as countries developed, exploitation of ‘old growth’ forest shifted to ‘second growth’ forest and plantations. The shift was described as a forest transition. Mather also made the case for a second type of forest transition in which forest cover contracted and expanded as societies moved from resource-dependent economic growth to industrialization and urbanization. The transition from net deforestation to net reforestation has been documented throughout Europe and North America and more recently in tropical developing countries (Mather, 2004; Mather, 2007; Mather & Fairbairn, 2000; Mather et al., 1998). Keenan et al. (2015) found that 13 tropical countries have either passed through their forest transition between 1990 and 2015 or have embarked on the path of forest expansion.

Examining empirical evidence of forest transitions, Rudel et al. (2005) developed two forest transition pathways; forest recovery driven by forest scarcity and economic development. However, on further examination of forest transitions in Asia, Mather (2007) found recent forest transitions to exhibit different characteristics to their European predecessors, prompting scholars to identify new transition pathways. Building on Rudel's work, Lambin and Meyfroidt (2010) derived five pathways to describe causal mechanisms associated with forest transition trajectories; (1) economic development; (2) State forest policies; (3) global pressure; (4) forest scarcity and; (5) forest recovery driven by smallholders. These five forest transition pathways are now well described and empirically examined in the literature (Lambin & Meyfroidt, 2010; Liu et al., 2016). These pathways do not exist in isolation; multiple factors interact in several ways to drive forest transitions across geographic and temporal scales. Reforestation may happen simultaneously to deforestation, or deforestation can occur long after a country appears to have moved through the forest transition (Drummond & Loveland, 2010; Lambin & Meyfroidt, 2010). In addition, factors that may drive transitions in some countries contribute to continued deforestation in others (Liu et al., 2016).

Numerous econometric models analyse the social, biophysical and economic drivers of forest transitions (Ashraf et al., 2017; Meyfroidt & Lambin, 2008a; Satake & Rudel, 2007; Sloan, 2015). Many of these studies highlight the role of macroeconomic policies and socio-political institutions (Bhattarai & Hammig, 2001; Ewers, 2006; Satake & Rudel, 2007) and shed light on the actors and incentives that contribute to reforestation (Rodríguez & Pérez, 2013). Yet more recently, researchers have called for better analysis of forest transitions as social-ecological systems, by considering forests as “contingent, power-laden, dynamic relationships between an assemblage of diverse natural and human actors in particular geographic spaces and times” (Kull, 2017). In their book on navigating social-ecological systems, Berkes et al. (2008) highlight three key limitations of traditional analytical models: (1) the inadequacy of models based on linear thinking, (2) a lack of recognition of the value of qualitative analysis to complement quantitative approaches, and (3) a disregard for the importance of using multiple perspectives in the analysis and management of complex systems. Given the multiple actors, objectives, and interests involved in forest cover change, forest transitions are non-linear processes that cannot be reduced to a single set of variables or causal linkages.

The majority of econometric models fail to capture the role of governance in shaping forest cover trends. Addressing these concerns, Barbier and Tesfaw (2015) developed a model of competing land uses that explicitly includes governance using a combination of Worldwide Governance Indicators (Kaufmann & Kraay, 2017) and other sources. They found that poor governance delays the onset of a forest transition. Barbier and Tesfaw's model is comprehensive, but governance indicators are often imperfect measures of a complex reality. They are “imprecise proxies for the broader concepts they

are intended to measure” (Kaufmann et al., 2011). Governance indicators fail to capture human-made governance systems (Duit et al., 2010) in which individual actors and institutions may interact differently to prescribed policies or regulations. Examples include adaptive policy making, state capability, collective leadership, how institutions function, and different subnational social-ecological contexts; legislation and policies do not guarantee implementation (World Bank, 2017b). In addition, analysis of national forest transitions fails to capture the influence of transnational governance and in turn, transnational displacement of deforestation (Ashraf et al., 2017; Meyfroidt & Lambin, 2009).

Evaluating progress towards poverty alleviation and economic development is not the aim of forest transition theory but multiple scholars acknowledge the strong interaction between forest cover and economic development (Ewers, 2006). The 2015 FAO Forest Resources Assessment shows that since 1990, wealthier countries have registered forest gains, middle income countries are moving through the forest transition and poorer countries are still losing forest (Sloan & Sayer, 2015). Forest transitions as a broad-scale, country wide phenomenon often rely on analysis from coarse scale data such as gross domestic product, production values, remotely sensed land cover categories, demographic indicators and trade (Ashraf et al., 2017; Liu et al., 2016). Multiple elements of social and economic development that affect both land use and forest cover are not captured in national statistics. Some of those elements are the unevenness of development, land-grabs, elite capture and enclosure, patron-client relationships and landscape-scale drivers of change. Claims that understanding forest transition trajectories can contribute to broader societal goals of land-use sustainability (Ashraf et al., 2017) are insubstantial if complex interactions between forests and poverty are not understood at the appropriate scale and context (van Noordwijk, 2017).

Quality of forest cover is also crucial; often forest assessments do not distinguish between natural and planted forests resulting in no net loss of forest cover reported if natural forests are converted to plantations (Chazdon et al., 2016). National forest cover statistics for low income countries are often imprecise (Grainger, 2010; MacDicken, 2015). The definition of ‘forest’ is also problematic, as State forest can also include land areas with no tree cover (Contreras-Hermosilla et al., 2005). Few forest transition studies consider whether the provisions that make forests environmentally significant such as the protection of biodiversity, the upkeep of ecological, hydrological and climatological functions, the prevention of soil erosion and the maintenance of habitat connectivity, are retained throughout the transition (Perz, 2007). These factors may be crucial in prioritizing natural forests that should remain intact throughout the transition to maintain irreplaceable forest biodiversity and ecological values (Gibson et al., 2011). By overlooking the quality and traits of the newly established forest cover, forest transitions can fail to acknowledge the environmental consequences of replacing natural forest with new forests, for example, monoculture plantations (Zhai et al., 2017). The spatial patterns of

different types of forest and of non-forest land are important determinants of biodiversity and ecological values and should form a key component of forest transition analysis (Sayer et al., 2004).

Whether forest transitions can lead to improved ecosystem services and societal benefits should be of great concern to scientists and scholars engaged in global development processes. As the global climate agenda moves forward in the 21st century, governments and international institutions are placing increasing emphasis on reducing emissions from deforestation and land-use change (UNFCCC, 2005). In 2017, scientists issued a second “Warning to Humanity” expressing grave concern over the depletion of natural resources and the need for improved environmental stewardship (Ripple et al., 2017). Forest cover and climate change are regularly dealt with as interconnected policy issues (Buizer et al., 2014; Lima et al., 2017). The global Bonn Challenge aims to restore 350 million hectares of deforested and degraded land by 2030 through forest landscape restoration, restoring “ecological integrity at the same time as improving human well-being through multifunctional landscapes” (Bonn Challenge, 2017). Future utility of forest transition theory might provide insights into leverage points for steering countries towards these climate and land use goals.

Methods

In the analysis below, we use both quantitative and qualitative data to explore the impact of governance and its inhibiting influence on potential forest transition pathways in Cambodia. We define governance as “the interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say” (Graham et al., 2003). We use the five forest transition pathways described in detail by Lambin and Meyfroidt (2010) to demonstrate how poor governance plays a decisive role in progress towards forest transitions. The five pathways were selected as an explanatory framework due to their applicability and relevance to recent forest transitions (Meyfroidt & Lambin, 2011). Recent analyses of Asian forest transitions utilise analytical frameworks stemming from the five pathways, allowing for discussion and comparison between Cambodia and neighboring countries (Ashraf et al., 2017; Liu et al., 2016; Youn et al., 2016). Our analysis examines whether Cambodia has met the pre-conditions for each forest transition pathway; (1) economic development; (2) State forest policies; (3) global pressure; (4) forest scarcity and; (5) forest recovery driven by smallholders. We explore historical and political factors that cannot be reduced to a set of path dependent variables, demonstrating the limitations of econometric studies in describing the influence of complex governance arrangements on forest cover.

Our findings are the result of an in-depth study of forest governance and legislation in Cambodia and insights from wider research that took place in two landscapes containing protected areas in

Cambodia between April 2017 and February 2018. We reviewed legislation and policy pertaining to forest cover change in Cambodia, focusing on events that took place following the United Nations peace-keeping operation in 1991 until present. Our review included global agreements covering forest, biodiversity, and climate change as well as domestic forest legislation and policy, including national action plans and strategies. Peer reviewed journal articles, government documents, and organization reports were used to analyse the implementation and impact of policy and legislation. Our desktop findings were queried through discussions with rural communities and actors involved in forestry and conservation in Preah Vihear and Monduliri province in Cambodia. We focused our study on two protected area networks, the Northern Plains Landscape in Preah Vihear and Eastern Plains in Monduliri. Both landscapes are of high conservation value and experiencing rapid change due to investment in infrastructure and agricultural concessions. Increased accessibility is providing rural communities with development opportunities that have negative environmental consequences (Beauchamp et al., 2018a; Travers et al., 2015). Government and non-government institutions are embedded in both landscapes to mediate forest cover decline and support local community development. Our fieldwork included interviews with institutions (NGOs, government departments and community groups, n=64) and key informant interviews with people living in the protected landscapes (n=48). We selected key informants to maximise a diversity of perspectives. Diversity came from a deliberate consideration of people from the range of livelihoods, demographics and economic and social status. Interviews covered historical drivers of environmental and social change, how institutions at different scales influence change, and barriers preventing sustainable development in rural Cambodia. We used the data gathered through interviews to verify the impact and implementation of policies and programs previously documented, primarily forest conservation initiatives and rural development programs. Our observations and conclusions were corroborated through discussions with professionals working in the conservation sector in Cambodia during this period.

Results and Discussion

Forest cover change in Cambodia

The 2015 Forest Resources Assessment (FRA) reports total forest cover in Cambodia at 9.5 million hectares, equating to 52.29% of total land area (FAO, 2015b). Forest area declined at a rate of 1.2% annually between 1990 and 2015, with a total loss of 3.5 million hectares. Detailed FRA data for Cambodia is recorded in Table 1 below, however these figures should be interpreted carefully. The Forest Administration of the Ministry of Agriculture, Forest and Fisheries (MAFF) is responsible for compiling the FRA report. External reports have commented frequently on the MAFF's lack of adequate national data collection and reporting (Banks et al., 2014; GFS, 2015). Another caveat is the

definition of 'Forest' under the MAFF includes timber, rubber and palm oil plantations, as well as heavily disturbed forest mosaics in which the percentage of actual forest is more than 40% (Forestry Administration, 2011). Open Development Cambodia (ODC) created an independent set of forest maps using satellite images, obtained from the United States Geological Survey (USGS). They estimate total forest cover in Cambodia at 8.6 million hectares, just 47.7% of total land area (Open Development Cambodia, 2015). These trends are consistent with Hansen et al. (2013). MAFF also published data on forest cover trends in 2011 with support from the International Tropical Timber Organization (ITTO). That publication provides details on forest cover change between 1965 and 2010, also demonstrating a long term decline in forest cover (Forestry Administration, 2011). All three datasets conclude that forest cover in Cambodia is declining at a reasonably constant rate with no evidence of a slowing deforestation rate.

Table 1: Cambodia Forest Cover Change retrieved from Forest Resource Assessment 2015 (FAO, 2014c), Open Development Cambodia Forest Cover Study (Open Development Cambodia, 2015), and Ministry of Agriculture, Forests and Fisheries and ITTO in 2011 (Forestry Administration, 2011). Data shows type of land cover, area (1000ha), percentage of total land cover and year recorded for each assessment.

Forest Resources Assessment 2015												
Area (1000ha)/%	1990		2000		2005		2010		2015			
Forest	12,944	71%	11,546	64%	10,731	59%	10,094	56%	9,467	52%		
Other wooden land	335	2%	300	2%	133	1%	133	1%	133	1%		
Other land	4,373	24%	5,805	32%	6,788	37%	7,425	41%	8,062	45%		
inland water bodies	452	2%	452	2%	452	2%	452	2%	452	2%		
Total Land	18,104	100%	18,104	100%	18,104	100%	18,104	100%	18,104	100%		
Open Development Cambodia 2015												
	1973		1989		2000		2004		2009		2014	
Total forest	13,096	72%	12,334	68%	12,105	67%	11,451	63%	10,929	60%	8,660	48%
Dense forest	7,606	42%	7,082	39%	6,269	35%	5,569	31%	4,095	23%	2,988	17%
Mixed forest	5,490	30%	5,252	29%	5,836	32%	5,882	32%	6,834	38%	5,672	31%
Total Land	18,104	100%	18,104	100%	18,104	100%	18,104	100%	18,104	100%	18,104	100%
Ministry of Agriculture, Forests and Fisheries 2011												
	1965		1992/93		2002		2006		2010			
Total Forest	13,227	73%	10,860	60%	11,104	61%	10,731	59%	10,364	57%		
Evergreen					3,720	20%	3,669	20%	3,499	19%		
Semi-evergreen					1,455	8%	1,363	8%	1,275	7%		
Deciduous					4,834	27%	4,692	26%	4,481	25%		
Other					1,095	6%	1,007	6%	1,109	6%		
Non-Forest	4,883	27%	7,293	40%	7,056	39%	7,430	41%	7,797	43%		
Total Land	18,111	100%	18,153	100%	18,161	100%	18,161	100%	18,161	100%		

Forest transition pathways in Cambodia

(1) An economic development (transition) pathway occurs when agricultural populations decline as industrialization and urban migration increase. After a period of deforestation, abandoned agricultural land is reforested.

Following the peace agreement in 1991, the Government of Cambodia focused on economic growth through neoliberal trade and investment policies. From 1998-2008 the expansion of the garment industry propelled Cambodia into rapid growth: annual GDP grew at a rate of 9% between 1998 and 2008 (World Bank, 2016). Trends show urbanization is increasing yet 79% of the country's 15.5 million inhabitants still live in rural areas⁴ (World Bank, 2016). Significant improvements in social indicators suggest that economic growth is contributing to improvements in health and education and poverty reduction (World Bank, 2016). However, insecure land tenure and illegal land acquisitions are widely reported across the country, reflecting elite capture of wealth and land assets (Milne, 2015; Un & So, 2011). Rural to rural migration is nearly twice rural to urban migration, largely due to land shortages in the central plains. Farmers, retreating from areas of concentrated land use and land conflict in the lowlands, and without the necessary skills for limited non-farm labour opportunities in peri-urban regions, are migrating farther north where there is available land in forested areas (Diepart et al., 2014). As such, the restructuring of the economy away from agriculture exceeds the ability of people to transition out of agriculture and away from rural areas (World Bank, 2007). As younger generations move to urban areas for employment in manufacturing, rural landholdings continue to act as a safety net for households (Ministry of Planning, 2012).

Attempting to deal with rising issues of landlessness, the Government responded with a contentious rapid land titling scheme in 2012 (Milne, 2013). New settlements in forests became widespread in the upland areas, driven largely by smallholders looking to expand holdings to increase their income while fearing that private concessions will hinder future access. Without effective law enforcement and protection, legally protected forest areas were transformed into settlements and industrialized agriculture. On the Eastern border of Cambodia, 70% of the 75,000 hectare Snoul Wildlife Sanctuary was cleared for rubber during 2009-2013, despite its legal status as a protected area (Warren-Thomas et al., 2015). The allocation of land in rural areas to industrialized agriculture, known as Economic Land Concessions, is intended by the Government to boost agricultural production and generate work for local communities. However, multiple studies find evidence that ELCs are 'mechanisms for the Cambodian ruling elite to enable land grabbing, clear-cutting and selling of high value timber' to profit Cambodian political interests, rather than rural economic development (Beauchamp et al.,

⁴ 15.6% of the population lived in urban areas in 1990, in 2015 this rose to 20.7%

2018b). Cambodia’s per capita GDP is much higher (Table 2) compared to when neighbouring Vietnam reached net reforestation. We see no evidence that urbanization and manufacturing are delivering real benefits to rural livelihoods and thus driving a forest transition.

*Table 2: Selected Explanatory Conditions for Asian Forest Transitions (Adapted from Youn et al, 2017). Additional Sources: Cambodia GDP per capita from World Bank (2017a), food provision data from (FAO, 2014a) forest cover data from (FAO, 2014c) *Forest cover statistics are collected from a variety of sources and may represent different definitions of forest cover.*

Country	Period	GDP per capita (current USD)	Food Provision (kcal/day)	Forest Cover Before Transition* (percent)	Forest Transition?
China	1980-2010	195 (1980)	2819 (2001)	12.7 (1976)	yes
India	1971-2010	117 (1971)	2331 (2001)	19.1 (1970)	yes
Japan	1946-1980	479 (1960)	2729 (1971)	51.9 (1943)	yes
Philippines	2001-2010	958 (2001)	2516 (2006)	22.3 (1990)	yes
South Korea	1956-1987	158 (1960)	2899 (1971)	34.3 (1955)	yes
Vietnam	1991-2010	143 (1991)	2402 (2001)	27.8 (1990)	yes
Cambodia	2018-	1270 (2016)	2411 (2011)	52 (2015)	no

(2) The State policy pathway occurs when States use policy instruments to trigger forest transitions. Forest policies must be distinctly different from pre-transition policies, such as decentralized forest management or nation-wide reforestation.

In the past 25 years, the State’s role in governing Cambodia’s forest has largely focused on expanding concessions and reducing illegal logging. The Government issued several logging bans, each with little or no impact on reducing timber offtake and shifting the country towards a forest transition (Asian Correspondent, 2016; Le Billon, 2002). Between 1992 and 1996, the Government declared a logging ban on five occasions, each subsequently removed to serve the interests of the political elite and protect deals made between political leaders and timber companies (Le Billon, 2002). In 1996, Cambodia introduced a ban on the export of unprocessed timber, followed by a moratorium on logging in forest concessions in 2002, and a ban on all timber exports to Vietnam in 2016. Despite the bans, the illegal trade of timber to Vietnam has continued uninterrupted since the 1990s, and perversely increased following the recent ban (EIA, 2017).

To deal with society’s rising discontent over uncontrolled logging, the Prime Minister announced a jurisdictional reform of natural resource management, redefining the roles of the Ministry of Environment (MoE) and the Ministry of Agriculture, Forests and Fisheries (MAFF) and transferring

protected area management from the central Ministry to the provinces. The move is supported by conservation NGOs, as increased areas came under protection; 41% of total land cover was protected in 2017 (Open Development Cambodia, 2017). However, the impact of these changes will depend on governance; how those in power choose to implement and manage forest policies. South Korea's successful State driven forest transition can be attributed to an effective integrated institutional framework for reforestation, land management, and social development (Park & Youn, 2017). Strong leadership, coordination, and synchronization across vertical and horizontal institutional structures alongside significant investment in local capacity-building to implement state policies contributed to a well-governed forest transition (Bae et al., 2012). In China, systematic environmental governance reform led to a fundamental shift in the country's forest management paradigm (Wang et al., 2004). The State provided new legislation and significant funding, incentivizing participation in afforestation programs. Research from He et al. (2014) and (Bennett et al., 2014) show the importance of effective local institutions in adapting top-down policies to the local context and engaging households in afforestation. In Cambodia, improved State capacity for managing natural resources cannot be addressed through reforms in environmental management alone. Cambodia's recent decentralization of forest management may have perverse outcomes; governments may compromise environmental sustainability to secure political support, especially during election campaigns. Similar events occurred in Indonesia following decentralization as local governments promised land in protected areas in exchange for votes (Bettinger, 2015). Thus, while recent State policies appear to follow the same pattern seen in recent Asian forest transitions, political and economic interests are likely to hinder their implementation.

(3) The globalization pathway exists when external factors impact the state of the forest in a country, such as international pressure for conservation or trade.

When the United Nations peacekeeping operation began in Cambodia in 1991, well-intentioned international donors sought to support sustainable timber management. Challenging their good intentions was the demand for forests as a key resource in a politically unstable and impoverished State. Political parties secured logging deals to gain power and leadership, eager to gain control of resources and build support networks (Le Billon, 2002). Regional companies began to operate in Cambodia, resulting in the sale of large timber concessions to international investors and an inflow of cash into political and military factions. As Cambodia moved through the process of post-conflict political reconstruction guided by the United Nations Transitional Authority in Cambodia (UNTAC), timber provided the source of growth as well as power, profit and political positioning for Cambodia's elite (Le Billon, 2000). International concern over environmental exploitation grew, driven by the advocacy of international NGOs such as Global Witness. The IMF and the World Bank, with support of other multilateral donor institutions responded by advocating forest policy reform (Cock, 2016).

The Government of Cambodia responded with multiple logging bans and the suspension of the timber concession system in 2002.

However the Government's action opened up a new extractive regime under a range of different mechanisms, such as large scale agricultural concessions, infrastructure projects and social land concessions (Milne, 2015). Forest clearance for industrialized agriculture, economic land concessions, became the dominant mechanism for timber extraction. Between 2000 and 2014, forest cover in Cambodia fell from 66.6% of total land area to 47.7% (Open Development Cambodia, 2015). The failure of external actors to implement sustainable timber management in Cambodia did not deter international conservation NGO engagement. NGOs responded by focusing on the conservation of natural forest cover as a rear-guard action, an unsustainable strategy in the face of overriding political powers. China continues to assert its dominance in the region by financing infrastructure projects. China's incentives for infrastructure development are crowding out other global initiatives that strive to enhance conservation, including forest protection and illegal timber and wildlife trade.

Cambodia is signatory to several global environment and climate initiatives and engaged in bilateral and multilateral agreements related to forests and natural resources. Many of these initiatives have prompted Government commitments and proclaimed strategies, such as the Rio Declaration in 1992, United Nations Framework Convention on Climate Change (UNFCCC) and Convention on Biodiversity (CBD) in 1995. Despite public commitment, many of the agreements are limited by governance constraints (Preece, 2013). For example, the Rio Declaration, CBD, and the United Nations Declaration on the Rights of Indigenous People (adopted in 2007) require or emphasize the role of Environmental and Social Impact Assessments (ESIAs). However, according to Schulte and Stetser (2014), ESIAs are either rarely conducted or insufficient to address social and environmental concerns. The Government of Cambodia ratified the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1997, prohibiting the trade of rare and endangered timber species in the 2002 Forestry Law. However, trade of CITES listed timber species is frequently reported, made possible due to corruption and the exploitation of legal loopholes in domestic and regional policies (Siriwat & Nijman, 2018). In recent years the global forest governance initiative REDD+ (Reducing Emissions from Deforestation and Degradation) has incentivized the Cambodian Government to engage in multi-lateral forest conservation. However, its impact is limited by extractive industries' political alliances (Nathan & Pasgaard, 2017). As in the case of Indonesia, global initiatives such as REDD+ may fund conservation but cannot drive a forest transition without addressing underlying power structures (Wibowo & Giessen, 2015).

(4) A forest scarcity pathway occurs when there is a scarcity of forest products or a decline in forest ecosystem services, prompting governments and land managers to commence reforestation or afforestation.

It is difficult to compare Cambodia's current forest cover with other countries prior to their forest transition because the definition of forest varies across countries. The FRA reported 52% forest cover remaining in Cambodia in 2015 but includes forest cover where it is not possible to distinguish between planted or natural forest types (FAO, 2015a). India, China, and Vietnam had significantly less forest cover at the time of transition (Table 2), however these figures also represent varied definitions of forest. In each of these countries, scarcity of forest products played a role in creating incentives to plant forest but it was State intervention that encouraged both conservation and reforestation (Foster & Rosenzweig, 2003; Meyfroidt & Lambin, 2008b). In Cambodia, no large-scale timber plantations exist in Cambodia due to the cancellation of the failed timber concession scheme in the 1990s. Naturally occurring high value timber provides the Government with revenue both formally and informally, creating a disincentive for the expansion of timber plantations. Pulp and paper plantations comprise of less than 1 million hectares of economic land concessions and rubber concessions cover over 1.8 million hectares, neither of which provide timber for domestic or international markets (LIDACHO, 2016). As more than half of Cambodia's classified forests are allocated for conservation, Cambodia's timber supply comes mainly from economic land concessions, which are mostly natural logged forests. Approximately 79% of economic land concessions were allocated over forest areas, with only 36% cleared as of 2015 (Yin, 2017).

As the clearing of natural forests for economic land concessions are expected to meet the demand for timber in the coming years, the main concern is whether these areas will be planted with tree crops or allocated to agricultural crops that will not provide the same environmental services. If Cambodia is to achieve a forest transition through planted forest for production, afforestation programs must provide adequate incentives for local participation. Cambodia's first large scale reforestation initiative, a 34,007 hectare project developed by Korean company Think Biotech, has been detrimental to both local communities and the natural environment (Scheidel & Work, 2018). Despite being labelled as reforestation project to fulfil Cambodia's commitment to the United Nations Framework Convention on Climate Change (UNFCCC), the project cleared natural forest for acacia monoculture without meeting legal requirements of Environmental Impact Assessments and community consultation (Scheidel & Work, 2018). Despite its challenges, India's Joint Forest Management Program provides an example of participatory forest management that aimed to address social and environmental goals through partnerships between State, civil society and external organizations (Bhattacharya et al., 2010). In Vietnam, land privatization, including the transfer of State forest land to private ownership, provided rural households with tenure security and an

economic incentive for afforestation (Clement et al., 2009; Nguyen et al., 2010). Both schemes have been criticized (see Sikor & Thanh, 2007; Sundar, 2017) but demonstrate how elements of good governance such as secure property rights, political voice, and democratic accountability play important roles in nurturing forest transitions.

(5) Forest recovery driven by smallholders occurs when smallholders promote reforestation through land-use intensification and agroforestry activities.

More than 75% (2.7 million hectares) of arable land is devoted to rice cultivation in Cambodia; rice is the primary commodity and source of income for the majority of smallholders (FAO, 2014b). The remaining 25% is devoted to other food and industrial crops, mainly maize, cassava and rubber. Commercial monoculture dominates rubber production, however smallholder rubber plantations have increased rapidly over the past 25 years (Fox & Castella, 2013; Yem et al., 2015). Farmers from lowland areas are migrating to Cambodia's fertile uplands and smallholders are discontinuing their swidden farming practices. Both groups are planting cash crops including cashew, rubber, cassava and pepper (Mahanty & Milne, 2016; Travers et al., 2015). However, with few opportunities to improve farming skills and with few farm inputs, rather than intensifying their cropping or agroforestry systems, most farmers convert forest land to monocultures producing low yields (Yem et al., 2015).

Despite the large number of protected areas, without strict land restriction policies, poor law enforcement and low incentives for intensification means migrants and smallholders are rapidly expanding into forest land. This trend is symptomatic of broader issues; smallholders fear land grabs by larger corporations and have no control over commodity prices. They do not have access to agricultural extension and knowledge of sustainable farming practices. Many lack access to markets and education to make use of income opportunities when they arise, hampering incentives to move out of subsistence (Engvall et al., 2008). Households unable to acquire enough capital or mechanize their agricultural practices remain in a poverty trap (Beauchamp et al., 2018a). Without secure tenure and income, smallholders make land-use decisions in the context of food insecurity and poverty. For many, this means logging natural forests and investing in crops with short-term returns; reforestation is not an attractive option.

Poor governance as an inhibitor of forest transitions

The examples outlined above highlight how poor governance inhibits forest transitions. In Cambodia, natural resource exploitation has not led to inclusive sustainable development. The public and private sector have converted natural assets to financial assets but have not reinvested these assets into other forms of capital (financial, human and social) to benefit rural people. While the country continues on

a trajectory of industrialized economic development, weak socio-political institutions allow for unequally shared prosperity and ongoing natural resource depletion. Deforestation has become a product of poor rural development. Efforts to strengthen political institutions are undermined by patron-client politics (Le Billon, 2000). Intact forest in Protected Areas has been allocated to industrial agriculture to serve elite interests (Peter & Pheap, 2015). Economic land concessions and reforestation projects have not delivered benefits to rural development and have instead facilitated logging and accelerated deforestation (Beauchamp et al., 2018a; Davis et al., 2015; Scheidel & Work, 2018). Illegal logging has remained pervasive despite multiple logging bans (EIA, 2017). Environmental and Social Impact Assessments are rarely conducted or insufficient (Schulte & Stetser, 2014). While some robust legal frameworks exist, institutions lack capacity and credibility, impeding their ability to uphold the law. Transparency International ranks Cambodia as the most corrupt country in South-east Asia (Transparency International, 2017). Law enforcement and the judiciary are not politically independent; the head of the national Anti-Corruption Unit is appointed by the ruling Cambodian People's Party (Johnson et al., 2014). As a country still recovering from war, citizens lack trust in their institutions; among each other, and in their political, economic, and legislative systems. Consolidation of power across the entire governance system has hindered progress in land and natural resource management, largely at the expense of the rural poor.

World Governance Indicators show no meaningful governance differences between Cambodia and other South-east Asian countries that have already passed through a forest transition (Kaufmann & Kraay, 2017). However, case studies of forest transitions in Asia (Joint Forest Management in India, privatization in Vietnam, state-driven reform in China and governance integration in South Korea) demonstrate how elements of good governance such as collective leadership, conducive policy and state capability can act as leverage points for afforestation and reforestation. In the case studies highlighted, researchers used in-depth knowledge of historical, social and political factors to analyse governance in forest transitions. They found local institutions and social-ecological conditions can be crucial for facilitating or hindering State-driven forest transitions (Bhattacharya et al., 2010; Clement et al., 2009; He et al., 2014). The case of Cambodia shows that governance failures at all levels of the governance hierarchy, including State and macroeconomic levels, can impede movement along forest transition pathways. Combining landscape-level insights with broader national and regional governance insights may help contextualize forest transition frameworks, strengthening their utility for improving forest governance and landscape interventions.

Finding leverage points for nurturing progress

Forest landscapes are increasingly understood as complex and dynamic social-ecological systems (Messier & Puettmann, 2011). Traditional econometric and analytical models are insufficient for

capturing processes of complex change in natural and social systems (Duit et al., 2010). Recent calls for the application of complex systems theory in natural resource management and forest transition analysis recognize these limitations (Perz, 2007). The identification of conditions that could accelerate forest transitions (see Meyfroidt & Lambin, 2011) must be accompanied by in-depth understanding of political, social and economic dimensions of forest cover change. Comprehensive analyses incorporating systems thinking, qualitative information, narratives and quantitative data is required for broader understanding of the role of governance and institutions in forest transitions.

Emerging concepts of Theory of Place (ToP) and Theory of Change (ToC) are useful diagnostic tools for understanding social-ecological systems in their specific contexts (van Noordwijk et al., 2015). They enable researchers and practitioners to articulate causal change blockages and potential future mechanisms, making trade-offs explicit and acknowledging the importance of context and scale (van Noordwijk, 2017). Dewi et al. (2017) claim that both tools have strong potential for diagnosing the livelihoods, landscapes and governance dimensions of forest transitions as they provide a logical appealing account of the diversity of situations (ToP) as well as plausible directions of historical and future endogenous or induced change (ToC). Pairing land-change science with political ecology to analyse forest transitions can integrate normative research agendas with in-depth analysis of complex human-environmental interactions, providing insights into the role of power and institutions in forest transition dynamics (Turner & Robbins, 2008). Site specific studies that incorporate political ecology in their analysis of forest cover change may not yield generalizable results but can provide a more nuanced view of local institutional conditions, ethnographic and household factors that influence forest transition pathways (Hecht, 2002; Klooster, 2003). By eliciting causal change mechanisms, goals and challenges in specific societal and environmental contexts, Theories of Place and Change can help institutions identify 'deep' leverage points; interventions that may be more difficult to alter but have the potential to result in transformational change (Abson et al., 2017), or where incremental adjustments can be made to tweak systems for better societal trust-building and learning.

Further research providing in-depth insights into drivers of forest transitions can only be effective if completed *in situ*; collaborating with the institutions and agents of change within the landscapes where transitions are occurring. Embedded research focused on the co-generation of knowledge among scientists, policy makers and local institutions is needed to link evidence-based decision making with political processes. Land use decision making is highly complex and involves taking into account multiple types of knowledge, interests and objectives. Insights from forest transitions should feed into decision-making, helping to identify leverage points for nurturing transitions in countries where forest area continues to decline. In Cambodia, improving governance to nurture a forest transition will require addressing underlying issues of inequality, poverty and power. Strengthening democratic systems and empowering rural communities through property rights will help support

sustainable land use systems and tenure security. Local institutions need resources and capacity building to empower local voices and strengthen relationships with decision makers to gain political support. Externally driven projects must ensure they contribute to building state capability, rather than reducing it (Andrews et al., 2017). Externally driven projects and investments should involve increasing the dialogue between government and civil society to encourage social development that adheres to environmental safeguards (Ascensão et al., 2018). More studies that address the quality of natural capital maintained throughout or restored following forest transitions are needed, examining how and if forest transitions lead to multifunctional landscapes that deliver forest environmental values (Kull, 2017). It is therefore crucial that forest transition theory moves beyond a normative approach, breaking from “traditional linear science-policy approaches to ones that embrace complexity, diversity of knowledge systems and contextual politics” (Evans, 2017).

Conclusion

Much of the remaining natural forest in Asia is under pressure from competing economic interests. For the States yet to transition from net deforestation to reforestation, pressures to convert compete with pressures to conserve. Attempts to nurture the forest transition will require a comprehensive understanding of social, economic and biophysical dynamics of forest transitions and the influence of entire governance systems. As the case of Cambodia illustrates, poor governance across all sectors does not nurture forest transitions. Superficial efforts to build State capacity have not led to equitable and accountable governance, resulting in widespread deforestation and stagnant socio-economic development. Poverty and lack of political freedoms are masked by high economic growth and oversimplified measures of socio-economic performance at the national level. In the current political and economic climate, inclusive sustainable development in Cambodia will not be achieved without further environmental losses. As a small, fast growing country, Cambodia will not be able to retain forests on the 41% of land designated as protected areas. Conserving Cambodia’s future forests does not mean preserving forests of the past. Rather, it requires building a national constituency for conservation and sustainable land use (Steinberg, 2009). In Cambodia, governance and institutions can nurture the forest transition by nurturing development; building a society, economy and polity that ensures people are not driven by inequality, poverty or power (Grotenhuis, 2016). Creating trust through transparency and accountability at all levels of government can foster civil society’s engagement in processes supporting social and ecological sustainability. Current efforts to clarify land tenure and provide rural communities with a political voice should continue to receive government and international support. Elsewhere, research integrating the politics of resource use with other economic and social drivers could contribute to the development of equitable and viable policies that nurture forest transitions for sustainable development. Expanding forest transition frameworks to incorporate in-depth analysis of governance and institutions could provide insights for nurturing this

process. Independent science must embed itself for societal learning, encouraging the co-production of legitimized knowledge with Governments and civil society. Finding leverage points that trigger good governance and macroeconomic management will be crucial to achieving better environmental stewardship and meeting long term goals of sustainable development.

Chapter 2: Examining trajectories of change for prosperous forest landscapes in Cambodia

Abstract

Tropical forest landscapes are undergoing rapid transition. Rural development aspirations are rising, and land use change is contributing to deforestation, degradation, and biodiversity loss, which threaten the future of tropical forests. Conservation initiatives must deal with complex social, political, and ecological decisions involving trade-offs between the extent of protected areas and quality of conservation. In Cambodia, smallholders and industrial economic land concessions drive deforestation and forest degradation. Rural economic benefits have not kept pace with development aspirations and smallholders are gradually expanding agriculture into protected forests. We examine the drivers and effects of rural forest landscape transitions in Cambodia to identify trade-offs between conservation and development. Using historical trends analysis and information gathered through key informant interviews, we describe how local communities perceive social and ecological changes, and examine the implications of local development aspirations for conservation. We explore three scenarios for the future of conservation in Cambodia, transformative change, stagnation, and incremental change. Each has different conservation and community development outcomes. We contend that conservation efforts should focus on strengthening governance to meet social and environmental requirements for sustainable forest landscapes. We suggest potential entry points for governance improvements, including working with local decision-makers and fostering collaboration between stakeholders. There is a need for realistic priority setting in contested tropical forest landscapes. Prosperous rural economies are a necessary but not sufficient condition for conservation.



Introduction

Negotiate a river by following its bends, enter a country by following its customs.

Khmer Proverb

Tropical forest landscapes are in transition. Demand for the conservation of global public goods, including irreplaceable tropical biodiversity, is competing with pressures for local social and economic development. Seventy-three percent of tropical and sub-tropical deforestation is due to the conversion of forest to agriculture (FAO, 2016). Throughout the tropics, human population and development aspirations continue to grow. Countries are pursuing greater affluence through infrastructure development (Laurance & Arrea, 2017). Rural economies are still highly dependent on agricultural commodities but there is increasing investment in manufacturing and services to stimulate economic growth (Szirmai, 2012). Global efforts to conserve tropical forests are also intensifying (Barlow et al., 2016; Laurance, 2007; Morales-Hidalgo et al., 2015). Yet conservation efforts are struggling to prevent the loss of irreplaceable biodiversity or severe environmental degradation (Balmford & Cowling, 2006; Ghazoul & Chazdon, 2017).

In Cambodia, forest landscapes are on a trajectory towards an unsustainable future. Deforestation is high and governance is not ensuring equitable development opportunities from resource conversion (Beauchamp et al., 2018b; Hansen et al., 2013; Riggs et al., 2018). The country lies within the Indo-Burma biodiversity hotspot (Mittermeier, 2004) and the Government of Cambodia allocates 41% of the national territory to protection. But these protected areas (PAs) are vulnerable to pressures associated with weak governance and a slow pace of development, including lack of political and public support, food insecurity, poverty and low levels of education (Johnson et al., 2014; Mahanty & Milne, 2015). In recent history, PAs have been a source of development benefits for rural forest-dependent Cambodians (Clements et al., 2014b). But agrarian change via the expansion of smallholder cash crop production and industrial economic land concessions is driving forest conversion at a rapid pace (Davis et al., 2015; Kong et al., 2019). Increasing access to infrastructure, education, and physical assets is enabling more lucrative livelihood strategies (Jiao et al., 2017). As development needs and aspirations rise, the economic foundations for development will likely require relinquishing much of the PAs to other, more profitable land-uses. Efforts to conserve significant Cambodian biodiversity must reconcile these basic trade-offs.

Navigating conservation and development trade-offs and synergies between humans and natural resources has become one of the defining issues of the Anthropocene (Lewis et al., 2015; Mehrabi et al., 2018; Palomo et al., 2014). Fervent debates over intensified 'land sparing' farming approaches vs.

low intensity ‘land sharing’ systems highlight the dichotomy between biodiversity conservation and human development needs (Kremen, 2015; Phalan et al., 2011). Recently, these debates are converging to a discourse beyond that dichotomy, towards multi-functionality (Fischer et al., 2017). The path to sustainability in tropical forest landscapes is complex and requires comprehensive considerations of multiple knowledge systems, actors, and decision makers (Cornell et al., 2013; Gibson et al., 2000; van Noordwijk, 2017). Too often, efforts to conserve forested landscapes do not take into account the needs and aspirations of people living in those landscapes (Agrawal & Gibson, 2001; Boedhihartono et al., 2018; Brown, 2002). Without local support, conservation is not sustainable. Yet finding locally appropriate development pathways that might simultaneously have a more benign effect on biodiversity is challenging (Terborgh & Peres, 2017).

In this paper, we present a case study of two forest landscapes representing the conservation development nexus in Cambodia. We examine socio-economic, political, and environmental components of landscape change to identify trade-offs between biodiversity protection and local community development. From this, we derive three potential scenarios with contrasting strategies and different outcomes for conservation and development. In both landscapes, efforts to conserve tropical forests compete with local development aspirations and exogenous economic and political forces. Conservation agencies, including non-government organizations and government institutions, attempt to reconcile conservation and development trade-offs, but must deal with rapidly changing and uncertain circumstances. We use key informant interviews, focus group discussions and quantitative household surveys to examine underlying drivers and effects of rural forest landscape transitions in Cambodia, emphasising how changes are perceived by local communities and their impact on the natural environment. Acknowledging the complexity and depth of social-ecological challenges in both landscapes, we apply transdisciplinary research principles, working with local partners to generate research objectives, and integrating knowledge from multiple disciplines to solve real world problems (Lang et al., 2012; Scholz, 2000).

Conservation and development trade-offs in Cambodia’s transitioning landscapes

At the base of the Lower Mekong, The Kingdom of Cambodia is emerging as a rapidly developing state. Described as a frontier of change (Mahanty & Milne, 2015), political dynamics and market processes are shaping economic growth and natural resource exploitation. Development banks and foreign investment are promoting regional economic integration within the Greater Mekong Sub-region, with widespread investment in transport networks and infrastructure (ADB, 2012, 2016). Industrial agriculture, new road development and demand for land among the rural population are driving landscape transitions; the social, economic, and environmental changes apparent at a landscape-scale (Bürgi et al., 2005; Ichikawa et al., 2006; Zhang et al., 2016).

Emerging from landscape ecology, landscape transitions recognise that human influences, including economics, politics, social structures, technology and value systems, shape the natural environment and the use of natural resources, and vice versa (Bailes, 1985; Kaplan & White, 2002; Russell, 1998). Studies examining landscape transitions emphasise the emergence of institutions and governance arrangements that influence the pace and direction of environmental change (Dewi et al., 2017; Pokorny & De Jong, 2015). In the context of Cambodia, landscape transitions provide a useful framework for analysing the temporal interactions between socio-economic, political, cultural, and environmental complexities in rural forest landscapes. By acknowledging the complex nature of social-ecological systems, we can draw insights into opportunities and challenges for conservation and development from a diverse range of sources (Hirsch et al., 2011). From this, we can better understand drivers of change, future landscape trajectories, and opportunities to enhance sustainable development pathways.

Leveraging landscape transitions to improve social and environmental outcomes requires explicit identification of trade-offs (Brown, 2004; McShane et al., 2011). In Cambodia, both conservation and development are stated as priorities in the Government's long-term strategic development plans, yet in reality there are few opportunities for synergies (Beauchamp et al., 2018b). The Government established Economic Land Concessions (ELCs) in 2005 after the demise of the timber concessions in the late 1990s to drive rural development through large scale industrial agriculture. Implementation of ELCs has led to more than 2 million hectares of Cambodia's land being leased to private companies for economic development and this has greatly increased deforestation (Davis et al., 2015). The rapid spread of concessions and scramble for land resulted in social unrest in the form of land disputes, forced evictions and land grabs throughout Cambodia (Neef et al., 2013). Social Land Concessions (SLCs) to provide land to poor and landless Cambodians also require land in forest areas, contributing to further conflict and deforestation (LICADHO, 2015; Rainey et al., 2010). Since 2012, Prime Minister Hun Sen has maintained a moratorium on the allocation of new ELCs. Protected areas, already vulnerable to politically profitable cancellation, or encroachment, are currently influenced by a complex network of smallholders, industrial agriculture, SLCs, and a growing presence of energy and transport infrastructure.

Protected area management in Cambodia is supported by international and local non-government organizations, drawing on scientific methods for conservation planning and management (Clements et al., 2014b; Gray & Phan, 2011; Ibbett et al., 2017). Yet as Cambodia's rural landscapes become increasingly shared by diverse actors, finding sustainable landscape trajectories that meet the needs of stakeholders, including government institutions, private bodies, local communities and conservation advocates, is inherently challenging. Recent decentralization placed protected area management under

the purview of the Provincial Department of Environment (PDOE). Decisions are overseen by the General Directorate of Administration for Nature Conservation and Protection (GDANCP) and must be approved by the Provincial Governor. Conflicting conservation and development initiatives are often negotiated among a range of stakeholders, but negotiation is constrained by politics (Paley, 2015). Patronage networks exert substantial influence over the development of forest land, with little room for community involvement in decision making (Persson & Prowse, 2017). Conservation agencies must navigate provincial and national directives whilst responding to the needs of local people living in and around PAs. In general, the success of conservation depends on public support and societal values that shape conservation policy (Brown et al., 2010; Miller & Hobbs, 2002; Rose, 2015). The risk is that conservation in Cambodia will not succeed if it does not contribute to socially inclusive development and build a constituency for sustainable natural resource management. Yet navigating social-economic and political components of an unpredictable and complex system requires accepting some irreversible environmental costs. This paper provides contextual information to stimulate a practical evaluation of the trade-offs of different conservation and development decisions at multiple levels in Cambodia.

Study sites: The Keo Seima Wildlife Sanctuary and Northern Plains Landscape

We selected two study sites which exemplify conservation and development pressures on Cambodia's protected area network (). Both landscapes are subject to long-term interventions from conservation agencies, which have influenced management decisions and contributed to a repository of diachronic data on social and biophysical components of the landscape. The Keo Seima Wildlife Sanctuary (KSWS) and surrounding area has undergone transformative agrarian change since conservation activities began in early 2000s, most apparent since the construction of the major road linking the province to Phnom Penh that began in 2007 (Clements et al., 2014a). In contrast, the Northern Plains has remained relatively isolated from neighbouring provinces and is transitioning at a slower pace than KSWS in the Eastern Plains of Cambodia. Similar natural resource governance arrangements exist in both landscapes, with a significant exception being the strong presence of Indigenous communities in the Eastern Plains. Prior to 2016, PAs in Cambodia were under the management of the Ministry of Environment (MoE) or the Ministry of Agriculture, Forestry, Fisheries (MAFF) (Souter et al., 2016). In 2016, sub-degree 69 transferred PAs under the authority of the MAFF to the MoE. In the two study sites government-led PA management is supported by the Wildlife Conservation Society (WCS) Cambodia Program, which has been actively engaged in both landscapes since 2000.

KSWS⁵ (292,690 ha) is located within Mondulkiri Province. The local population consists of Indigenous ethnic groups, primarily Bunong or Stieng, and ethnic Khmer. Rural livelihoods are predominantly derived from agriculture and forest use, including rain-fed rice paddy, cassava, cashew, rubber and resin tapping from *Dipterocarpus* species, *D. alatus* and *D. intricatu* (Travers et al., 2015). KSWS conserves large areas of both Annamitic evergreen forest and deciduous dipterocarp forests of the eastern plains, forming a complex mosaic of forest types that provided habitat for endangered flora and fauna. The wildlife sanctuary includes an established REDD+ project, eco-tourism, Indigenous Communal Tenure (ICT) and community forestry schemes (Travers et al., 2016).

Large scale development projects exist and are planned in the landscape, including mining, economic land concessions for rubber, new roads, and power transmission lines. Due to the proximity of the Vietnamese border, illegal logging of high value timber is a major concern for PA authorities. Migration and demand for farming land continues to drive conversion of forest to agriculture in areas in close proximity to roads and markets. While deforestation is reducing wildlife habitat, conservation agencies perceive hunting to be the major imminent threat to terrestrial species. Biodiversity monitoring shows that populations of ungulates are decreasing but that primate populations are stable (unpublished data). Reduction or local extinction of populations of such species changes floristic and faunistic composition of forests (Wright, 2003). If species populations are reduced to such low levels that they are "ecologically extinct", they may be unable to fulfil their ecological role, with repercussions on the long-term diversity and health of tropical forests (Redford, 1992).

The Northern Plains Landscape consists of a network of three PAs in Preah Vihear Province, the Kulen Promtep Wildlife Sanctuary (KPWS), Preah Roka Wildlife Sanctuary (PRWS) and Chhep Wildlife Sanctuary (CWS)⁶, collectively encompassing 535,000 hectares. Rural communities primarily practice rain-fed paddy cultivation; some households also grow cash crops including cassava and cashew. Additional income is made through resin-tapping and the collection of Non Timber Forest Products (NTFPs) (Beauchamp et al., 2018a). Villages inside the PAs contain a mixture of Indigenous and non-Indigenous people, former soldiers, and recent immigrants from the central plains of Cambodia (Clements, 2012). Most of the Northern Plains landscape is dry deciduous forest, although patches of evergreen forest and other forest types exist. Forests and agricultural areas are habitat for critically endangered and vulnerable mammal and bird species.

Since 2008, over 61,000 ha of land inside CWS and KPWS has been allocated to economic and social land concessions, increasing the population of the area and impetus for illegal activities. Deforestation

⁵ Formerly Seima Protection Forest, management transferred from MAFF to MOE in 2016

⁶ Formerly Preah Vihear Protection Forest, management transferred from MAFF to MOE in 2016

is prominent in these areas. Conversion of forest to agriculture by local communities and immigrants also occurs, but a number of interventions are working to strengthen local incentives for conservation, including wildlife friendly agriculture, payments for environmental services (PES) programs, ecotourism and land use planning (Clements et al., 2014b). Monitoring of bird nests and fledglings in CWS and KPWS show that conservation interventions may be effective in maintaining bird populations, but no mechanisms exist for combating habitat loss by conversion in concessions (Harrison & Mao, 2017). According to Harrison and Mao (2017), the number of bird nests and fledglings rose between 2002 and 2008, after which they stabilised and then have fallen at a steady rate since 2012. The decrease in the number of nests and fledglings is attributed to habitat loss, logging of high value timber in nesting sites, hunting, and egg collection.

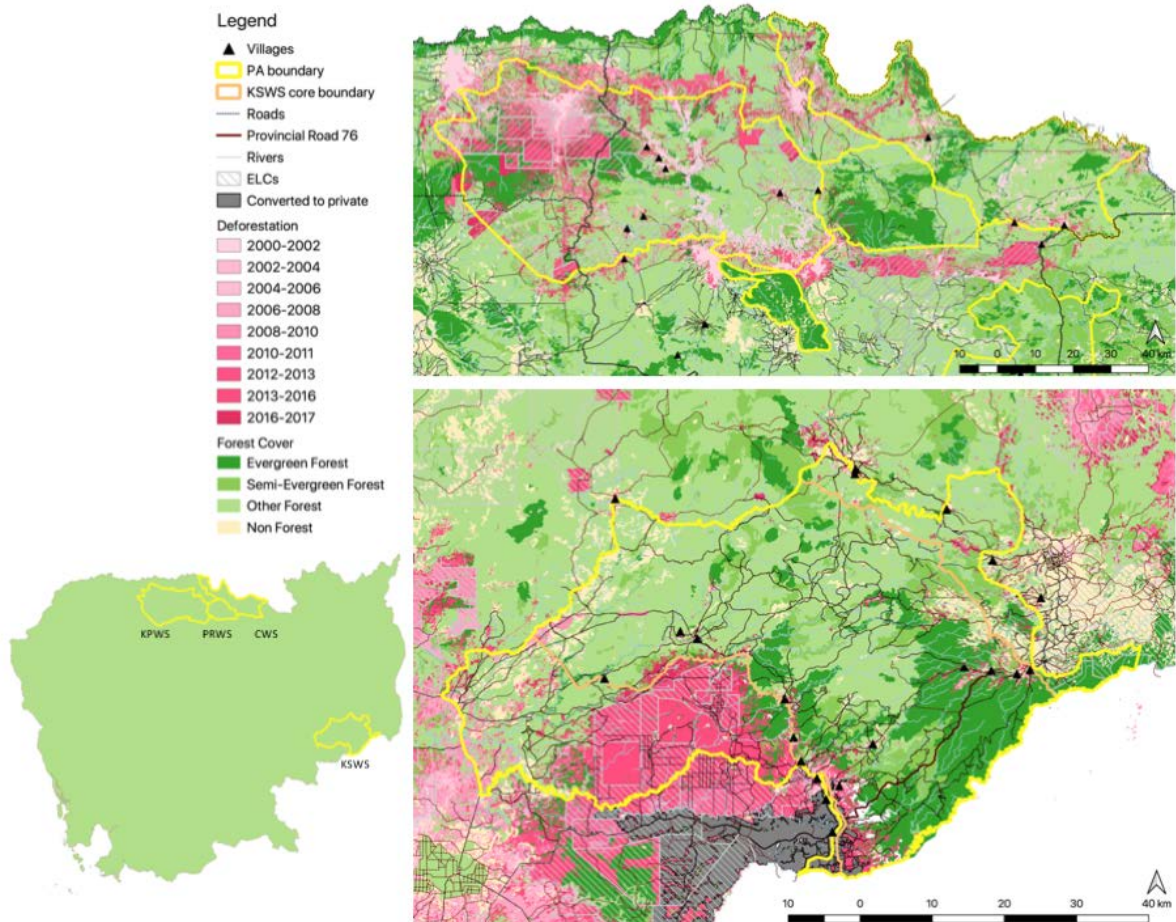


Figure 3: Location of study sites, villages surveyed, and deforestation between 2000 and 2017. Land cover data including forest cover, administrative data and other spatial components of the landscapes was obtained from WCS’s private spatial dataset. Detailed methodology is available in Rainey et al. (2010) and Evans et al. (2009)

Methods

We have visited the landscapes of focus for short periods annually since 2015 to explore and discuss research objectives with natural resource management institutions. Following principles of inductive research (Thomas, 2006), inquiry was driven by a broad set of issues and not a predetermined hypothesis. We reviewed existing data available for both landscapes, including forest cover change, biodiversity surveys and household surveys. Our preliminary findings indicated a wealth of available quantitative data covering both biophysical and social attributes of the study sites. We found gaps in information on how local communities perceive the social and environmental components of their landscapes and the governance arrangements that influence outcomes at a landscape level. These gaps emerged due to the changing governance in landscapes; past partnerships appeared to be based on informal relationships, which inherently change over time. Relationships and institutional memory have not kept pace with new leadership, new actors, and changing societal values.

We spent six weeks in each landscape between November 2017 – February 2018, engaging with natural resource management institutions and local communities. Principal attention was given to the following characteristics:

- Local perceptions of landscape transitions and future aspirations
- Institutional arrangements influencing conservation and development outcomes
- Leverage points for development pathways

Three villages were visited in each landscape. In KSWS, we visited Sre Preah, Gati and Chak Char and in the Northern Plains we visited Dangphlat, Kunapheap and Antil. Key informant interviews and focus group discussions were conducted by two authors and a translator. Translation of key concepts occurred prior to meetings. During the interviews and discussions, conversation was translated continuously, as well as after each meeting for further clarification. We sought to build from existing datasets through information gathered in formal interviews and focus groups and informal discussions for a more holistic problem focused approach (Leavy, 2016). We selected the villages to represent low, medium, and high accessibility inside or on the border of an established PA. As transport infrastructure is often an indicator of rural development (Roberts et al., 2006), accessibility was selected to capture villages at different stages of landscape transitions. Time and financial constraints limited our coverage to three villages in each landscape. Our second criterion was the presence of contemporary issues in rural Cambodia within the village, including economic land concessions, transport infrastructure, Indigenous communal tenure, migration and various conservation schemes (Table 3).

Table 3: Overview of villages selected for study, including socio-economic conditions, conservation activities, and sample contribution to study. Basic Necessities Survey (BNS) scores (Davies & Smith, 1998) are used as an indicator of wealth and normalised according to the maximum possible score for each landscape. Score is for comparison between villages but does not represent standardized value for comparison between the Northern Plains and Eastern Plains

Village	Northern Plains			KSWS		
	Dangphlat	Kunapheap	Antil	Sre Preah	Gati	Chak Char
Village Accessibility	High	Medium	Low	High	Medium	Low
Dominant livelihoods	Paddy rice, cash crops, labour	Paddy rice, chamkar rice, cash crops	Paddy rice, labour, cash crops	Cash crops, labour, paddy rice	Chamkar rice, labour, cash crops	Paddy rice, cash crops, labour
Ethnicity	Khmer, Kuoy	Khmer	Khmer	Bunong, Khmer	Bunong, Khmer	Bunong, Khmer
Basic Necessities Score (mean and standard deviation)	0.68, 0.11	0.59, 0.11	0.55, 0.11	0.63, 0.11	0.63, 0.12	0.57, 0.11
Indigenous Communal Tenure	No	No	No	No	Yes	Yes
Conservation presence:						
<i>Protected Area</i>	✓		✓	✓	✓	✓
<i>Birds Nest Protection</i>	✓		✓			
<i>Wildlife friendly rice</i>	✓					
<i>Community Forest</i>		✓				
<i>REDD+</i>				✓	✓	✓
Economic Land Concession	Nearby	Nearby	Nearby	Nearby	Distant	Nearby
Focus Group Discussion participants (F=Female)	6 (2F)	7 (2F)	5 (1F)	7 (3F)	7 (2F)	7 (2F)
Key Informant Interviews	13	11	10	10	10	12
Households surveyed 2017/2018	111	44	58	32	31	31

Key Informant Interviews

We selected our key informants based on their involvement in a specific component of the landscape, such as agriculture, small business, health, education, conservation, migration, decision-making, and wealth. Selection began with a consultation with the village chief, followed by snowball sampling whereby we asked individuals (key informants or villagers) to recommend interviewees until we reached a saturation point (Newing, 2010). Recognizing the heterogeneous nature of social landscapes, informants represented a range of age groups, income levels and cultural backgrounds. We interviewed 65 informants at the village level (Table 3) and conducted a further 47 interviews with representatives of institutions engaged in natural resource management decisions in the landscapes. Institutions operated at various scales, from village to national, but actions directly impacted the landscapes of focus. Grounded theory (Corbin & Strauss, 1990) - the integration of data collection and analysis - guided our interview process. Key informant interview questions were structured around themes of governance, natural resources, wealth, development aspirations and perceptions of change over time, but tailored to individuals and topics. We analysed each interview for the emergence of issues and concepts relevant to our research objectives, and pursued these issues further in subsequent interviews. We followed principles of appreciative inquiry (Reed, 2006), discussing potential solutions to issues as they emerged locally.

Focus Group Discussions

In each village, we convened a focus group to discuss drivers of change and social-ecological impacts. We worked with the village chief to invite participants in person, selecting villagers in the older demographic with knowledge of the history of the village. We ensured the final group reflected the diversity of household incomes in the village and included both women and men to build consensus on the discussion outputs. In each group, we used historical trends analysis (adapted from Basuki et al., 2011; Boedhihartono, 2012; Shepherd & Blockhus, 2008) to understand social-ecological change and local perspectives at the village scale. In each discussion, we built a historical timeline for the landscape, including social, environmental and political events that occurred within the village and at higher scales. We did not define a timeframe, allowing participants to offer information on what they felt was relevant to the discussion. We asked participants to identify key events that had an impact on natural resources, and whether the impact was positive or negative. We repeated the question for life in the village, asking which events have brought positive and negative changes to people's lives. We did not restrict or define quality of life, instead leaving the question open-ended for participants to define individually. We then asked participants their future expectations for the landscape and which institutions they expected to have influence in future conservation and development outcomes.

Household surveys

During the period of research, WCS conducted household surveys in the Northern plains landscape and in KSWs. The 2017 surveys covered socio-economic information and local perceptions, and contributed to long term datasets on local livelihoods in areas where conservation activities are taking place. The household survey in KSWs is part of the Social Impact Assessment (SIA) for the REDD+ project. Households were randomly selected in each of the twenty villages involved in the REDD+ project, with a minimum sample of thirty households per village for a total of 620 responses. In villages that are separated into discrete settlements, the sample was proportionally stratified by settlement. The design and purpose of the household survey in the Northern Plains is to evaluate the impact of biodiversity conservation on local communities (Clements, 2012). Household selection was initially random stratified sampling based on a participatory wealth ranking exercise in villages inside and outside the PA network, according to the original survey design by Clements and Milner-Gulland (2015). The 2017 survey followed the original survey design and involved 1046 responses from 18 villages, (11 within the PAs). The methodology and medium term results of the impact evaluation are described in Beauchamp et al. (2018a).

In both sites, interviews were conducted with the household head using structured questionnaires. The Basic Necessities Survey (BNS) is used in the Northern Plains and KSWs as a wealth index, specifically derived in the local context. Davies and Smith (1998) outline the procedures for establishing and using the BNS to monitor livelihoods in a specific location. As such, BNS scores cannot be compared across the two landscapes. For the purpose of this study, household surveys covering the period 2008-2014 are used to verify long term landscape trends described in interviews and focus groups. The 2017 surveys provide landscape-wide perspectives on natural resources, governance and livelihood performance.

Analysis

The iterative nature of grounded theory allowed for the categorization of themes as they emerged, which further directed inquiry. Focus group discussions elucidated key drivers of development and consequent deforestation and degradation, which were further explored in key informant interviews. Interview content was categorized into ten themes that inductively emerged from discussions: institutions, natural resources, aspirations, migration, infrastructure, agribusiness, health, education, wealth, and illegal activities. The historical trends analysis conducted in each focus group discussion was collated for each landscape to expose key events and trends. Historical similarities between all villages gave rise to key trends, reflecting thematically similar but temporally different development

pathways. Timelines allowed for exploration of themes over time, verified by historical data, observations, and secondary sources, including articles from peer-reviewed journals and grey literature. From the information gathered we identified feasible development pathways in each landscape and potential repercussions for conservation. We determine likely future scenarios and potential leverage points for navigating trade-offs. Scenarios were developed post-hoc with the intention of contrasting social-ecological change in landscapes under different conservation approaches, building from historical trends. Three scenarios were chosen to capture different conservation paradigms of exclusion, integration and prioritization. Themes highlighted in scenarios reflect those that were raised during discussions about the future of each landscape.

Results

Forest landscape transition histories

The pace and direction of change in rural forest landscapes in Cambodia over the past 40 years have been influenced by diverse factors at multiple scales. The focus groups generated historical timelines in each village documenting important social, economic, cultural, political, and environmental events. While each village conveyed unique histories, similar themes ran through both landscapes. According to focus groups, the Khmer Rouge (1975-1979) affected all villages, forcing communities to relocate to the district centre. Resettlement occurred at various stages after 1980. When communities returned, they began a process of rebuilding livelihoods, restoring farmlands and exploiting forest products for food, shelter, and income. Gradual stability and tenure security between 1980 and early 2000s enabled a slow accumulation of capital and resources, leading to capital accumulation. Table 4 highlights key features of the historical timeline. Focus groups, key informant interviews, and secondary sources are used to expand the timeline below.

Table 4: Historical Timeline for the Northern Plains (left) and KSWS (right) in Cambodia. Information on events were gathered in discussions in three villages in each landscape and amalgamated to form a rich history of changing forest landscapes in rural Cambodia

	Northern Plains	KSWS
1975	Khmer Rouge Regime <i>People were moved from their villages to the district</i>	
1980	Rebuilding and Instability <i>People returned to their villages, began to farm collectively and then privately. Khmer Rouge maintained a presence in Preah Vihear, conflict continued, and some people were unable to settle in their village</i> <i>Fear of Khmer Rouge meant people did not participate in elections</i>	Rebuilding <i>People returned to their villages, collected resin, farmed rice and vegetables, raised livestock and hunted</i> <i>Bridge and road were damaged from war, repaired in 1990.</i> <i>Accessible villages began to grow cashew</i> <i>Health Centre built</i>
1995		Asset transformation <i>Samling logging company established</i> <i>Khmer migration to more accessible villages</i> <i>Villagers buy motorbikes, open shops</i> <i>Villagers log high value timber, grow cassava and cashew</i> <i>NGOs commence conservation and development initiatives in villages</i>
2000	Asset transformation <i>Conflict ended in 1998, and people began to build houses and open shops. Bucket wells were built, followed by pump wells. Some people bought motorbikes. More accessible village bought minitractors</i>	
2007	Capital accumulation <i>Better roads increased access to healthcare and markets</i> <i>Less accessible villages bought mini-tractors</i> <i>Villagers began to diversify crops, including cassava and sesame</i> <i>Economic Land Concessions established and begin to clear forest</i> <i>Health and education infrastructure improved</i>	Capital accumulation and re-investment <i>More accessible villagers grow rubber</i> <i>Micro-finance available</i> <i>Indigenous Communal Tenure initiatives and private land tenure established</i> <i>Economic land concessions established and clear forest</i> <i>Corruption and illegal logging are high concerns</i> <i>Transport and communication infrastructure improve accessibility of remote villages</i>
Present		

During the focus groups in the Northern Plains villages of Dangphlat, Kunapheap and Antil, participants shared how guerrilla warfare between the Khmer Rouge and Government continued to threaten local communities after resettlement, inhibiting their ability to recover from the war and regain social and economic stability. Villages grew rice for subsistent consumption, unable to produce and sell surplus due to the continued conflict, challenging environmental conditions, and Preah Vihear’s relative isolation from external markets. In the 1980s, households increased their income by expanding their farms, shifting from communal rice to farming as households, and selling resin. When

the Khmer Rouge dissolved, ex-Khmer Rouge, demobilized soldiers and displaced people remained in the area, and villages consisted of large settlements comprising heterogeneous groups (Clements, 2012). As conflict de-escalated in the late 1990s, households began to build their assets with small shops, motorbikes, and improved houses. Gradual stability brought new infrastructure to the villages, including wells, schools and basic health facilities. In the early 2000s, farmers in the more accessible villages began to purchase mini-tractors and expand land for cultivation, contributing to growing incomes and accumulation of assets.

In the late 2000s, new roads began to increase accessibility. The road from the district town to Dangphlat village was initially built in 2008 and improved in 2013, creating access to healthcare, markets, and services. The road to Kunapheap village was built in 2012 by the Government prior to commune elections but a local leader told us the road has remained in poor condition as the Government did not allocate funding for maintenance. A good road to Antil village is yet to be built, although mini-tractors and motorbikes can access the village most of the year. The value of roads for improving livelihoods was highlighted in all three focus groups and in key informant interviews, as stated by a young teacher in Antil village:

“Only a new road can change their lives. With a new road people will have more exposure to outside markets and opportunities and they will be motivated to improve their lives”

With improved access to markets and mini-tractors to expand land holdings, villages in the Northern Plains have recently started to produce cash crops such as cassava, cashew, and sesame. Household surveys show cash crop farmers in the Northern Plains were twice as numerous in 2014 as they were in 2008, and five times as numerous in 2017. Wealthier households in more accessible villages capitalize on new opportunities and diversify their income, while households with smaller landholdings or in more remote villages continue to grow subsistence rice. Key informants stated that when households owned a mini-tractor, they could clear more forest, increase efficiency and diversify income. According to Beauchamp et al. (2018a), wealthy households in the Northern Plains are more likely to own a shop and provide a service, to own a mini-tractor and a higher number of cattle, and to be highly involved in programs organized by local conservation NGOs. Households unable to acquire enough land, livestock, or agricultural resources to reinvest in assets or mechanised agricultural practices remained in a poverty trap (Beauchamp et al., 2018a).

More recently, local leaders stated that economic land concessions have posed threats to villages, including the expropriation of land and logging of resin trees with little or no compensation. In response, households are clearing forest to secure farmland, unperturbed by its legal status as a protected area. In two of the villages, key informants reported conflict with neighbouring economic

land concessions, involving loss of resin trees, issues of compensation and disagreement over land ownership. Social land concessions providing land for soldiers and their families also influence the trajectory of change in the Northern Plains. The proximity of the landscape to the Thai border has led to strategic placement of military in the area, resulting in forest clearance, other illegal activities, and a complicated social and political situation.

In KSWS, focus groups stressed the significance of the proximity of the villages to Vietnam as a driver of economic growth for the area. In 1988, local authorities began repairing the road on both sides of the Vietnamese border, allowing for trade. Subsequently, villages close to the border generated income from a range of activities, including retail shops and the sale of resin, vegetables, cashew, livestock and rice. Remote villagers did not develop at the same pace; the focus group in Chak Char said the village did not start growing cashews until 2000, and shops did not open until 2005. Close to Sre Preah, the Samling International Chhlong logging concession was granted in 1994. It was logged for three dry seasons between 1997 and 1999 before closing due to the nation-wide moratorium on logging concessions. Although the concession was established as a protected forest soon after, logging tracks increased accessibility into the forest, creating avenues for illegal logging and hunting. In the late 1990s, communities began to invest income from farming into new assets, including motorbikes, housing and village infrastructure, such as pump wells, health posts, and schools.

The rehabilitation of Provincial Road 76, linking the provincial town to the capital, coincided with the establishment of economic land concessions, as well as the introduction of cassava by Vietnamese traders and increasing waves of Khmer and Cham migration. These events set the landscape into a rapid and transformative transition, evident by the large scale of deforestation that occurred during this period (Figure 3). In all three focus groups, participants described how villagers and new migrants increased their wealth by growing cassava and engaging in the illegal timber market, giving rise to issues of debt, corruption, and elite capture of resources. Key informants emphasised how illegal logging generated wealth for households, but gave various dates for when this activity peaked. According to one farmer in Gati village:

Logging of high value timber began in 2002 when middlemen arrived in village, and peaked in 2006. The villagers benefited, they bought rice, paid labourers to farm their land and upgraded their houses. Now there is less timber, so families have stopped logging and returned to farming. But logging continues to occur because of corruption.

In Chak Char, increased logging coincided with the conversion of neighbouring forest in Snoul Wildlife Sanctuary and part of KSWS to a rubber concession in 2012. Roads built through the rubber

concession brought benefits of increased accessibility to the village, but participants in the focus group felt conflict between villagers and the concession and corruption overshadowed these benefits.

Similar to the Northern Plains, road rehabilitation in KSWs is followed by new infrastructure, including electricity, cell towers and village buildings, bringing new opportunities to villages. The 2017 REDD+ SIA in KSWs found that in 2012 and 2017, wealthy households were associated with owning more land, operating a shop, having at least one source of off-farm income or better educated household heads (unpublished data). Remote Indigenous communities with strong ties to their environmental surroundings are facing tough decisions on how to ensure their families can access development opportunities while protecting forest for future generations. We spoke with a local representative of the Indigenous Peoples Party, who expressed the challenges of conserving culture in a landscape of changing values and expectations. He felt development had brought positive changes to the village, but was concerned about concessions and migration taking away forest and land from Indigenous people.

Indigenous Communal Tenure (ICT) was recently established in Gati and Chak Char, formalizing Indigenous ownership over forest and land. Still in its early stages, key informants in both villages had mixed feelings over the benefits of ICT. They hoped ICT will help to leverage NGO support for conservation and development through the REDD+ project. Yet the perceived value of ICT in delivering social and environmental benefits depended on the functionality of local institutions, which varied between villages. As identified in Travers et al. (2015), communal land management is influenced by community leadership, institutions, and shared values within the community, affecting both compliance with local rules and the sustainability of ICT.

Local perceptions of key events in landscape transitions

In the historical trends analysis, focus groups identified several events and changes that have had a positive impact on the villages (Figure 4). Expanding land-holdings, logging, roads, and cash crop production brought wealth to households, creating development opportunities. Participants frequently noted the importance of ‘outsiders’ or external institutions in facilitating these opportunities, particularly the role of middle-men and migrants opening shops and logging. As stated by a young male entrepreneur in KSWs:

“It is good that new people arrive, they know outside economics and people can learn from them”

As shown by Figure 4, the villages most accessible by road in each landscape, Sre Preah and Dangphlat, identified more positive changes than the villages with lower road accessibility. Three

villages identified logging as positively impacting their development. However, all six villages also identified negative impacts. Logging and the associated corruption negatively affect the environment, which in turn negatively affect people’s lives through events such as flooding. In Sre Preah, the focus group viewed the establishment of microfinance in the village as both positive and negative. Participants noted that microfinance brought opportunities for villagers to increase agricultural production but if yields are low, it can bring debt and difficulty. Currently, both landscapes are undergoing extensive road improvement, and the SIA for REDD+ finds that wealth indicators in remote villages of KSWs are catching up to accessible villages (unpublished data).

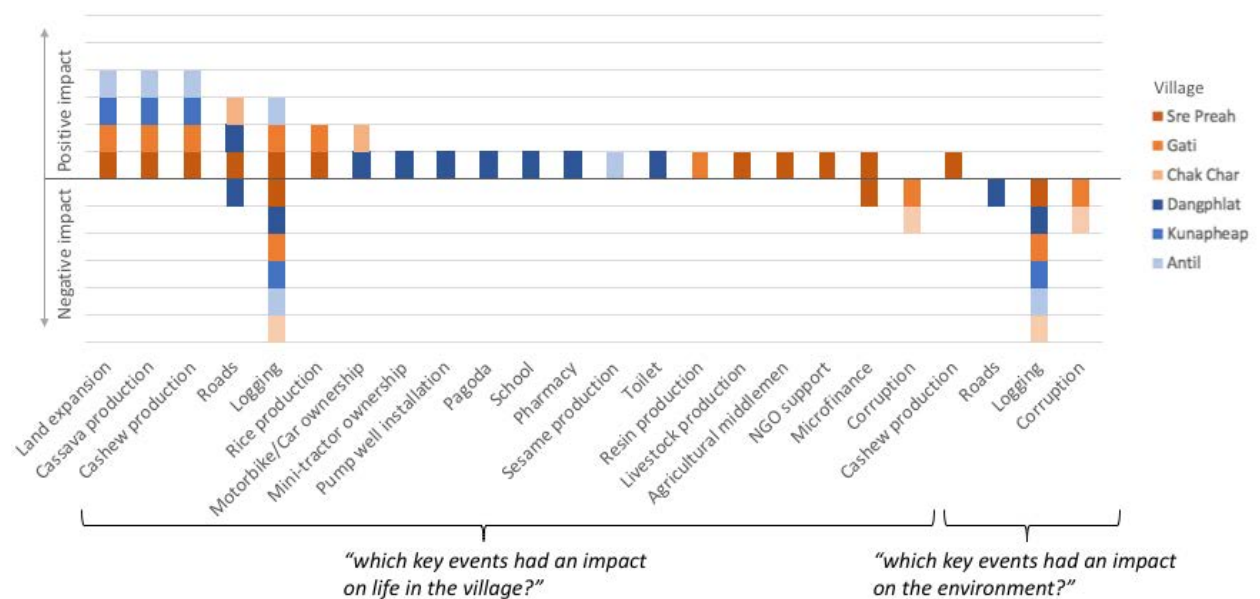


Figure 4: Events and changes with the most significant impact on livelihoods and the surrounding environment, as perceived by villagers. Columns show if the event was listed as significant in the focus group discussion that took place in each of the six villages. If the event was identified as a positive impact, it is marked above the black line. Events with a negative impact are marked below the black line. The four events identified with an environmental impact are on the right

In focus groups and interviews across all six villages, respondents felt that change positively impacted their communities and life improved with each new generation. At the household level, improvements in livelihoods largely focused on income, reflected in the 2017 household surveys. In response to the question “has your livelihood improved in the past 5 years?”, 53% of households in the Northern Plains and KSWs combined responded “improved” (Figure 5). When asked why, 74% and 60% of households in Northern Plains and KSWs respectively explicitly referred to income, earnings or involvement in commerce.

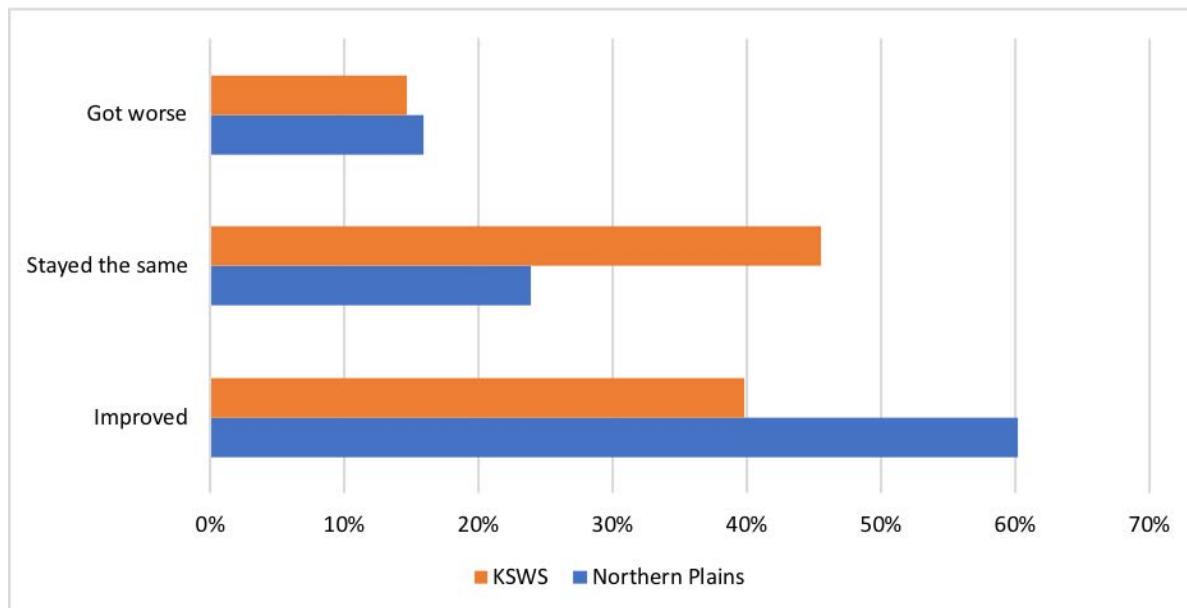


Figure 5: Response to “Has your livelihood improved in the past 5 years” in the 2017 Household Survey in KSWs and the Northern Plains

During interviews, we also discussed broader aspects of wellbeing linked to sustainable livelihoods, including natural, economic, human and social capitals (Scoones, 1998). Key informants frequently raised subjects of access to land, secure and stable income, healthy family members and fairness when discussing quality of life. Villagers referred to fairness as inclusion in local decision making and development opportunities and fair implementation of local rules. Broader issues regarding corruption and law enforcement that extended beyond social relations in the village were also a concern for many key informants, especially if rules were perceived to unfairly restrict access to land or natural resources. Improvements at the village level or higher were observed to be easier access and better-quality education, infrastructure such as electricity, roads and cell towers, and access to credit through micro-finance institutions and savings groups. But, as an elderly poor rice farmer observed, village-level improvements had a greater effect on households that could afford to benefit.

“The road has no effect on me because I can’t sell rice to the middleman. I do not have a mini-tractor and grow rice only for eating”

Our key informant discussions echoed well-being dimensions explored in-depth in Beauchamp et al (2018), specifically the importance of land. According to some of the poorest households in the villages, land underpins wellbeing. Key informants felt that without land, households cannot grow their income, as an elder farmer stated:

“The best way to improve households is to clear more land so they have land to farm in the future”

Villagers also recognise that land is a scarce resource in both landscapes. Many farmers grow fragrant rice which is low yielding, requires fewer inputs but receives a premium price. From the household surveys, average yields for paddy rice are 1.9t/ha in the Northern Plains and 1.6t/ha in KSWS. For cassava, the average yield is 4t/ha in the Northern Plains. In KSWS, cassava productivity has dropped from 3.5t/ha in 2012 to 1.8t/ha. Declining yield is consistent with reported trends in cassava cultivation across Asia, as continuous cassava production over long periods of time without fertilizer inputs degrades the soil and reduces its productivity (Howeler, 1991).

In focus groups, participants anticipated future livelihoods that are dependent on agriculture and off-farm income. In both landscapes, they expected the continued expansion of agriculture to replace forest cover, as well as smaller land parcels, more concessions, and natural hazards due to forest loss. Despite this, participants were eager for the younger generation to remain in the village and support the local economy, as stated by an elderly woman in the Northern Plains;

We want [the younger generation] to have a good education and become a teacher or doctor or mechanic because there will not be enough land to farm. We do not want them to move, but to create better jobs in the commune.

All groups desired improved infrastructure (schools, hospitals, toilets, wells, electricity) and identified a role for government and NGOs in reaching their desired objectives, based on observations of current and past projects. Focus groups in the more remote villages desired improved roads. When we inquired about the future in key informant interviews, responses reflected a focus on the present and less thought for the future, typical of poor rural populations (Banerjee et al., 2011). Interviews echoed the responses in the focus group discussions, expecting forests to decrease but also hoping for the villages to continue to develop. Some interviewees expected their children to farm, others hoped for high skilled jobs through improved education. In KSWS, the representative of the Indigenous Peoples Party spoke of ‘*protecting poor people in the village from powerful concessions companies that take their land*’. His response reflects the pervasive discourse throughout rural Cambodia on dispossession due to land concessions (Baird & Fox, 2015; Neef et al., 2013).

Declining forest cover and implications

In the 2017 household questionnaires, 98% of respondents said the forest provided them with benefits. The six most common responses were consistent across both landscapes (Figure 6). In the Northern Plains, 91% of respondents identified construction as the main benefit from forests. However, in KSWS, respondents were more likely to identify ecosystem services, possibly due to the presence of the REDD+ project.

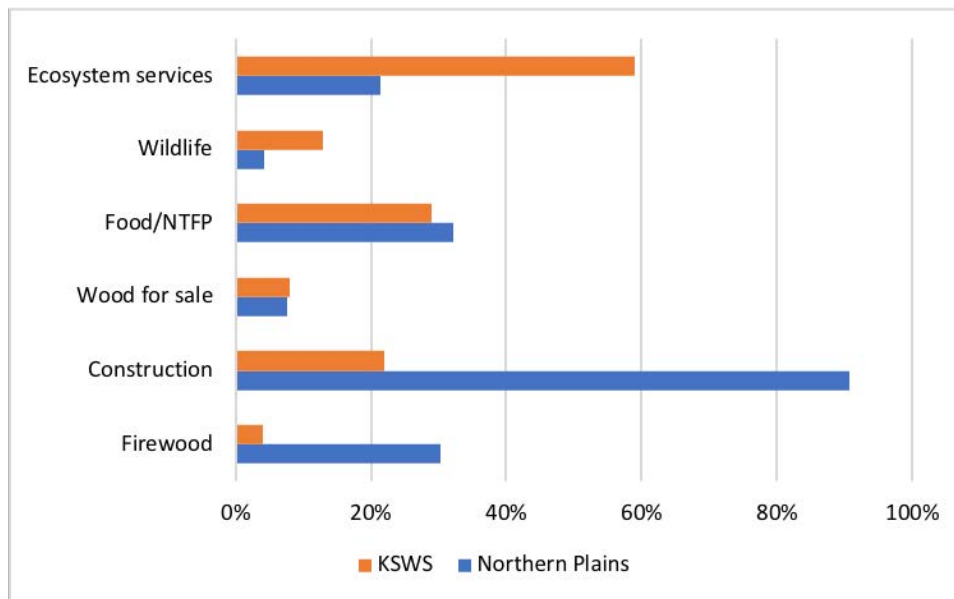


Figure 6: Perceived benefits from forests, obtained through household questionnaires in 2017. Participants often identified more than one benefit. Responses were coded into categories. Graph shows frequency of category mentioned in responses

Despite recognising indirect values, people tended to be fatalistic about the future of the forest, seeing it as a resource that would eventually diminish for future generations.

“If we keep clearing land and have no forest then that is our destiny” – Farmer, Northern Plains

Focus groups were also not optimistic about the future of the forest. In Gati and Chak Char villages in KSWS, participants wanted help from NGOs to protect the forest for future generations. In interviews we received mixed responses on whether forest should be protected; some felt PAs were inhibiting land expansion and income, others felt the need to conserve forest for future generations. In the Northern Plains, we spoke with villagers involved in bird nest protection who expressed the difficulty of the situation. He said some people were glad to take part in conservation programs, but local authorities also gave permission to villagers to cut trees and clear forest in nesting sites. While they thought stronger law enforcement could strengthen protection, they were uncertain how to bring about that change. No observations were made about change in management for KSWS and CWS from MAFF to MoE. In KSWS, we spoke with an Indigenous person who did not see a conflict between conservation and land expansion, but instead emphasised the importance of management.

“Land clearance is not a problem because Indigenous people have managed their lands for generations without harming the forest”.

Our discussions on forests frequently tended to shift towards rights and access, rather than conservation and threats. Views on whether to protect or use the forest were diverse in all villages, but emphasis on the lack of fair rules and implementation remained consistent. During interviews and focus groups, protected forests were at the centre of corruption concerns, including government agencies facilitating illegal logging and inequitable implementation of laws and regulations regarding forest clearance and use. As a result, some of our key informants shared their distrust in village and PA authorities and were concerned about growing disparities between wealthier, well-connected households and poorer households.

“Only the rich can afford to cut trees. The [conservation intervention] makes poor people poorer and the rich richer”.

Distrust in local authorities was also reported in KSWS 2017 household survey, with 68% of households responding no to the question “local leaders consider your concerns when they make decisions that affect you”. Similarly, in the Northern Plains 2017 survey, 79% of households responded disagree to the question “I think that everybody in the village is able to obtain land fairly”.

Discussion

Livelihoods in rural Cambodia are improving across generations. Driving this improvement is accessibility, expanding agricultural markets, and resource exploitation. Yet as households have built and accumulated capital in the years following the Khmer Rouge, they have also confronted issues of corruption, elite capture, and inequality. Control of, use of, and access to land has become a key issue of concern in many rural communities, especially those living in and around highly valued tropical forest.

Development pathways in the Northern Plains and KSWS show similar trends but are unique to their geographical, political and historical circumstances. In KSWS, proximity to the Vietnamese border, earlier accessibility and soil conditions enabled the uptake of cash crops as the dominant livelihood. The social and environmental change resulting from the boom and bust cycle of the cassava crop in Mondulkiri is a primary example (Mahanty & Milne, 2016). In the Northern Plains, limited accessibility and the longstanding practice of rice cultivation resulted in a slower uptake of cash crops, with mechanized agriculture driving livelihood improvement.

Currently, villagers in the Northern Plains and KSWS see agricultural expansion as the most viable pathway for improving livelihoods. For some households, migration and an illegal economy of high

value timber, is providing the push they need to build assets. Protected areas are constraining expansion, and illegal and corrupt use of forest resources are creating dissatisfaction among villages. Portions of PAs that have not received NGO support and investment are already lost to settlement and are emerging as flourishing rural towns. Remote villages desire better infrastructure and access, and despite recognition of natural values, accept that settlements may replace forests in the future. As populations grow, economic activity and migration to these landscapes is likely to continue, intensifying the rate at which forest is converted to other land use. Observing current trends, it appears unlikely that pressure on forests in Cambodia will decrease in the foreseeable future.

We see three plausible scenarios for the future of forest landscapes in Cambodia under different conservation approaches. We describe these scenarios as transformative change, stagnation, and incremental change. The three scenarios draw from the historical trends analysis and aim to capture components of the present that may intensify in the future under different management approaches, such as agricultural expansion, population growth, economic activity, and NGO involvement in the landscape. Different conservation approaches are distinguished to highlight difficult trade-offs in meeting socio-economic and environmental objectives along landscape transitions. By grounding these trade-offs in realistic futures for tropical forest landscapes, we hope to guide decision making for long term engagement in protected areas and rural development. The scenarios are stylized to typify across a spectrum of possibilities and cannot represent the full complexity of the situations they describe. In reality, development pathways will fall along a spectrum due to the complexity and unpredictability of social-ecological systems.

Under the transformative change scenario, conservation agencies collaboratively prioritise geographic areas for *in situ* protection of biodiversity at the national or regional level. Prioritization directs resources towards a smaller number of PAs, reducing competition between biodiversity and processes that threaten its existence (Cullen, 2013). Prioritization assumes PAs in Cambodia constrain smallholders and that rural economies will benefit from development opportunities made available through increased land access and security. Several methods are proposed for conservation prioritisation (Margules & Pressey, 2000; Sarkar et al., 2006), all of which require accurate and comprehensive inventories of components of biodiversity such as taxa sub-sets, habitat types, etc. In this scenario, it is essential that prioritization takes into account social and political conditions that constrain conservation and include tenure, law enforcement, cultural ties to land, and future land use scenarios, in addition to biophysical conditions. Reducing the geographic size of PAs strategically targets resources towards existing conservation, but also allocates resources towards socio-economic programs that can lead to long term conservation wins. For example, secure tenure, infrastructure, and agricultural intensification may reduce smallholder deforestation if supported by good governance (Acheampong et al., 2018; Kubitzka et al., 2018; Robinson et al., 2014). This pathway is about getting

the human population quickly engaged with potentially prosperous development opportunities and building a constituency for conservation once they are relatively well-off. It assumes that strategic targeting of conservation resources will increase effectiveness, and accepts a degree of loss of biodiversity in exchange for long term conservation outcomes for other species. Broad-scale conservation is a future by-product of development in this pathway.

In the stagnation scenario, existing PAs are retained, and conservation agencies restrict development to protect ecological integrity. The entire area of intact forest inside PAs is considered core conservation and cannot be allocated for future conversion. Smallholders are considered a threat to PAs, and conservation agencies take strict actions to prevent encroachment and logging. Proposed infrastructure development is subject to rigorous environmental impact assessment, and remote communities remain inaccessible to avert negative repercussions of road development.

Conservation agencies attempt to restrict the use of chemicals in agriculture and all wildlife hunting is banned. As a result, rural economies remain socio-economically stagnant; they are not able to intensify their agriculture, and they are penalized for logging or expanding agricultural land. In this future scenario, conservation agencies direct their resources towards threat-based conservation, responding to stresses instead of into long-term strategic planning, or proactive, adaptive theories of change. Conservation programs such as birds nest protection and wildlife friendly rice do not exist, and farmers struggle to increase their income. Day-to-day conservation activities in this scenario might correspond to what Boedhihartono et al. (2018) describes as whack-a-mole, in which interventions are triggered by issue-cycles and populism, instead of an integrated long-term approach to solving problems within a system. Threat-based measures taken by conservation organizations create animosity among local farmers and drive insidious exploitation, resulting in a degraded and unproductive landscape, and death by a thousand cuts (Laurance, 2010). Strict protection may lead to social conflict and immigration out of PAs. A key assumption in this scenario is the power of conservation agencies to carry out strict protection and have the highest authority on land use decisions. Recent conversion of large tracts of PAs in Cambodia to industrial agriculture (Yin, 2017) suggest conservation agencies may not be able to withstand forest conversion by powerful elites, reinforcing the notion that it will be poor smallholders who suffer under this scenario.

We characterise the third scenario as incremental change, as it describes a landscape that is transitioning gradually. In this scenario, Cambodia continues to designate significant land to protection, but all PAs are zoned as required by the 2008 Protected Area Law. Strict conservation areas exist in a mosaic of core, conservation, sustainable use, and community zones. The sustainable use zone is used for ecotourism, community forestry, recreation, mining, and economic land concessions. Incremental change assumes a degree of muddling through (Lindblom, 1959), in which decisions are made in response to social, economic and political signals, with the best available but

incomplete information at the time. Indigenous Communal Tenure exists in the mosaic of land uses, and remote communities are gradually more accessible as they become recipients of infrastructure initiatives led by government and non-government agencies. Endangered species remain at high risk due to smallholder forest conversion as accessibility within PAs increases, but over time households depend more on off-farm income to improve wellbeing. In this scenario, agencies use community-based conservation approaches to support local livelihoods and meet conservation goals. Conservation initiatives compete with more lucrative livelihood opportunities, limiting their ability to reduce degradation and deforestation (Brooks et al., 2013; Wright et al., 2016). As rural communities accumulate wealth over generations, forests are degraded and gradually decline. Incremental change assumes that zoning PAs will reduce pressures on forests, as communities are not strictly excluded. Yet the opportunity cost is high for locals to conserve their lands. Despite the presence of community conservation programs, locals pursue livelihoods that make the most sense to them and their economic needs. As a consequence, rural households continue to seek livelihoods that compete with conservation, and conservation agencies must continue to respond to changing conditions.

Collaborative governance of landscape transitions

Governance arrangements in each scenario described above will evolve differently, both affected by and affecting conservation and development outcomes. Good governance, including secure property rights, democratic participation, accountability, trust in collective leadership, and a conducive policy environment, would underpin prosperous and environmentally sustainable rural landscapes in Cambodia.

If the conservation strategy is to support a gradual shift to a sustainably managed mosaic landscape, conservation agencies would add value by contributing to a conducive institutional setting that supports collaborative approaches for governing systems (Armitage et al., 2012; Lockwood et al., 2010). The recent decentralization of natural resource management to the provincial level in Cambodia creates a window of opportunity for collaborative governance of PAs. Decentralized systems offer potential advantages such as subsidiarity, shared decision making authority, and democratic involvement in the allocation of resources (Colfer & Capistrano, 2005). Yet they also raise significant risks, such as elite capture and resource exploitation, especially if inhibited by governance constraints (Tacconi, 2007). The actors that can influence the social and environmental outcomes of landscape transitions are not restricted to conservation agencies; they include the informal and formal leaders within the village and at higher levels. Robust relationships characterized by high levels of communication and clear perceptions of roles and responsibilities among these leaders is fundamental for consensus driven decision making and navigating trade-offs. If conservation agencies can work

with key local decision makers, they can strengthen their capacity for good governance, which may lead to mutually beneficial collective action with positive social and environmental outcomes.

Recognising the difficulties of collaborative governance of natural resource management systems, it may be that conservation agencies are limited in their ability to refocus existing operations with the goal of improving governance. The experiences of conservation bodies in the Northern Plains and KSWS demonstrate the value of long-term engagement, and the continued challenges that arise. In both cases, multiple methods and disciplines have contributed to a better understanding of the social and political attributes that influence conservation and development outcomes and have led to evidence based interventions (Clements, 2012; Evans, 2013). While other PAs in Cambodia are also co-managed by NGOs, many do not receive the same support, and are faced with similar or more extreme challenges. In the Northern Plains and KSWS, WCS works directly with local decision makers to strengthen their capability for natural resource management. Yet, as the pace and nature of landscape transitions evolve, conservation strategies must be continually revisited and adapted to local conditions (Langston et al., 2019c). Building rich histories and understanding local perceptions of change can ensure that interventions to improve livelihoods connect with major economic opportunities. Approaches that strengthen governance and foster collaboration can help achieve targeted and contextually driven conservation and development objectives (Bennett et al., 2019)

We observed two initiatives that offer an opportunity for strengthening partnerships for better governance. In the Eastern Plains, conservation organizations are working with Indigenous groups to formalize Indigenous Communal Tenure, providing secure access and ownership over land to Indigenous communities. These partnerships also provide mechanisms for distributing and managing funding for the REDD+ project in KSWS. Some villagers we spoke with were enthusiastic about community driven schemes for protecting forests, but clearly stated needs for building capacity, authority and financial resources. In the Northern Plains, three conservation projects, a bird nest protection program, a premium payment scheme for wildlife-friendly rice, and an ecotourism program are providing incentives for communities to engage in conservation, with economic benefits (Beauchamp et al., 2018a). These projects are strengthening collaboration between conservation agencies and local institutions, creating a space for regular interaction and dialogue that could mobilize and engage more actors.

Conclusion

Tropical forest landscapes in Southeast Asia are in transition. Understanding, interpreting and navigating the diverse pressures for social, political, economic, and environmental demands of managing forest landscapes is inherently difficult. Situations are often highly complex and beyond the

direct control of decision makers (Evans et al., 2017). Yet, if conservation scientists wish to embed themselves in tropical forest landscapes to protect biodiversity and environmental services, they must be prepared to reconcile conservation and development trade-offs (Langston et al., 2019c).

Our results demonstrate the difficult trade-offs required if conservation is to better serve the needs of people living in tropical forest landscapes. In Cambodia, win-win scenarios meeting both biodiversity conservation and short term development goals do not exist. Conservation agencies will have to work with decision makers at multiple scales to strengthen governance and explore realistic scenarios for the future of protected areas and rural development. Harboring realistic expectations, understanding that trade-offs are necessary and making those trade-offs explicit can help conservation agencies target their efforts to protect biodiversity accurately whilst contributing to the development of prosperous rural communities.

Chapter 3: Learning from Local Perceptions for Strategic Road Development in Cambodia's Protected Forests

Abstract

Road development in tropical forest landscapes is contentious. Local preferences are often subordinated to global economic and environmental concerns. Opportunities to seek solutions based on local context are rare. We examined local perspectives on road development within Cambodia's Keo Seima Wildlife Sanctuary to explore opportunities for optimizing conservation and development outcomes. We conducted household surveys to document the perceived benefits and risks of road development. We found that in the sanctuary, road rehabilitation may accelerate transitions to intensified agriculture and diversified, off-farm incomes. All households prefer good roads and poorer households prioritize road development over other village infrastructure. Households perceive the most prominent benefit of roads to be access to hospital. Local government authorities are responsible for controlling land use and conversion within village boundaries and are therefore highly influential in determining the social and environmental outcomes of roads. Strategies to mitigate environmental risks of roads without constraining development benefits must focus on improving local capacity for decision-making and transparency. Local institutions in tropical forest landscapes must have greater control over development benefits if they are to reinvest assets to achieve conservation success.



Introduction

Reconciling the trade-offs between negative environmental impacts and societal benefits of roads is inherently challenging. In tropical developing countries, roads can increase the effectiveness of agricultural extension services and adoption of improved agricultural technology, increase school enrolment, increase market access by lowering transportation costs, and shift households from agriculture to service-based employment (Aggarwal, 2018; Khandker et al., 2009; Mu & Van de Walle, 2011; Rammelt & Leung, 2017). Roads also disturb tropical forest ecosystems (Laurance, 2015; Laurance et al., 2009; Laurance et al., 2015b; Trombulak & Frissell, 2000). The correlation between road density and deforestation is well documented across the global tropics (Angelsen & Kaimowitz, 1999; Barber et al., 2014; Geist & Lambin, 2001). Less is known about the complex social, economic, and political aspects of road development at the landscape scale, especially from the perspective of remote forest communities (Alamgir et al., 2017; Clements et al., 2018).

Conservation is increasingly recognising the importance of understanding local perceptions, preferences, and priorities for sound environmental management (Bennett, 2016). Yet rural people are rarely consulted when identifying potential gains and risks of roads through tropical forests (Clements et al., 2018). Road development is often part of political agendas to achieve economic growth (Fernández-Llamazares et al., 2018; Laurance, 2018; Sloan et al., 2018). Roads can provide access to markets and health and education services, opportunities for information exchange, and enabling conditions for the provision of electricity and water services (Hettige, 2006; Jacoby, 2000). Yet evaluations of rural road projects often lack rigorous or transparent empirical impact assessment. Unjustified assumptions over local impacts are frequent (Van de Walle, 2009). Recently, scholars have drawn attention to hidden socio-economic and political risks of roads and the impacts of roads on Indigenous people in the tropics (Alamgir et al., 2017; Clements et al., 2018; Laurance, 2018; Sloan et al., 2019a). Benefits of road development may be unevenly distributed and can lead to increased competition for labour and exacerbate wealth inequalities between rural households (Jacoby, 2000; Rammelt & Leung, 2017).

Identifying benefits and risks of roads before their development gains momentum is important to make spatial and temporal trade-offs explicit (Conde et al., 2007; Laurance & Arrea, 2017). As roads improve accessibility, they enable access to technology for improving livelihoods (Jouanjean, 2013). Combined with environmental protection policies, the transition from low productivity livelihood systems into more prosperous livelihoods can facilitate long term conservation benefits (Muller & Zeller, 2002; Munroe et al., 2002). In Ghana, Acheampong et al. (2018) find that road improvement enhances smallholder productivity and thereby reduces forest encroachment. In India, Kaczan (2017) found road construction contributed to tree cover expansion, indicating the role of

rural roads in facilitating reforestation. Over a longer timespan and with appropriate policies, roads can provide the impetus for rural communities to move out of poverty – the standard rationale for road development (Jouanjean, 2013). Societies may then reinvest remnant in forest conservation after initial deforestation or reduce pressure on forests via urbanization (Ehrhardt-Martinez et al., 2002; Mather et al., 1999).

The increase in the number of infrastructure projects in tropical countries driven substantially by the China-led Belt and Road Initiative requires a concomitant increase in targeted, evidence-based, holistic, contextual research on road development (Ascensão et al., 2018; Lechner et al., 2018). Countries that may have the most to gain from improved infrastructure are also at risk of substantial harm to natural ecosystems (Balmford et al., 2016; Laurance et al., 2014a). Compromise solutions of environmentally-viable road development such as the re-routing of new roads to maximise social-economic returns and minimize ecological costs are rare (Caro et al., 2014; Hopcraft et al., 2015). Top-down, external pressure requiring governments to restrict road building through forests is unlikely to resolve issues in areas that do not receive international attention (Caro et al., 2014). Solutions will be easier to find if they are inspired by the people living in and governing tropical forest landscapes, in line with principles of ‘sustainability science’ (Clark & Dickson, 2003). That means problems must be framed collaboratively (Brondizio, 2017), relevant to locally contextualized development problems, with the inclusion of local decision makers. Solutions must be perceived as credible both within and outside the scientific community (Langston et al., 2019b; Wall et al., 2017). Through partnerships and stakeholder forums, scientists have the opportunity to influence decisions that improve sustainability, as well as learn from their implementation. Empirical learning and technological innovations can help reduce the cost of infrastructure development in tropical countries and environmental impacts (Clevenger & Waltho, 2005; Schweikert et al., 2014; Van Der Ree et al., 2015).

In this paper, we examine landscape-level decision-making systems concerning road development in Cambodia. Cambodia exemplifies tensions between conservation and development and the urgent need for holistic research. More than half of the country’s 6,000 km of roads are of poor or bad quality and remote villages often do not have all-season access to basic needs (Ministry of Public Works and Transport, 2018). Yet roads are one of the largest threats to forest ecosystem integrity and conservation efforts (Lacerda et al., 2004). Focusing on Keo Seima Wildlife Sanctuary in Mondulkiri province, we explore the process of road development and improvement when roads are desired by local Indigenous communities but where environmental risks are high. We build on previous work that identifies roads as a major driver of deforestation in the area (Evans et al., 2009) and explore how local communities perceive and prioritise road development. We suggest how local institutions and development strategies might mitigate the environmental impacts of roads. Our case study

demonstrates the value of local perceptions in framing and identifying opportunities for strategic road development.

Road development in Cambodia

The Kingdom of Cambodia lies within the Indo-Burma biodiversity Hotspot, one of the world's most important and threatened biological regions (Myers et al., 2000; Sloan et al., 2014). Despite a growing urban industrialised economy, almost 80% of Cambodians live in rural areas (World Bank, 2019). Forest area is declining at a rate of 1.2% annually and has decreased from 71% to 52% of the national territorial extent over 1990-2015 (FAO, 2015b). High deforestation, poor governance, and high rural migration places Cambodia on the initial stages of the forest transition curve (Mather, 1992), with no indication of conditions changing (Riggs et al., 2018; Scheidel & Work, 2018). Government policies prescribe a balance between conservation and development, but in reality political interests favour economic growth (Beauchamp et al., 2018b).

Cambodia's economic policies strategically align with China's Belt and Road Initiative, which seeks to connect and integrate Asia with Europe and Africa through infrastructure and investment (Chheang, 2017). Investment in transport infrastructure is spreading further into remote areas of Cambodia, giving rise to concerns about the social and environmental consequences (Balmford et al., 2016; Mahanty & Milne, 2015; Sokphea, 2017). As is common in other countries, rural road construction in Cambodia is often the responsibility of local government authorities that do not have sufficient funds and resources to carry out Environmental Impact Assessments (EIAs) or allocate funding towards mitigation strategies and road maintenance (Alamgir et al., 2019; Crist et al., 2013). Even when mandated by law, EIAs are broadly considered superficial and inadequate in many aspects (Schulte & Stetser, 2014). In protected areas, conservation authorities must work within local governance systems to balance social, economic and environmental objectives.

Case study: Keo Seima Wildlife Sanctuary

Keo Seima Wildlife Sanctuary is located at the southern perimeter of Mondulkiri province, bordering Vietnam. Previously demarcated as the Samling Industrial Logging Concession, the area was designated a biodiversity conservation area in 2002 and declared as Seima Protection Forest in 2009 under the Ministry of Agriculture, Fisheries, and Forestry (MAFF). The 292,690 ha Protected Area (PA) became Keo Seima Wildlife Sanctuary (KSWS) when the Ministry of Environment (MoE) became responsible for all protected areas in Cambodia in 2016. The PA is managed by the MoE with technical support from the Wildlife Conservation Society (WCS) and recently became the site of one of Cambodia's first active REDD+ projects, comprising of a 166,983 ha core protection zone (Evans,

2013). The KSWS species checklist records a total of 959 species, including plants, animals, and fungi (Griffin, 2019). A total of 75 species are listed as Critically Endangered, Endangered, or Vulnerable on the International Union for the Conservation of Nature's Red List of Threatened Species, including the world's largest known population of Black-Shanked Douc langur (*Pygathrix nigripes*), regionally important populations of Gaur (*Bos gaurus*), and globally important populations of Green Peafowl (*Pavo muticus*). Threatened flora include several species within the Fabaceae and Dipterocarpaceae families.

As a frontier area, KSWS is subject to high rates of in-migration, forest clearance by smallholders, hunting for the illegal wildlife trade, and logging for high value timber. Villages mostly consist of Indigenous Bunong communities, with a growing Khmer population. The Protected Area Law (2008) requires protected areas to be divided into four management zones; core zone, conservation zone, sustainable use zone and community zone. Villages can exist within the community zone and access resources within the community, sustainable use, and conservation zones. Many of the protected areas in Cambodia, especially those recently coming under the management of the Ministry of Environment such as KSWS, are not yet legally zoned, although the zonation process is currently under way in KSWS. Villages located inside KSWS therefore currently have a mix of official and unofficial boundary agreements with the MoE. Officially recognised boundaries and title include the Indigenous communities living in KSWS that have received "Indigenous Communal Title" (ICT), which recognises their land ownership based on traditional and historical use for residential land, agriculture, forest protection, spirit and burial forest, and future conversion⁷. Mapping village boundaries and providing support to ICT villages is a core part of the KSWS management strategy, clarifying which forest areas inside the KSWS border can be reserved for community use and which areas are part of the wildlife sanctuary.

In the early 2000s, the construction of National Road 76 transformed the landscape. The road extends across KSWS and the recently dissolved Snoul Wildlife Sanctuary, connecting Mondulkiri with provinces closer to the national capital Phnom Penh. The road catalysed forest conversion (Clements et al., 2014a) and facilitated trade between Vietnam and local villages. By 2013, almost all of Snoul Wildlife Sanctuary had been cleared of natural evergreen forest for agriculture and settlement, providing rationale for its degazettement in 2018 (Figure 7). Improved accessibility has enabled the provision of infrastructure, including electricity, and supported the shift from subsistence to cash crop farming, and in some cases into services and trade (Hak et al., 2018). Yet the majority of local roads to remote villages are still in poor condition, with some impassable during the rainy season.

⁷ For detailed account of ICT in KSWS, see Travers et al (2015).

Local commune authorities have limited budgets and cannot fulfil road maintenance investment requirements of all villages. The German Development Bank (KfW), in cooperation with the Ministry of Rural Development, recently rehabilitated four roads inside KSWS, totalling 16km in length. The initial proposal in 2015 included the rehabilitation of five roads in the core zone of KSWS. In consultation with conservation authorities, KfW assessed one road (highlighted in Figure 7) as conflicting with KfW sustainability principles and eliminated it from the program. The rehabilitation of four other roads on the border of KSWS, considered to be of lower environmental risk, was completed in 2017. Other road projects in the area include the recent construction of a road through a rubber concession bordering KSWS in 2016, ongoing road rehabilitation funded by commune authorities, and small-scale road maintenance with REDD+ funding. In addition, a new road is being built along the border of Vietnam for national security purposes, connecting to National Road 76 and cutting through intact evergreen forest within KSWS.

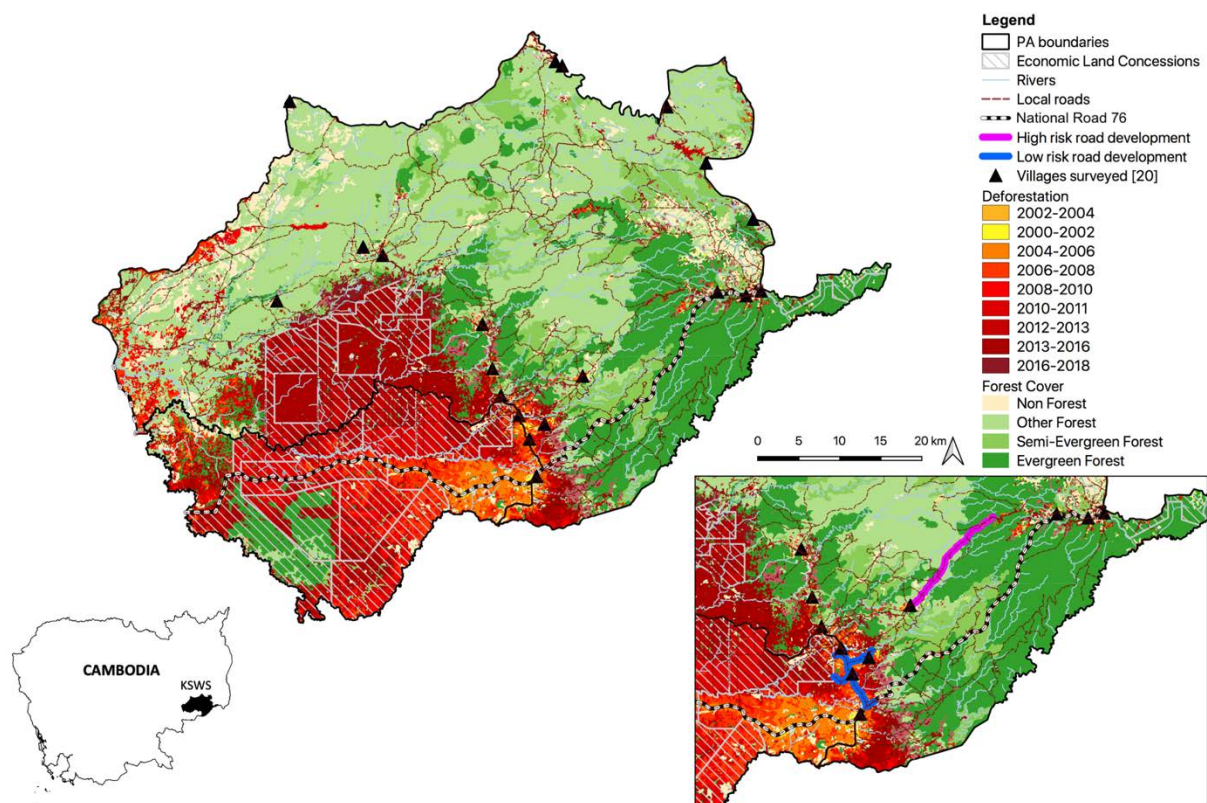


Figure 7: Keo Seima Wildlife Sanctuary and Snoul Wildlife Sanctuary showing deforestation from 2000 to 2017 and location of National Road 76. Land cover data was obtained from WCS's spatial dataset. Insert shows KfW road rehabilitation and risk assessment. Villages shown are the 20 included in the household survey.

Methods

We selected Keo Seima Wildlife Sanctuary as the study site due to the long-term engagement by WCS in the landscape and emerging issues concerning roads and conservation and development trade-offs. Recognizing roads as a persistent issue for conservation of KSWS and given the existing

depth of knowledge of environmental risks, we sought to better understand how local people living in the landscape perceived road development. We attempted to answer the following questions, by interviewing people in, and surveying, 20 villages within and around KSWS:

- What are the perceived benefits and risks posed by road development?
- Do remote communities prefer to remain isolated, or do they prefer increased accessibility?
- Is road development a priority for village infrastructure? If so, why?

In 2017 we completed a household survey within the 20 villages. The household survey was part of the Social Impact Assessment (SIA) for the REDD+ project in KSWS. Survey design was guided by previous household surveys conducted in KSWS (Evans, 2007; Travers et al., 2015), and was piloted in a village bordering the study site prior to data collection. Households were randomly selected, and interviews took place with the household head when possible, with verbal consent. Interviews were conducted independently by an experienced team of Cambodian surveyors contracted by WCS to avoid biased responses. The survey gathered information on social and economic conditions of the households, land ownership and agricultural expansion, and perceptions on governance, environmental values, and roads. Respondents were also asked about forest-related activities, such as collecting non-timber forest products and logging, with a specific focus on resin tapping – the dominant forest-based livelihood in the area (Evans et al., 2003). In the questions regarding road development, we distinguished between ‘good roads’ and ‘bad roads’ to differentiate between the existing roads in very poor condition and roads that are easier to traverse. In KSWS, good roads are typically wider, accessible year round, and surfaced with compacted laterite. Roads in bad condition are subject to flooding, often impassable during the wet season and in some cases too narrow for 4-wheel vehicles, necessitating use of motorbikes with wheel chains (Figure 8).



Figure 8: Examples of roads in Keo Seima Wildlife Sanctuary in good (left) and bad (right) condition.

As village population sizes were not known, a minimum sample size of 30 households was interviewed in each village, resulting in 620 responses overall. To complement the survey, we also

conducted key-informant interviews in three villages, each with a different level of accessibility (low, medium, high). Interviews were conducted independently of the conservation agencies by the first and second authors with a translator. We consulted with the village chief to select our initial key informants, then followed a process of snowball sampling in which individuals were recommended by interviewees. Key informants were selected to represent the diversity of households in the village with respect to age, ethnicity, income source, wealth, length of local residency, and local social status, until a saturation point was reached (Newing, 2010). We also interviewed local authorities, provincial government departments, and PA managers to build an understanding of decision-making relevant to road development (Table 5). Additional information was gathered through informal discussions with villagers and non-government organizations active in the landscape.

Table 5: Sources of Information

Household Survey	20 villages, 620 households
Key Informant Interviews	3 villages, 25 individuals
Local Authorities (Government and Traditional)	3 village authorities, 2 commune authorities, 1 district authority, 2 Indigenous communal tenure leaders
Provincial Government	Department of Rural Development Department of Public Works and Transportation Department of Land Management Department of Environment
PA Managers	2 Rangers 1 Park director 2 Police Wildlife Conservation Society Cambodia

In the household survey, questions addressing perceptions of roads were open-ended, allowing respondents to use their own words and level of detail. On completion of the survey, open-ended responses were coded by theme regarding benefits and risks of roads. For responses that fit more than one theme, multiple codes were assigned to the response. Frequency of themes across all respondents was calculated using NVivo V12.2.0 (2018).

The household survey involved a priority setting exercise that required respondents to rank village infrastructure types by perceived importance. Five infrastructure types were available for ranking: community buildings, sanitary toilets, domestic water supply, road improvement, and electricity. We then asked respondents to explain their choice of highest-ranked infrastructure. Statistical analysis

was used to explore the relationship between households' choice of most-important infrastructure and their socio-economic characteristics. The purpose of this step was to better understand the characteristics of the households that prioritised road development. With this knowledge, efforts to mitigate environmental impacts of roads might better target and complement the livelihood strategies of those living in the protected area (Bennett, 2016; Cinner & Pollnac, 2004). Households were categorized into a binary response variable differentiating households that prioritized roads over other infrastructure types (n=255) from all other households (n=355):

$$Y_{i,j} = \begin{cases} 1 & \text{if the } i\text{th household ranked roads as first priority for infrastructure in the } j\text{th village for } i = 1, \dots, n_j \\ 0 & \text{otherwise} \end{cases}$$

All household socio-economic predictor variables gathered from the survey were individually tested against this response variable to determine the statistical significance of its association. For continuous predictor variables, a two-sampled t-test was performed while the Wilcox rank-sum test was performed if the normality assumption was violated. For categorical predictor variables, we used Pearson's Chi Squared test. Subsequently, using only those predictor variables with bivariate significant associations of $p < 0.05$ (Table 2), we performed a logistic regression to describe the multi-variate relationship between the response and these predictor variables. A mixed-effects model was selected to account for the correlations between household data within a single village (Soe & Yeo-Chang, 2019; Wu, 2009). The mixed effects logistic regression was a random-intercept model using Y_{ij} as the response variable. The predictor variables were treated as fixed effects while the respondent's village was incorporated as a random effect (Table 6).

Table 6: Variables used in logistic regression with significant association to the response variable of roads ranked as first priority for infrastructure.

Variable	Description	Effect Type	Expected relationship for $Y_{ij} = 1$
Wealth index	Calculated using the Basic Necessities Survey (BNS), which provides a household poverty score derived from ownership and access information for a list of household assets and services. The survey was designed for KSWS following the procedure outlined by Davies and Smith (1998).	Fixed	Negative
Resin trees tapped	Number of trees tapped for resin as an income source	Fixed	Positive
Cassava production	Kilograms of cassava produced by household between April 2016 and March 2017	Fixed	Negative

Paddy rice production	Kilograms of paddy rice produced by household between April 2016 and March 2017	Fixed	Positive
Education	Household head years of schooling	Fixed	Negative
Accessibility	Village travel time to nearest health centre in wet season (hours)	Fixed	Positive
Village		Random	

Results

Local infrastructure priorities

Overall, 44% of respondents (255 households) identified roads as the highest priority for infrastructure development in the household survey (Figure 9). Domestic water supply ranked second to roads. Households identified multiple reasons for prioritizing road development, including access to health care and markets. Responses aligned with the perceived benefits of roads described in

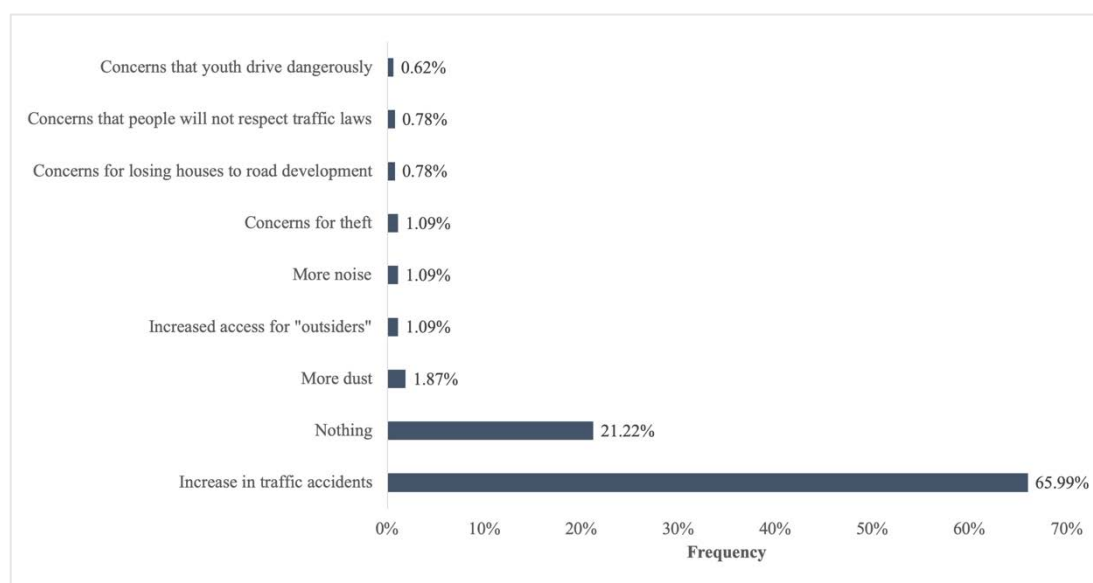


Figure 11: Negatives of good roads as perceived by households. Data obtained through household survey. Responses identified by more than one household.

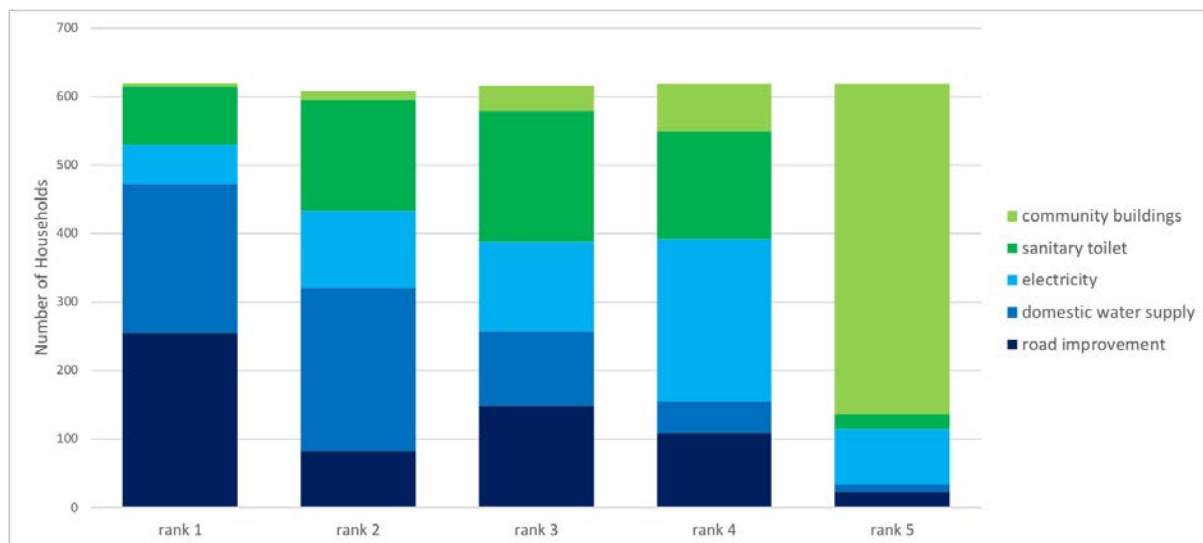


Figure 9: Prioritization of infrastructure development by household respondents. Respondents were provided with five types of infrastructure development and were asked to rank them in terms of perceived importance.

Logistic regression identified the household wealth index ($p=0.04$) and current accessibility to health care ($p=0.03$) as significantly predictors of whether a household ranked roads as the most important infrastructure development (Table 7). The odds ratio for these two variables indicates that households that ranked roads as their first priority for development were significantly poorer and more remote from health centres than other households. The model correctly classified 70.5% of household responses, including 58% of households that ranked road development as their first priority.

Table 7: Results of the fixed effects in logistic regression predicting likelihood of household ranking roads as first priority for infrastructure in village.

	Coefficient	SE	t	p	Odds Ratio	95% CI for odds ratio	
						Lower	Upper
Accessibility	.39	.18	2.20	.03*	1.48	1.04	2.11
Education	-.01	.03	-.18	.86	1.00	.94	1.05
Resin trees tapped	.00	9.00E-4	1.14	.26	1.00	1.00	1.00
Cassava production	-1.04E-5	8.17E-6	-1.27	.21	1.00	1.00	1.00
Paddy rice production	5.09E-5	4.90E-5	1.03	.30	1.00	1.00	1.00
Wealth index	-.07	.03	-2.03	.04*	.94	.88	1.00

Locally perceived benefits and risks of roads in Keo Seima Wildlife Sanctuary

In the 20 villages located inside and on the border of KSWs, all households included in the survey identified benefits of good roads. The most frequent response was “easy to travel to hospital”, followed by a general statement of easier travel (Figure 10). When asked about negatives (risks) of roads, the most frequent response was traffic accidents (

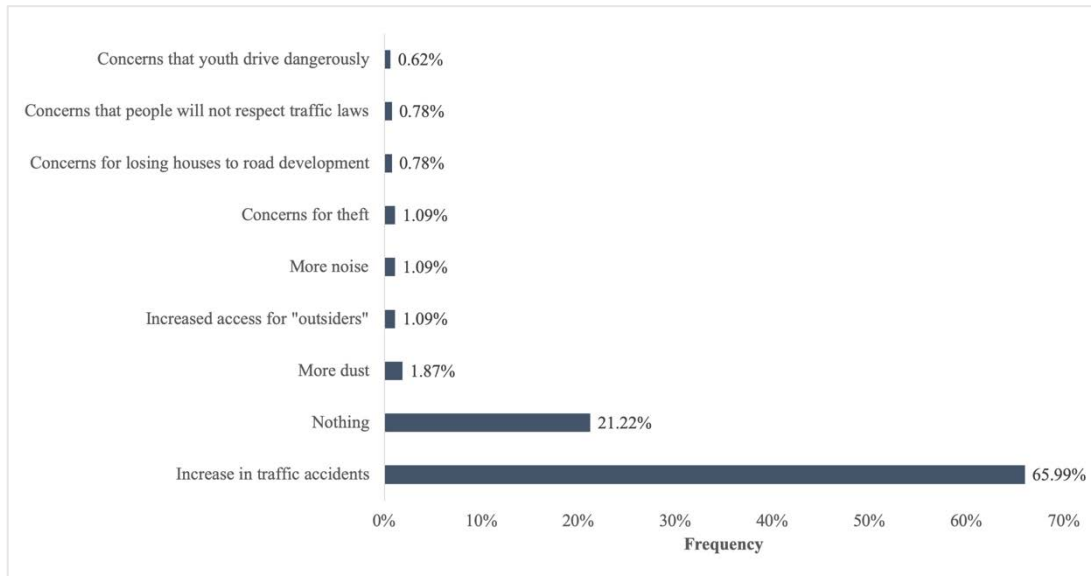
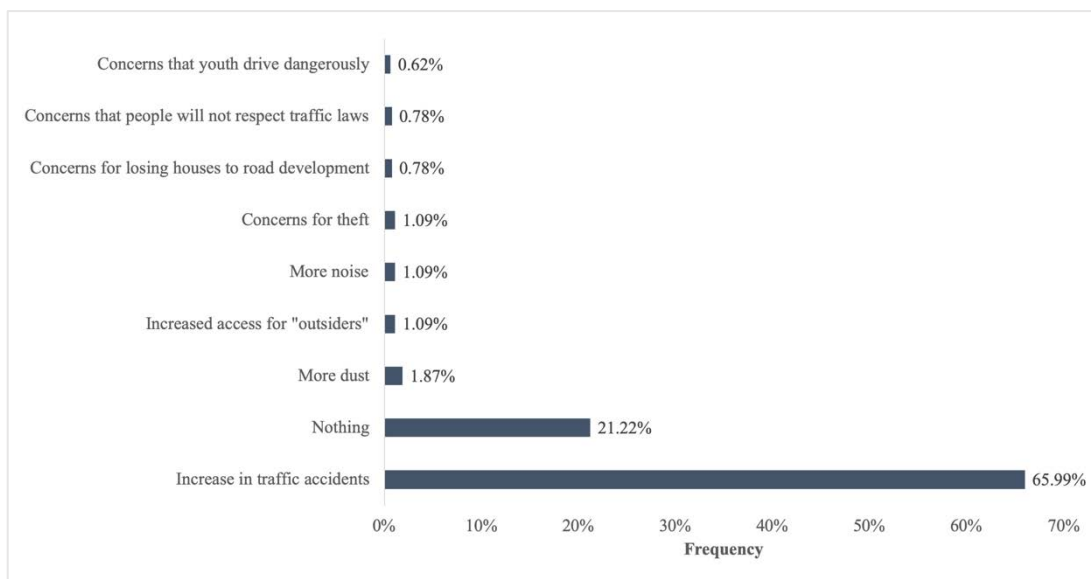


Figure 11).



Some 136 households (22%) stated that there were no negatives of good roads. After asking respondents to identify benefits and risks of roads, we asked if they preferred to have a good road or not, without specifying the second option as no road or a bad road. All 620 participants stated they preferred to have a good road, including the 72% of respondents that identified as Indigenous.

Household surveys were substantiated by key informant interviews in three villages. In one of the more remote villages, a previous commune chief stressed the importance of roads in improving livelihoods, noting that poor roads prevent the commune administration from providing services and

human resources. Village interviews also raised important nuances in road development. For some villages in KSWs, accessibility has increased due to roads developed by companies to access concessions. People acknowledged the benefits of the roads but they also reported that the concessions led to land conflicts and logging. For other villages, road rehabilitation enabled migration to the village, increasing competition between small businesses and increasing land prices:

“The new road has had a negative effect on business, more people come to sell goods in cars and on motorbikes and less people come to my shop. But it is easier for me to travel” – male shop owner

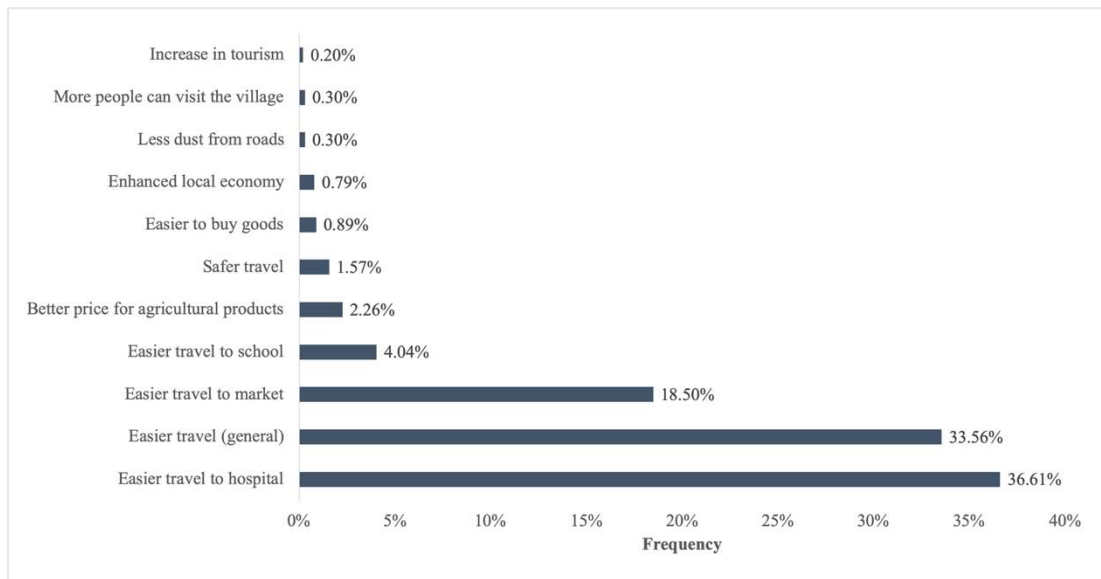


Figure 10: Positives good roads as perceived by households. Data obtained through household survey. Responses identified by more than one household.

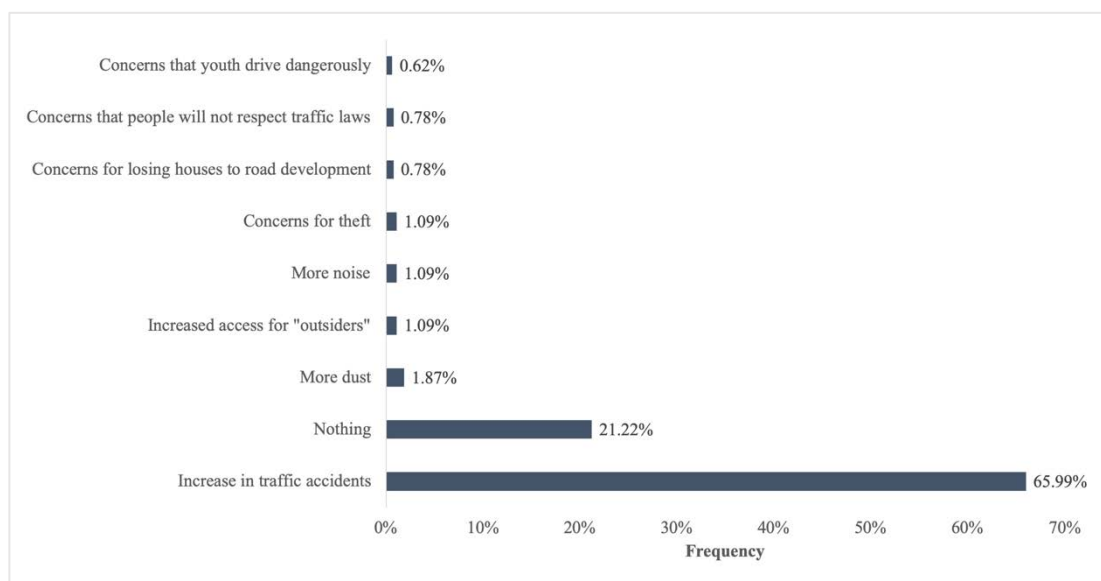


Figure 11: Negatives of good roads as perceived by households. Data obtained through household survey. Responses identified by more than one household.

Local institutions and road development

Multiple actors are involved in decisions concerning road development in Cambodia. The majority of road development inside KSWS falls under the responsibility of the commune administration and the Provincial Department of Rural Development (PRDT). Communes have a limited budget allocated for road development and demand frequently exceeds available funding. In 2018, funding was made available to 20 villages involved in the REDD+ program in KSWS. Half of villages identified funding for road improvement, construction or maintenance as a priority. To limit environmental impact, it was agreed that REDD+ funds could contribute to repairing roads within villages, rather than new road construction and rehabilitation roads through forest and agricultural areas prone to new settlement.

Preventing the establishment of new settlements and agricultural expansion following road improvement is a core part of the KSWS conservation strategy. Rangers conduct regular patrols in KSWS, focusing on areas at risk of conversion, identified by satellite imagery or patrol observations. During interviews, the KSWS park director raised the proposition that improved roads may help reach conservation goals, as it would enable rangers to traverse a larger area of the wildlife sanctuary. He then identified major constraints for improving protection and patrol, stating “*the problem here is capacity and resources*”. KSWS rangers struggle to prevent the creation of new settlements in KSWS, and are often required to investigate forest clearance after it has been identified by satellite. When we spoke with a ranger about the challenges and potential solutions, he offered a long-term perspective;

It's difficult to stop people and (the) transport of logs because they clear at night. To stop logging and clearance, people need to improve their quality of life. When they are wealthy, then they will stop logging.

To see if conservation strategies matched local government intentions, we asked key informants and village chiefs what the protocol was for new migrants wishing to settle in the village inside the PA. The village chiefs responded that they could permit new migrants to settle in the village if they had received permission to leave their prior village from the village chief. They stated that migrants obtained land in various ways; they could either purchase land, live with relatives or under some circumstances the village chief could allocate a piece of land for them to build a house or farm. The outcome depended on the social and institutional setting in the village. According to a local leader in one village that frequently receives new arrivals, the village or sub-village chiefs give migrants land for residential housing and farming at no expense. In another village that rarely receives new arrivals,

the village chief told us that no land use arrangement existed for migrants, and the village hoped to “keep out outsiders” in the future. In both cases, the village was located inside the protected area, and recently received ICT. Inconsistent policies between villages create ambiguity over rules, making it difficult to build a cohesive conservation strategy across KSWs. It also contributes to tenure insecurity, with 32% of respondents to the household survey stating they do not feel secure about their land rights (Figure 12). When asked to explain, the majority of respondents stated it was because they do not have a land certificate or are concerned about companies taking their land – a recent and highly publicised issue in Cambodia (Beauchamp et al., 2019; Gironde & Peeters, 2015).

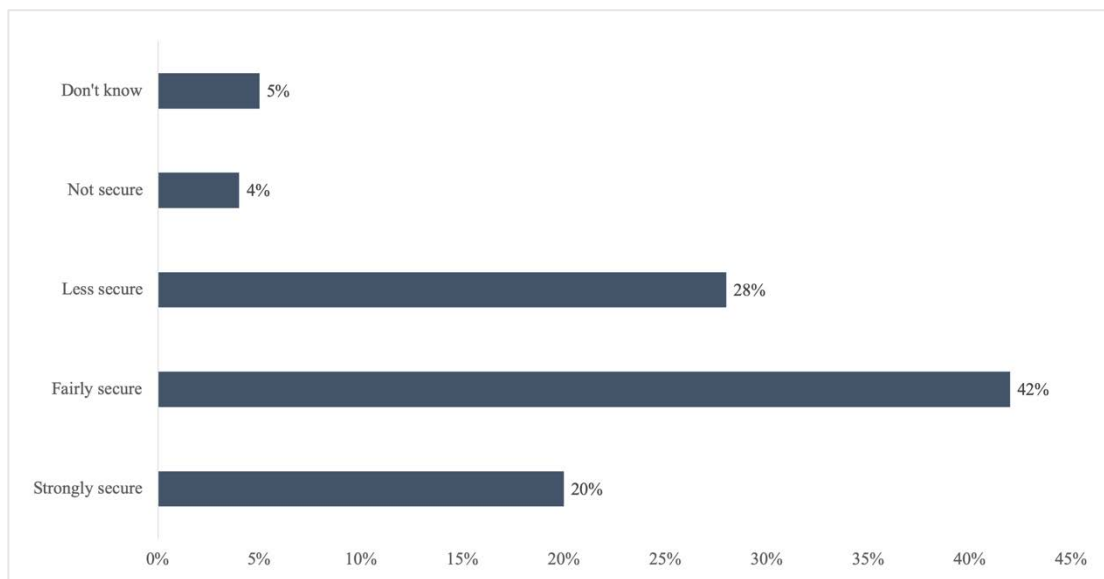


Figure 12: Tenure security as perceived by households. Data obtained through household survey

Discussion

Limiting road expansion in protected areas is a difficult but often necessary trade-off to maintain biodiversity located near rural human settlements (Caro, 2015). Yet an in-depth understanding of local conditions and perceptions can aid transparent decision-making to ensure trade-offs lead to more winners and fewer losers (Reed et al., 2016). Our results show that local perceptions of road improvement in KSWs are closely linked to improvements in wellbeing, including health, education, income, and satisfaction with travel (Beauchamp et al., 2018c). Local people expect that as access to remote villages improves, livelihood opportunities will increase, better prices will be obtained for agricultural commodities, goods for household consumption will be cheaper, and access to healthcare and schools will improve. These expectations align with wellbeing assessments on rural road

development (Duncan, 2007). The ex-post social impact assessment⁸ conducted by KfW following road rehabilitation in KSWS identifies several benefits to recipient villages, including improved income and prices for agricultural produce, easier access to schools and healthcare facilities, and reduced soil erosion. Poorer households in remote villages observe this trend, prioritizing roads over other infrastructure as a way to improve their livelihoods.

From the perspective of rural development, these results are not surprising. However, they force critical reflection on the future protection of the wildlife sanctuary. In KSWS, local communities desire improvements to the current road network and government agencies are responding to rural transport infrastructure needs. Trends show that poverty is decreasing across generations, and wealthier households are more likely to generate income from sources other than agriculture. In the long term, the increase in off-farm income among households may lead to land-use stabilization, reducing forest conversion (Klooster, 2003; Rudel et al., 2000; Zhang et al., 2008). Strategically planned roads, and the provisional infrastructure that often follows, may support this trend. Examples of increased accessibility leading to land-use stabilization exist, but are rarely documented (see Acheampong et al., 2018; Kaczan, 2017). Further research is required to evaluate empirical evidence on the policies and conditions that enable this transition (Ewers et al., 2009; Nanni et al., 2019; Rudel, 2015).

Understanding local perception of governance, accessibility, and well-being also offers a means for strengthening support for conservation (Bennett et al., 2019). A growing body of work demonstrates the importance of incorporating local conceptualizations of human wellbeing into the design and practice of conservation (Beauchamp et al., 2018c; Fry et al., 2017). Addressing local wellbeing is not only identified as an essential component of success (Clements, 2012), but the fulfilment of ethical obligations of conservation agencies towards local people (Milner-Gulland et al., 2014; Robinson, 2011). The most common response for benefits of road improvement, “easier to travel”, is similar to responses from Indigenous people of Malaysia in support of roads (Clements et al., 2018). Satisfaction with travel is linked with subjective well-being (Ettema et al., 2016; Sapkota, 2018), especially in poor remote areas. Local communities identified traffic accidents as a significant risk of road development, consistent with growing number of fatalities from road traffic accidents in Cambodia nationwide (Kitamura et al., 2018).

In KSWS, local perceptions of the connection between accessibility and well-being could help to strategically target funding towards community-based conservation efforts. As identified by the ranger interviewed, pressure on forest resources in KSWS may only decrease if people meet their

⁸ Sample size for Ex-Ante (2014) and Ex-Post (2017) social impact assessment was 90 households.

development aspirations. Deforestation rates in KSWs have slowed in recent years, although the cause and likelihood of this trend continuing is uncertain. If conservation agencies can continue to maintain a strong presence in KSWs, through programs such as REDD+, selective rehabilitation of roads may contribute to long-term conservation goals. This would require rigorous cost-benefit analysis to model potential gains against disruptions. For example, high vegetation density, high rainfall during the wet season and low accessibility limit effective law enforcement in protected areas (Jachmann, 2008). Roads can facilitate poaching and new settlement (Clements et al., 2014a; Laurance et al., 2009; Linkie et al., 2014), but road networks that are easy to access by vehicle can be more cost-efficient for patrolling, especially if resources are limited (Plumptre et al., 2014).

Although accessible villages are exposed to social-political risks often associated with roads, respondents did not explicitly identify these in the household survey. Social tension (Bettinger, 2014), unequal benefits (Khandker et al., 2009), and illegal wildlife poaching (Wilkie et al., 2000) were not identified by respondents. However, during key informant discussions, villagers were very aware of the social disruptions associated with increased accessibility of forest areas, including logging, migration, and concession development. Interviewees supported the prioritisation of roads identified in the household survey, but also shared grievances over the changing landscape. Many of these issues are symptoms of elite-driven policies that create highly unequal economic benefits, including investment in transport infrastructure (Alamgir et al., 2017). Logging and illegal exportation of high value timber such as Siamese Rosewood (*Dalbergia cochinchinensis*) inside protected areas has been the subject of multiple government and non-government investigations (Global Witness, 2015; Milne, 2015). Logging and its consequences are closely linked with agroindustrial concessions, which have caused significant social and ecological disruptions in rural forest areas (Davis et al., 2015; Tsujino et al., 2019). In KSWs, road improvements are not the direct cause of deforestation, but they cannot be separated from the changes that have occurred in the past decade that have transformed the area (Clements et al., 2014a; Mahanty & Milne, 2016).

Enhancing opportunities for strategic road development

Prioritize existing road networks

Our discussions with government actors involved in road development highlighted crucial information that could help strengthen gains and minimise environmental disruptions of roads. Firstly, ensuring that future road development in KSWs is restricted to rehabilitating existing roads could prevent further forest fragmentation and associated negative impacts (Goosem, 2007; Laurance et al., 2009). Enforcement of this rule for intact forest adheres to the principle of “avoid the first cut” (Laurance et al., 2015a). KSWs are part of the Eastern Plains protected area network and thus is

integral to maintaining intact wildlife corridors for the movement of large mammals. Villages located inside KSWS are already accessible via tracks and narrow roads in poor condition. However, this is not to say all existing roads in KSWS should be rehabilitated. Environmental impacts of wider, paved roads can be far worse than narrow tracks with partial canopy cover (Develey & Stouffer, 2001; Laurance et al., 2002; Laurance et al., 2009). An integral component of the road rehabilitation project completed by KfW was the screening phase. KfW consulted with WCS to assess environmental impacts of potential roads in KSWS. Roads that did not comply with KfW sustainability principles were withdrawn from the project.

Collaborative partnerships for impact assessment

Conservation NGOs supporting the management of protected areas in Cambodia may be well positioned to fill gaps caused by legal or procedural weaknesses in Environmental and Social Impact Assessment (ESIA). Uninhibited by Government standards, non-government actors can provide the nuance and detail necessary to evaluate roads on an individual basis, for both broad scale and local development (Laurance et al., 2015b; WWF, 2015). Yet NGOs are often limited by technical capacity and time and resources to sufficiently meet ESIA needs. Government collaboration with research organizations can bridge knowledge gaps and provide the datasets necessary for rigorous systematic analysis, including the mapping of official and unofficial road networks (Hughes, 2018; Laurance & Arrea, 2017; Meijer et al., 2018). Prioritization of projects that require ESIA will depend on the scale of the initiative, actors involved, and potential impacts. External involvement should contribute to strengthening partnerships for strategic road development, ensuring processes enhance transparency of internal governance and do not displace government's responsibilities and capabilities to do this in the future (Sloan et al., 2019b).

Improve capacity of local authorities

In KSWS, village authorities have the mandate to monitor migration and claims to land. In villages with communal title, an ICT committee is responsible for ensuring compliance with local regulations governing land use within ICT zones (Travers et al., 2015). Targeting and strengthening the capacity of local institutions to prevent smallholder forest clearance following road development may help to prevent negative environmental impacts. In their meta-analysis of the links between tenure and deforestation, Robinson et al. (2014) find tenure security is associated with less deforestation. In KSWS, 32% of households do not feel secure about their land. Initiatives that enhance tenure security may help mitigate long term environmental risks of roads in KSWS, but could also accelerate resource degradation (Deacon & Mueller, 2006; Milne, 2013). Addressing tenure issues in KSWS

therefore requires a careful approach, involving collaboration between rangers and local leaders to monitor and enforce compliance (Linkie et al., 2014).

Funding for maintenance

Road maintenance in tropical forests can ensure effective drainage, prevent soil movement and reduce damage to aquatic and terrestrial ecosystems (Sessions, 2007). The household survey found that easier travel to health services was seen by the local community as a major benefit of good quality roads. Distance is a significant factor in whether households use health centres in rural Cambodia, limiting the geographic coverage of public health services (Yanagisawa et al., 2004). Healthcare costs can lead to household debt and incentivise participation in illegal activities. Further research that explores healthcare challenges of the 20 villages located inside KSWS is needed to fully understand the role of roads in reducing healthcare costs and increasing accessibility. This information could inform future prioritisation and maintenance of roads in landscape. In some cases, closure and revegetation of roads constructed for logging may reduce ecosystem disturbance (Kleinschroth et al., 2015) and contribute to the prioritization of funding for maintenance (Walzer et al., 1987).

Implications for Conservation

Long term protection of biodiversity in tropical forests requires recognition of the present and future aspirations of people that live in forested landscapes. The immediate environmental costs of roads in tropical forests are undisputed, but opportunities to maximise benefits from finite road investment must be grounded in local systems. Larger scale, national conservation priority setting should be harmonized with these localized realities in ways that encompass the representative biodiversity refuges among rapidly growing and developing rural communities. The relationship between poverty, road development, and deforestation in KSWS demonstrates the need to incorporate local perceptions into long-term conservation strategies. Placing greater emphasis on the multiple dimensions of human wellbeing, the potential for roads to deliver long-term environmental gains deserves greater attention and requires stronger empirical evidence. Knowing the actors involved in decisions on road development and the ways in which local institutions govern subsequent impacts can support local strategies for mitigating social and environmental risks. With this information, strategic road development can support tropical forest landscapes that strive to incorporate and balance the needs of people and biodiversity.

Chapter 4: Actor network analysis to leverage improvements in conservation and development outcomes in Cambodia

Abstract

Network analysis has emerged as a useful tool for characterising relationships in decision-making structures and providing insights to the power relations that govern natural resources. We applied Actor Network Analysis in two rural Cambodian landscapes to examine decision-making structures that affect conservation and development systems. Using questionnaire data, we analyse structural features of networks of cooperation and exchange to identify patterns of action and processes of change. We supplement our analysis with qualitative information gathered on power and social-ecological components of landscapes to ensure comprehensive understanding of natural resource systems. Our study finds that power in Cambodia is distributed through a central hierarchy, and external actors must work at multiple scales to influence decision making; there is no single leverage point for interventions. Until now, cooperation between conservation and development actors has been lacking, we observe that actors tend to cluster within similar groups. Cross-sectoral collaboration may be enhanced by actors positioned as knowledge brokers, but these actors lack capacity to fulfil this role and require external support. Our study highlights the importance of non-government actors as conveners and facilitators to shape natural resource governance in the context of weak institutions. We contend that network analysis is greatly enhanced by comprehensive social-ecological understanding of landscapes. We hope to inspire more institutionalised use of diagnostics such as actor network analysis for enhanced natural resource governance.



Introduction

Natural resource governance involves decisions that are made by numerous and diverse actors, all affecting policy and implementation outcomes. Understanding their influence, recognizing their agency, and achieving better coordination among these numerous and diverse actors is vital for achieving sustainable resource governance. Yet many conservation initiatives fail because organizations pay inadequate attention to stakeholder characteristics and relationships. Social Network Analysis and Policy Network Analysis have emerged as tools for diagnosing and understanding patterns and relationships in decision making networks (Marin & Mayntz, 1991; Schneider, 1992; Scott & Carrington, 2011). Applied to natural resource management, network analysis can help identify the structures and processes through which policies and initiatives emerge, are organized, disseminated and implemented (Bodin & Prell, 2011). Network analysis involves the identification of influential actors and their mutual or conflicting interests and can provide insights to the power relations that determine development outcomes. It can be used to describe how relationships between relevant actors can constructively channel efforts for improving social, economic, and environmental outcomes.

Empirical evidence demonstrating the value of network analysis in natural resource governance continues to emerge (Angst et al., 2018; Downey, 2010; Mills et al., 2014; Sari et al., 2019). Recent studies cite the utility of Social Network Analysis (SNA) in understanding how local actors foster or hinder sustainable development (Bodin & Crona, 2009; Ernstson et al., 2008; Hirschi, 2010). Similarly, Policy Network Analysis (PNA) has been used to study governance structures and how actors participate in and are recognized in decision making processes (Brockhaus et al., 2014; Ndeinoma et al., 2018). In this paper, we combine these two approaches and use the term Actor Network Analysis (ANA) to describe the process of examining the relationships and structures of actors in a social-ecological system. We build from existing literature, recognizing the power of actors as decision makers or agents of change, as well as the importance of the structure of the network in influencing outcomes (Marsh & Smith, 2000). An actor may represent an organization, individual or group involved in decision making processes. By using the concept Actor Network Analysis, we acknowledge that actors may exist at multiple scales, and network analysis should include both components of SNA, such as power and relationships, and PNA, such as governance structure and decision making processes (Cash et al., 2006).

Natural resource governance is well recognized as being polycentric and multilevel (Andersson & Ostrom, 2008; Nagendra & Ostrom, 2012). As such, there is an increasing role for ANA to determine the conditions for improving the implementation of conservation and development initiatives. Rural landscapes in low and middle-income countries are changing rapidly (Laurance et al., 2014b).

Landscape scale interventions are attempting to influence the trajectories of landscape transitions with the goal of sustainable development (Reed et al., 2016). In many cases, conservation and development initiatives are in competition, requiring trade-offs and negotiated goals (Campbell et al., 2010; McShane et al., 2011). The extent to which interventions succeed in reconciling conservation and development trade-offs will be largely influenced by the actors involved in decision making and implementation (van Noordwijk, 2017).

In this paper, we use ANA to examine two landscapes in Cambodia where conservation and development are in conflict and actors are trying to improve natural resource governance. We ask the following questions; (1) which actors have the most influence in landscape development outcomes? (2) how do governance structures shape conservation and development outcomes? (3) how can institutional arrangements be leveraged to contribute to better management of landscapes? The results of our analysis have implications for the use of ANA in landscape scale initiatives and the methodological application of network analysis in natural resource governance.

Why networks?

Actor networks are comprised of individuals, groups or organizations (government and non-government) connected with each other through decision making relationships, such as policy, collaborative problem solving, co-management, and conflict resolution. ANA examines the structure of these relationships, looking beyond individual attributes of actors and focusing on network structure, power, patterns of information sharing, and how relationships enhance or inhibit functionality. ANA can provide insights into how and why decisions are made in societies, and how decisions shape social and environmental outcomes.

In natural resource systems, management and policy decisions often arise from complex arrangements of state and non-state actors that engage with decision making processes at multiple scales (Mwangi & Wardell, 2012). In low and middle-income countries, these natural resource systems are rapidly changing, and the number of actors with different objectives is increasing across temporal and spatial scales. Various actors are implementing initiatives at the landscape scale, aspiring to make long term improvements to conservation, production, and livelihoods (Sayer et al., 2016). Yet efforts to transform these systems require understanding how decision-making processes take place and how to influence them. Landscape transitions are not the result of a single organization driving change, but a constellation of actors working towards shared or conflicting objectives. Understanding leverage points, such as influential actors, knowledge brokers (Meyer, 2010), strong ties, weak ties, and synergies may enable actors to better meet both global environmental goals and the needs of local natural resource users (Prell et al., 2009).

The utility of network analysis to improve natural resource management is well argued in the literature (Bodin et al., 2006). However, if poor natural resource management stems from poor governance there may be a need to dive deeper into actors, structures and processes that are preventing social and environmental sustainability. By identifying causes of poor governance, we can then link network analysis to strengthening institutional capacity and building State capability. In this context, institutions may be the mechanisms and formal and informal rules that shape behaviour and decision making. Institutions are critical to ensuring good governance of landscape transitions, including property rights, managing common pool resources, creating sustainable livelihoods and preventing degradation and depletion of resources (Cleaver, 2017). Conservation and development initiatives frequently occur in the context of weak institutions, where externally driven interventions are not effective in the face of corruption and elite capture. Andrews et al. (2017) argue that successful policy implementation (effective functioning) stems less from good institutions, but instead it is effective functioning that builds good institutions. They suggest three processes for effective implementation of initiatives; leveraging – identifying charismatic and well-connected actors to build internal and external support, convening – creating interorganizational arrangements that bring together different people and resources, and connecting – creating indirect ties between actors to facilitate broad interaction. The strengthening and utilization of networks can then encourage learning between actors as changes occur and new ideas emerge, and actors make progress towards shared goals. In this virtuous circle, interactions lead to cooperation and consensus, and if actors perceive effectiveness, they are re-affirmed in their decision to take collective action (Lubell, 2003). Understanding how this process may occur in different contexts requires in-depth knowledge of power and influence, mechanisms for mobilization and information sharing and network structures.

Methods

Research setting

We conducted ANA as part of broader research on the social-ecological impacts of landscape transitions in Cambodia. As a country focused on peace building and economic growth, Cambodia exhibits both high rates of natural resource depletion and growth in prosperity. In rural areas, large portions of intact forest are being designated for private enterprise in industrial agriculture or mining at the expense of tropical biodiversity (Davis et al., 2015). With improved capabilities and resources, smallholders are expanding agricultural land into natural forest (Travers et al., 2015). While the agrarian transition has the potential to lead to permanent livelihood improvements, serious concerns are being raised over the degree to which globally significant biodiversity can continue exist in transformed rural landscapes (Mahood et al., 2016; Nuttall et al., 2017). Scheidel (2016) and Neef et

al. (2013) describe the expansion of agribusiness at the expense of local livelihoods. Actors engaged in conservation and development must make difficult management decisions; how to move through an agrarian transition while ensuring inclusive growth with minimal environmental harm.

Study Site

We completed two actor network analyses, the first in Preah Vihear province in Northern Cambodia and the second in Mondulhiri province on the eastern border of Cambodia and Vietnam. In each province we delineated a landscape of interest (Figure 13). Landscape delineation was determined by the emergent problems of each place. The delineations were a synthesis of diverse perspectives of problems, by local communities and regional and national natural resource-oriented organizations. The two landscapes, the Northern Plains (NP) and the Eastern Plains (EP), show characteristics of many of the rural landscapes in South East Asia; rapid land use change, high poverty and global interests in protecting areas of high conservation value. Forests and agricultural areas are habitat for threatened flora and fauna. Both landscapes consist of Protected Area (PA) networks managed by the Ministry of Environment with support from NGOs. Until recently, forest conservation responsibilities in Cambodia were divided among the Forestry Administration under the Ministry of Agriculture, Fisheries, and Forestry (MAFF) and the Ministry of Environment (MoE). In April 2016, sub-decree no. 69 transferred all protected areas to the MoE. The MAFF is responsible for economic land concessions and community forests outside of protected areas, as well as conservation areas and communities fisheries managed by the Fisheries Administration within the MAFF (Souter et al., 2016). Control of protected areas has also recently shifted from the central government to the provincial government. Consequently, decisions regarding protected areas must be passed through the Provincial Department of Environment (PDoE) and the provincial administration.

A number of protected areas in Cambodia are supported by conservation NGOs, which provide additional resources and strengthen government capacity. In the two study sites, the PDoE work closely with conservation NGOs and work with government and non-government stakeholders for land use planning and community development. With growing attention on development opportunities, protected area managers also engage with various private and government agencies representing agriculture, mining, Indigenous land tenure, and construction. The proximity of the protected landscapes to Cambodia's neighbours necessitates engagement with military, although this is more apparent in the Northern Plains. Detailed descriptions of the social and biophysical aspects of the two landscapes can be found in Clements (2012) and Travers et al. (2015). For the purpose of this study, the 'landscape' concept is defined by the actor's perceptions of their social and environmental systems – the landscapes do not have fixed boundaries. The landscapes depicted in Figure 13 are therefore reference points, but not exact representations of the areas studied.

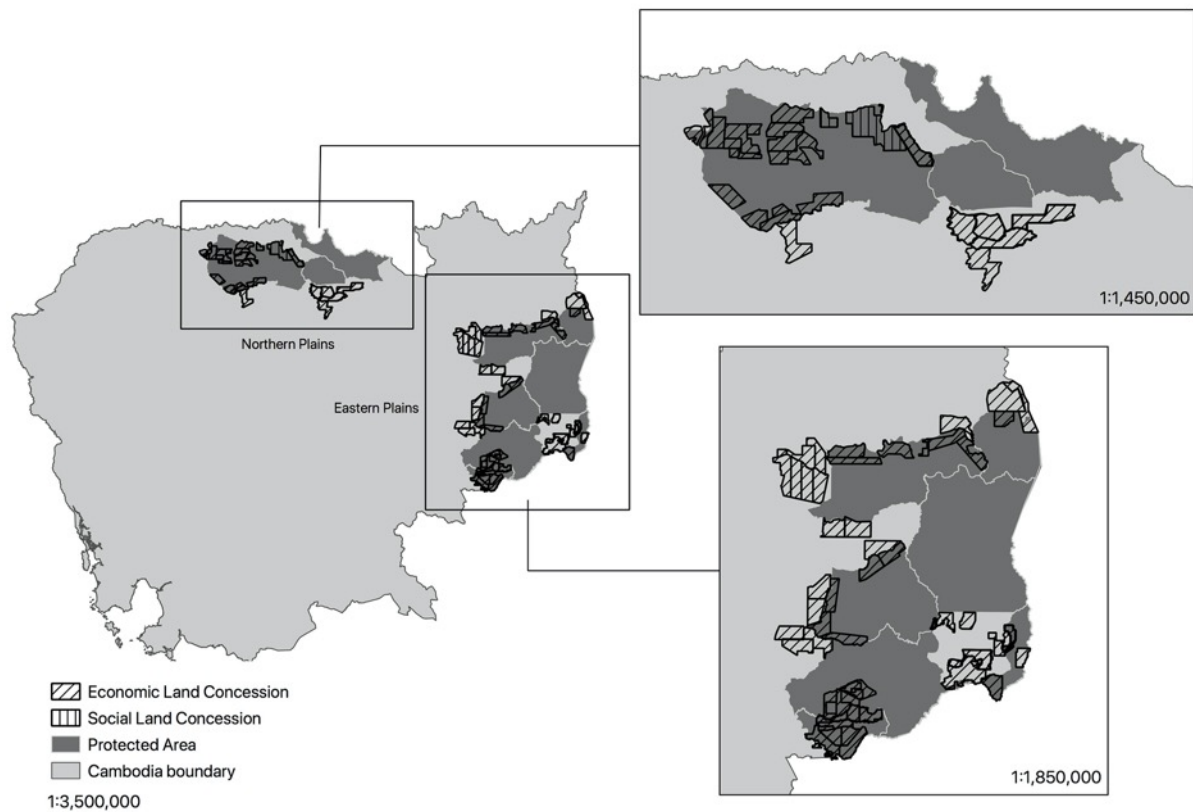


Figure 13: Northern Plains Landscape and Eastern Plains Landscape in Cambodia. The study focused on three villages within each landscape and actors present at the commune, district and provincial levels. Spatial data obtained from Wildlife Conservation Society Cambodia Program. Complete data on ELCs and SLCs is unavailable.

Data collection

We conducted interviews with actors involved in conservation and development initiatives in two landscapes from November 2017 to February 2018. Our sampling approach was two-pronged. We purposively selected actors to capture the full range of diversity of actors related to the problems identified in each landscape. We also selected using a chain referral, or snowballing process; first we consulted managers of the protected areas and then sought-out the key actors mentioned during the interview process. The two-pronged approach, the purposive and chain-referred interviews, allowed for approximately equal representation of government and civil society (NGOs and local groups) (Table 8). We selected provincial government departments involved in natural resource management and infrastructure development, as well as local authorities from the Ministry of Interior at the district, commune, and village level. Approximately half of the actors interviewed operated at the provincial scale or above (national or international), the second half operated at district level or below. Due to the challenges of connecting with companies, we were unable to interview representatives from the private sector but allowed respondents to include private sector actors in their response.

Each respondent answered eight questions, covering information sharing, influence, cooperation, evidence for decision making, principles, goals, and actors or conditions that prevent the landscape from functioning. Prior to interviewing, we ensured each respondent understood they could list an individual, organization (government or non-government), private company or civil society group in their response. We asked that respondents refer to the specific landscape studied when answering questions, and explained that landscapes could geographically include areas containing vegetation, agriculture and settlements. Additional information on the landscapes was collected through key informant interviews, observations and informal discussions. Given the geographic size of the area, local authorities and groups were selected in three villages that were studied in depth in each landscape. Interactions at the village level ensured responses could be verified with observed conditions and additional data collected in each site. Due to the sensitivity of the information, NGOs are not individually identified, instead we refer broadly to types of organizations involved in conservation and development activities in Cambodia.

Table 8: Categories of Actors interviewed. Actors are categorized by type.

Category of respondents	EP	NP
Armed Forces (Police)	2	1
Civil Society Groups** (CPA, ICT, Ecotourism)	2	8
Development NGO*	5	5
Government (Provincial Departments, Village, Commune, and District Authorities, PA Authorities)	17	16
Natural Resource Management NGO*	4	4
Total	30	34

† Community Protected Area Committee (CPA), Indigenous Communal Titling Committee (ICT)

‡ Most NGOs engaged in both conservation and development. They are categorized here by main activities.

Data Analysis

We analysed the network data collected using an open source social network analysis software called Gephi (Gephi Consortium, 2014). Each actor is represented by a circular ‘node’ and each relationship with another actor is linked with a line called an ‘edge’. If one organization had multiple respondents, we grouped the respondents into a single actor (node) in the landscape (i.e. three village heads were grouped into a single village authority). We created three networks for each landscape providing graphical visual representations of (1) information sharing; (2) cooperation; (3) evidence for decision making. We used weighted edges in the information sharing network based on frequency of communication. Edges were assigned directions according to one-way or two-way information sharing between actors as stated by the respondent. Weighted edges were given to the cooperation

sharing network based on how well the respondent felt the two actors cooperated (some, moderate, high).

We adjusted the visual representation of the graph using the display algorithms and ran a series of statistical metrics for deeper insight into the network structure and properties. We first obtained the modularity for each graph to determine how much the network clusters. We then calculated the betweenness, eigenvector and closeness centrality, as well as the clustering coefficient and degree. Table 9 provides information regarding key statistical metrics and the information provided by each metric. Results of the statistical analysis were compared to respondent’s perceptions of power and influence in the landscape.

Table 9: Description of key network concepts and statistical metrics used in the analysis

Metric	Description and utility in Actor Network Analysis
Modularity	Identifies clusters in the network, a grouping of nodes that are more strongly connected than in a random network. Clusters in networks may indicate homophily and poorly connected segments of networks.
Betweenness Centrality	Describes the centrality of a node based on its position between two disconnected nodes. An actor with high betweenness centrality may provide a link across disconnected segments of a network and be effective for diffusing information across a larger network.
Eigenvector Centrality	Measures a node’s influence based on its connection to other influential nodes. High eigenvector centrality indicates an actor’s proximity to influential actors based on their centrality in the network.
Closeness Centrality	Indicates how accessible every other node is from a single node in the network. A node with high closeness centrality is able to transfuse information at a faster pace than other nodes in the network.
Clustering Coefficient	Measures the degree to which a node clusters in a network. The average clustering coefficient of a network describes how likely the nodes cluster together (average of individual clustering coefficients).
Degree	Measures the centrality of a node in a network by how many other nodes it is directly connected to (number of edges). An actor with high degree may have high importance and influence in a network.

Results

Goals and perceived constraints

Almost all actors identified multiple goals, demonstrating a holistic approach to reaching objectives and multi-dimensional understanding of the issues. Local authorities (village and commune) identified more goals than other actors, likely due to the wide of range of responsibilities of the position and their proximity to both people living in the landscapes and institutions. Actor goals included improved

governance and law enforcement, conservation, sustainable resource use, and health. The most frequently identified goal was improved living standards, identified by 48% of actors. Provincial government departments and local authorities focused on strengthening current roles and activities of government bodies, including following national plans, issuing information, land use planning, and law enforcement. Their goals tended to be predetermined, reflecting mission statements, rather than a responsive goal to a democratically identified set of needs in the particular landscape. In Mondulkiri, actors gave more attention to the needs of Indigenous people and land use planning, likely due to the competition for land and high number of self-identified Indigenous communities living in the area in contrast to the Northern Plains.

In general, respondents were reluctant to discuss or label actors that prevented the landscape from functioning as well as it could. NGOs were more willing to make those barrier actors explicit. To enrich the question, we asked respondents what the key challenges were in the landscape and constraints to improving social and environmental outcomes (Table 10). Common challenges preventing landscape functionality identified by actors in both NP and EP included corruption, conflict and lack of cooperation, failure to uphold the law, and unclear boundaries. Lack of infrastructure such as roads and transmission lines add difficulty for actors when performing their tasks, but respondents also identified internal constraints, such as funding, short term nature of projects, and lack of capacity. Poor living standards in remote communities, such as poor health and education and a lack of willingness to engage also prevent actors from effectively implementing their activities. Government departments and law enforcement groups were identified as key actors preventing landscapes from functioning, due to their perceived role in facilitating corruption and power imbalances. This was reported as an issue from both government and non-government actors, indicating consensus that weak institutions is a major issue in both landscapes.

Table 10: Constraints preventing landscape from functioning as well as it could according to respondents

Type of Constraint	NP	EP	Example
Infrastructure	X	X	Difficult road, poor phone reception
Environmental	X	X	Natural hazards, remoteness
Knowledge, capacity and engagement	X		Lack of legal knowledge among local communities
Spatial	X		Communities restricted from expanding agricultural land in protected areas
Illegal activities	X	X	Illegal logging and hunting
Market	X		Market fluctuation, limited market opportunities
Demographics	X	X	Immigration to area
Governance	X	X	Land conflict, corruption, insecure tenure
Financial		X	Lack of investment in development

Clusters and cooperation

During interviews, respondents were asked to list actors they cooperated with, assign a value to the level of cooperation (low, medium, high) and identify actors they would like better cooperation with. Cooperation networks for both landscapes are displayed in Figure 14. Nodes represent actors and edges are weighted by the level of cooperation. For each network, we calculated the clustering coefficient and divided the nodes by modularity to determine clusters; groups of strongly connected nodes. The networks show that actors are more likely to have strong cooperation with other actors inside their cluster. In the Northern Plains cooperation network, five clusters were identified, representing (1) development (2) natural resource management (3) human rights (4) government and (5) agriculture. Clusters did not represent distinct objectives. For example, the PDoE was found to cluster with government departments and an NGO focused on sustainable agriculture inside the PA network clustered with natural resource management. Clustering shows that development NGOs cooperated well with provincial departments engaged in development, but there was little cooperation with actors engaged in natural resource management. Similar patterns were seen in the information sharing and evidence for decision making networks.

In the Mondulkiri, network clustering was less likely (lower clustering coefficient), and it was more difficult to identify distinct clusters of actors. As seen in Figure 14, similar groups are identified in the Eastern Plains and Northern Plains, but clusters overlap to a greater degree. In addition, a separate cluster emerged, agroforestry, consisting mostly of private sector actors in agribusiness. Lower clustering in the Eastern Plains is likely due to the recent and fast paced changes in the landscape, such as the entry of new private sector actors and immigration. Disruption to the landscape inspired the need for greater integration between sectors, leading to a more tightly entwined network, such as NGOs engaged in multiple activities in conservation, tourism, health and land use planning. With fewer disruptions and fewer organizations over a large geographical area, NP actors appear likely to remain within their sectors.

When asked to identify actors that respondents would benefit from having more cooperation, most respondents listed actors with whom they were already cooperating with inside their cluster. While acknowledging the benefits of wider networks of cooperation, respondents perceived improving cooperation within clusters to offer greater benefits than forming connections outside of clusters. This behaviour demonstrates the strength of strong ties (Krackhardt et al., 2003). In contrast to the strength of weak ties (Granovetter, 1977), strong ties between actors play a larger role in harnessing trust, motivation, and familiarity that can reduce friction and provide security. Respondents were more likely to want better cooperation with government actors than non-government actors, especially those that they perceived to have higher influence in the landscape.

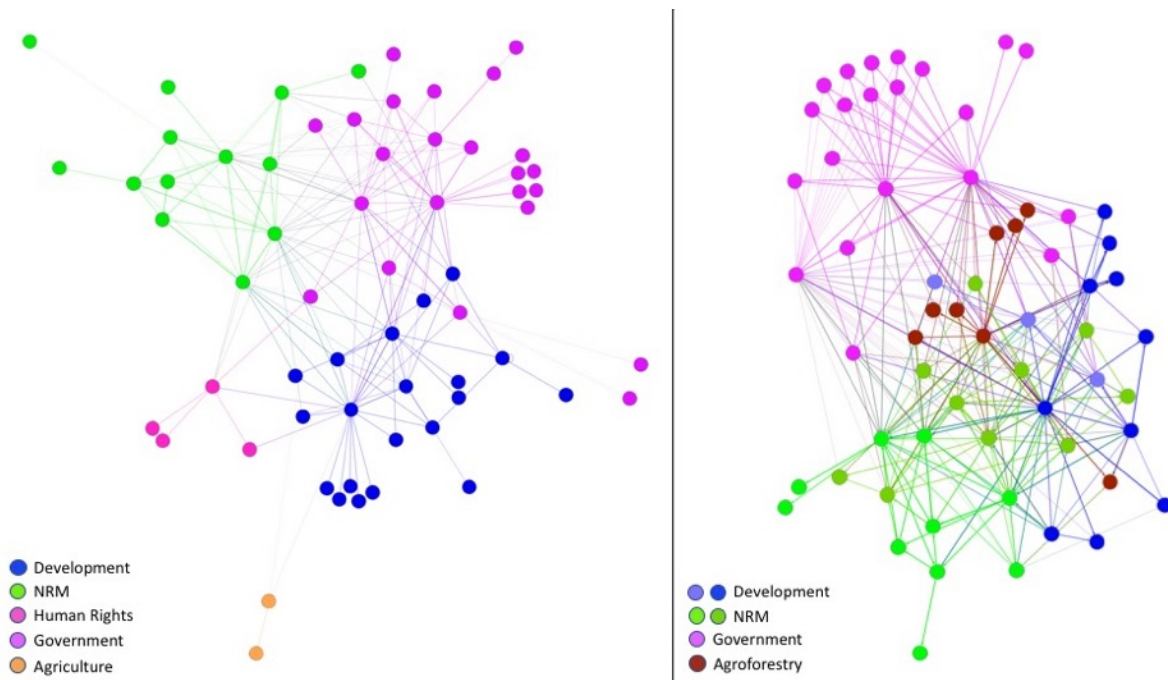


Figure 14: Cooperation Network for Northern Plains Landscape (Left) and the Eastern Plains (Right). Nodes are coloured by modularity class (cluster group). The graphs are displayed using Force Atlas layout algorithm. Nodes with high in-degrees are located in the centre of the graph. The average clustering coefficients are 0.55 and 0.41 for NP and EP respectively

Influence and centrality

In both the Northern Plains and Mondulkiri, respondents ranked the commune administration as the most influential actor in the landscape. Perceived influence was mainly due to the responsibilities of the commune administration; they are the primary institution responsible for the commune development plan and investment and must work with provincial departments and NGOs to fund and implement a wide range of activities. They are therefore responsible for identifying and prioritizing needs within the landscape and cooperating with appropriate actors to address those needs. As all interviewees operated at the landscape scale (including half at the district level or below), the prominence of the commune administration reflects the hierarchical power structure of the Cambodian Government. Responsibilities are devolved to the commune, but the commune administration defers to higher administrations for direction.

The NRM organization co-managing the protected areas ranked high in perceived influence in both landscapes, likely due to their high visibility as a natural resource manager in the two focus areas. In contrast, the Department of Planning was not perceived to be highly influential by other actors, yet the analysis shows high values for degree and closeness centrality (Table 11). As degree and closeness centrality are measures of the connectivity, the Department of Planning appears to be well connected,

but as stated by actors, in reality it does not influence decision making. In the Northern Plains, the Department of Planning also has a high eigenvector centrality value, indicating proximity to influential actors.

In Mondulkiri, actors with high perceived influence also exhibited high values for eigenvector centrality and medium values for betweenness centrality (Figure 15). Consequently, there may be a smaller network of key actors in Mondulkiri, that have both influence and close proximity to other influential actors. As such, the provincial administration and the PDoE are well placed in the network to exert influence. The NRM organization exhibits low betweenness centrality, suggesting they operate within a smaller network of actors. In the Northern Plains, actors with high eigenvector values are dispersed throughout the network, indicating higher participation of actors in decision making (Figure 15).

Actors with high degree values, such as the Department of Rural Development and Department of Planning, reach a broader network of actors. Both Departments have roles in diffusing information to a larger set of actors. Actors representing the Armed Forces exhibited smaller degree values and were more likely to cooperate with actors in the same category. A comparison of centrality values is shown in Table 3 for the information network, however our analysis is drawn from calculations completed on all three networks in each landscape.

Table 11: Key actors and centrality scores for the information sharing network in NP and EP. Degree and Influence are normalized values (N). Actors are categorized by the highest level they operate (C=Commune, P=Province, D=District, V=Village) and by type (G=Government, N=NGO, AF=Armed Forces).

Actor	Level	Type	NP	EP	NP	EP	NP	EP	NP	EP	NP	EP
			Degree (N)		Closeness		Betweenness		Eigenvector		Influence (N)	
Commune Administration	C	G	0.44	0.52	0.59	0.32	0.05	0.05	0.74	1.00	0.43	0.48
Provincial Administration	P	G	0.26	0.26	0.53	0.00	0.00	0.00	0.56	0.87	0.29	0.38
NRM NGO	P	N	0.36	0.45	0.56	0.41	0.03	0.02	0.60	0.50	0.28	0.40
Dept. Environment	P	G	0.40	0.55	0.57	0.40	0.05	0.04	0.63	0.89	0.28	0.27
Dept. Agriculture, Forests & Fisheries	P	G	0.18	0.62	0.51	0.53	0.01	0.07	0.38	0.57	0.25	0.14
Dept. Rural Development	P	G	0.28	0.95	0.53	0.64	0.06	0.12	0.50	0.30	0.24	0.32
District Administration	D	G	0.44	0.62	0.59	0.44	0.08	0.10	0.72	0.69	0.24	0.24
Military	P	AF	0.08	0.10	0.40	0.00	0.00	0.00	0.14	0.43	0.20	0.09
Dept. Public Works and Transport	P	G	0.04	0.17	0.45	0.33	0.00	0.00	0.12	0.19	0.19	0.19
Village Authority	V	G	0.34	0.43	0.55	0.36	0.03	0.05	0.61	0.94	0.16	0.18
Dept. Land Management, Urban Planning & Construction	P	G	0.58	0.64	0.60	0.59	0.13	0.03	0.70	0.13	0.13	0.13
Office Chief (PA management)	P	G	0.04	0.14	0.38	0.33	0.00	0.01	0.07	0.30	0.00	0.02
Dept. Planning	P	G	1.00	1.00	0.78	0.71	0.48	0.02	1.00	0.09	0.02	0.08

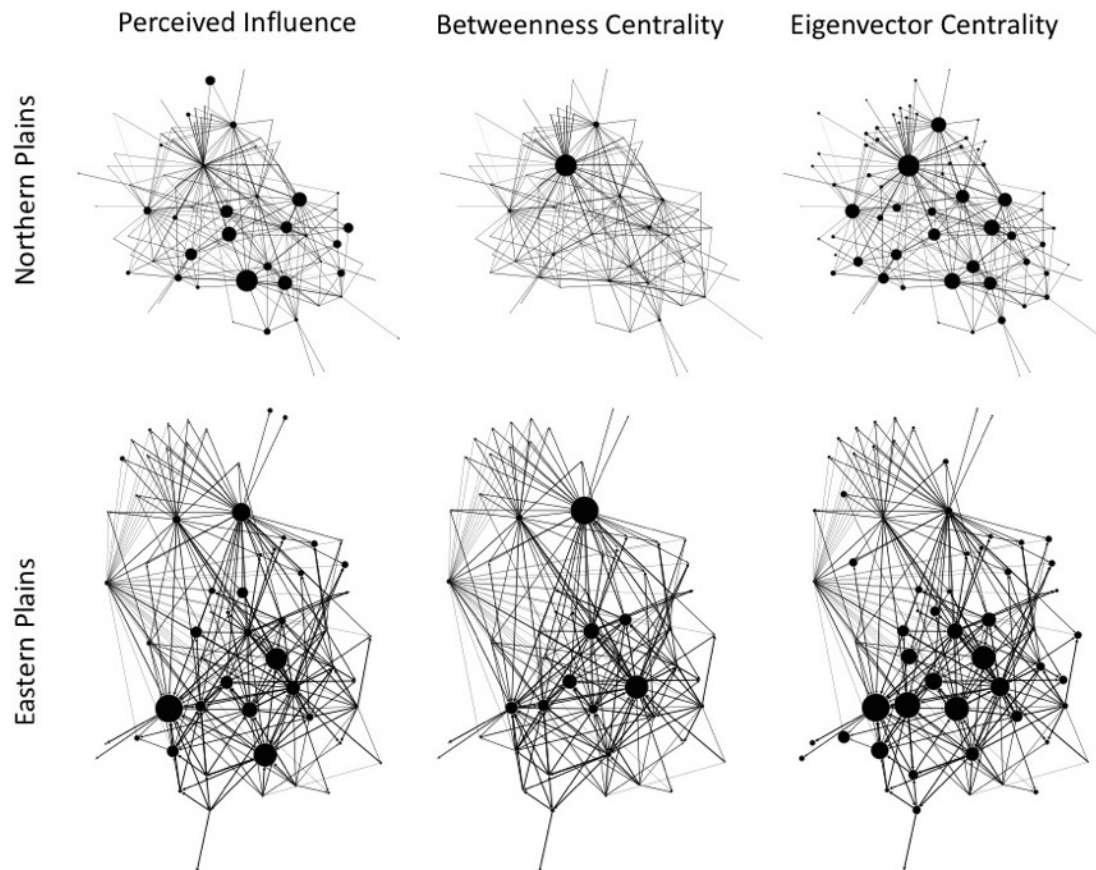


Figure 15: Information networks for the Northern Plains and Eastern Plains. Nodes are sized by (1) Perceived influence (2) Betweenness Centrality and (3) Eigenvector Centrality. In the Northern Plains, actors perceived to have high influence do not align with actors with high betweenness centrality. Influential actors are spread throughout the network. In the Eastern Plains, actors with high perceived influence align with actors with high eigenvector centrality, indicating an integrated and influential cluster of actors in the network.

Evidence for decision making and information sharing

Most actors identified internal mechanisms for gathering evidence for decision-making. For example, NGOs often collected data directly from the target area to develop a project focus. Actors at all levels stated they made decisions based on information gathered from local communities. We did not include a node representing local communities in the evidence network, and instead focus on evidence sharing between actors. In both landscapes, the local authorities, including village, commune, district and provincial administration exhibit a high level of degree, indicating centrality in the network. High centrality and connectivity are likely due to institutional affiliation with the Ministry of Interior; they are responsible for passing information and up and down the government hierarchy. Among the local authorities, the district administration exhibits a higher level of degree, as it both gives and obtains information from a large number of actors, sitting at the centre of the hierarchy. Although in all networks government actors appear to have higher values of centrality, large NGOs follow closely behind in both landscapes in degree and eigenvector centrality. Their strong position in the network is representative of their close involvement with government actors in planning and strategizing within their sectors.

Discussion

Communication and coordination

Our results show there is strong potential for conservation and development actors in rural landscapes in Cambodia to work collaboratively towards shared goals for sustainable development. In both the Northern Plains and Eastern Plains landscape, actors identify a wide variety of social and environmental needs and holistic measures to achieve landscape goals. Collaborative working groups are in place in both landscapes, supporting cooperation and coordination between government and non-government organizations. All actors demonstrated an active presence within the landscape. Working groups convened quarterly meetings and provided opportunities for actors to communicate frequently and coordinate their actions. Our interviews with actors indicate the strength of these networks had a visible impact on conservation and development outcomes in the landscape. For example, in both landscapes NGOs and government actors involved in the health sector meet quarterly for strategic planning. Actors active in the health sector reported these activities were functioning well. When we asked people in villages to share their views on NGO activities, they frequently identified prominent health NGOs and the benefits of their programs. Other sectors, such as natural resource management, demonstrated similar attributes of strong cooperation networks in small groups. However, cross-sectoral collaboration is less frequent, despite shared landscape goals. In our interviews with government actors and in villages, conservation was rarely viewed as

synergistic with development and in some cases identified as a major constraint to meeting development goals. Adversarial perspectives present challenges for actors seeking to expand a conservation network.

Perspectives on Influence

In this study we used perspectives and centrality measures to determine influential actors in each landscape. Both methods yielded the same response, with the commune administration receiving the highest values of eigenvector centrality in the two landscapes – an indication of influence and proximity to influential actors. When considering network dynamics this result is unsurprising; the commune administration is the decisive actor for implementing conservation and development activities at the landscape scale. However, interviewees frequently referred to the provincial administration, ranked second to the commune administration, as the definitive power. All activities under the provincial scale, including departments, NGOs, and local authorities, must be approved by the provincial administration. Outside of the actor network, our interviews with community members suggested that the commune administration played a significant role in infrastructure and land use decisions, but local leaders, either formally or informally elected, mobilized actions within the community. External actors desiring influence must therefore be well connected at multiple scales, recognizing the importance of cross-scale linkages and the different ways these interactions can take place (Adger et al., 2005; Berkes, 2002). The NRM organization perceived to have high influence in the landscapes placed strong emphasis on building relationships with authorities at all levels of government, evident in its high eigenvector centrality value. In this case, the PDoE (through the office chief and rangers) often acts as an intermediary between local authorities and the NGO, leading to a reciprocal relationship in which both actors strengthen their presence and influence in the landscape. However, despite the strong NGO presence, government authorities maintain ultimate control over decision-making and implementation at all levels. The perceived influence of government actors could explain the lack of presence of the private sector in the networks, as they are seen as an extension of decisions made within government. However, our interviews also suggest that concession holders may have more influence in networks at a higher scale, and while their presence has significant social and ecological impacts, they are less active in decision making at the provincial scale.

Leveraging change through networks

In the landscapes studied, actors successfully created interorganizational arrangements but were unable to effectively leverage these arrangements to make progress towards goals. Majority of respondents reported challenges in implementing activities, converging on two major limitations: (1)

lack of support from stakeholders and (2) individuals abusing their position of power to serve patron-client relationships. The limitations are reflective of broader challenges in rural Cambodia, particularly in frontier areas such as the Eastern Plains (Mahanty & Milne, 2015). Communities are resistant to conservation activities inhibiting their development and authorities struggle to balance local needs with top down directives. Households tend to prioritise immediate basic needs over long-term sustainability goals. Initiatives that target environmentally friendly agriculture compete with more lucrative income sources, such as logging or hunting which are not legal inside PAs. Illegal activities offer high financial return, which is a disincentive for communities to respect and uphold the rule of the law. Local authorities are responsible for enforcing the law, but struggle with lack of resources, capacity, competing interests, and financial incentive. Community involvement in conservation and development exhibits common challenges associated with incentive-based programs and development assistance (Mansuri & Rao, 2004; Spiteri & Nepalz, 2006).

Respondents also reported difficulties in gaining wider support from other government bodies when implementing conservation and development initiatives. Political willingness to fight corruption and engage with multiple stakeholders to solve complex social and environmental challenges is rare. The provincial and commune administrations have power to influence decisions made at the landscape scale, including the dispersion of commune budgets and allocation of resources. Yet the provincial administration has limited human capacity and financial resources to effectively carry out the designated responsibilities. The recent decentralization of power to the provincial scale has not been accompanied by adequate capacity building and resources. With greater responsibility and rising competing pressures for natural resources, actors at the landscape level need sufficient skills, knowledge, and resources to respond to local and global demands. In rural Cambodia, large scale changes to the landscape appears to be exogenous, either through large scale investments or top-down directives, such as the designation of previously protected land and as concession or private land. These externally-made decisions do not involve provincial actors, offering little opportunity for actors to navigate potential impacts and repercussions at outcomes at the landscape scale.

To leverage change, actors must have broad vision, deep understanding of social and ecological context, strong social networks, flexibility, and adaptability (Boedhihartono et al., 2018). Strong social networks imply not only strong ties within clusters, but appropriate knowledge brokers, constituencies at multiple levels of governance, support from diverse political bodies and sectors of society, charismatic leadership and entrepreneurship. The networks produced for the two landscapes of focus contain some of the characteristics described but are not functioning as well as they could.

Cross-sectoral agencies, such as the Department of Planning and Department of Rural Development may be appropriate connectors; actors that can facilitate weak ties at the provincial level.

Strengthening weak ties involves fostering relationships between groups, creating new channels for exchanging knowledge, ideas and influence (Granovetter, 1977). The Departments of Planning and Rural Development are in an ideal position to build ties between government and non-government actors, both within and across sectors, not necessarily to build collaboration, but to extend the reach of organizations interested in leveraging change. Similarly, the district administration is responsible for ensuring decisions made at the provincial level are carried out at the commune level, and feedback and input from local communities is incorporated into provincial strategies and development plans. Each of these actors have the potential to act as knowledge brokers but lack sufficient expertise and political independency. Their mandate is restricted to government plans, including the integration of commune and district development plans and the alignment of provincial development plans with national strategic plans. NGOs are invited to participate in the decision-making processes, integrating their activities and financial resources with proposed management plans at the commune, district, and provincial level. Targeting and using these processes to support government actors to develop broad vision and comprehensive understanding of social and ecological context may help organizations and civil society gain consensus on priorities and mobilize resources.

The expansion of networks to mobilise diverse actors will be limited by powerful individuals or actors that do not share goals of sustainable development. Changes in network structures and relationships between actors may not be enough to stimulate collective action (Lubell, 2004). Supporting charismatic leaders representing the interests of civil society with comprehensive understandings of social-ecological needs may be required to enable institutions to better meet landscape goals. Charismatic leaders, sometimes referred to as ‘local champions’ or ‘change agents’, have influence and are appropriately positioned in networks to diffuse information, knowledge and practices, and support and maintain initiatives (Kassam et al., 2014; Mbaru & Barnes, 2017). Change agents may also be ‘policy entrepreneurs’, individuals or organizations with credibility to form coalitions with whom they work to bring about policy change (Faling et al., 2018). They may be appointed by government or emerge from civil society, and should be able to work across scales, informing policy while ensuring they are sensitive to local realities (Bull et al., 2018).

In Cambodia, natural resource management initiatives face repeated struggles against corruption and elite capture of wealth and resources (Riggs et al., 2018). In our interviews, organizations identified actors perpetuating these activities, and actors opposing them. With support from organizations, leaders may confront these challenges and inspire a process of change throughout the network. Organizations can nurture this process by ensuring the co-generation of knowledge, such that government and civil society share the same understanding of issues and evidence for decision making. In this role, external actors must be cognizant of local needs and power relations, particular in the framing of initiatives involving diverse actors (Lebel et al., 2018). Collaborative knowledge

generation may limit the production of independent scientific data if the Government standpoint conflicts with the data. However, collaboration could build consensus and authority of emergent leaders to drive change. Actors referred to individuals of these characteristics in both landscapes, acknowledging potential for nurturing these relationships. In-depth social network analysis could provide further information on patterns of change and enhance this process.

Limitations

In our study we selected organizations involved in conservation and development decisions at the landscape scale. However, decisions regarding large scale development initiatives, with high impact in a landscape, are often made at a higher level of governance. For example, NGOs conducting participatory land use planning with rural communities have been forced to adjust their planning to spatial plans outside of their control, hindering trust and progress made with communities.

Understandings these patterns of change require complementing ANA with qualitative information, ensuring the scope of analysis is not restricted by location or respondents. Networks are simplistic representations of reality, they do not comprehensively map all communication and coordination. Sampling in this study was strategically designed to capture a wide range of actors in natural resource governance and allow for interviews with prominent actors as they emerged. Geographic boundaries and the broad range of actors that affect landscape scale conservation and development initiatives raise fundamental challenges for network analysis. Saturation points used in qualitative research offer guidelines for data collection, but these must be adopted in conjunction with locally specific information on governance structures. Individual and institutional characteristics are not captured in the networks displayed above, yet we learned from our interviews that individuals are integral to leveraging change. Studies that focus on the role of individuals as change agents could further enhance implementation and adoption of policies and initiatives (Mbaru & Barnes, 2017).

The networks described above are static representations of a dynamic social landscape. In conservation and development, actors enter and leave systems continuously, especially NGOs relying on short term funding for projects. By nature, actor networks are unstable and unreliable. Dynamic network analysis allows the examination of network structure and properties over time as features of institutions change, relationships develop, and actors move in and out of the landscape. Given the pace of change in governance structures in Cambodia, dynamic network analysis may help capture influential actors driving change. For example, the conflict along the border of Cambodia and Thailand in 2008 and recent establishment of Social Land Concessions in the Northern Plains introduced a large quantity of military actors into the landscape, shifting power structures. Similarly, industrial concessions have transformed rural landscapes, significantly affecting rural communities and conservation initiatives (Neef et al., 2013). The extent to which these concessions have affected

power relations within Cambodian landscapes is not sufficiently captured in the above analysis due to the separation of exogenous influences with localised decision-making processes by respondents. Further studies examining how commodity production affects institutional arrangements should help reconcile conflicts between private sector investments and landscape-scale conservation and development initiatives (Ros-Tonen et al., 2018).

Conclusion

In conservation and development initiatives, diverse actors can and should influence decision making. Yet, understanding how actors influence change and utilizing this knowledge for better social and environmental outcomes locally and globally is challenging. In this paper, we present an actor network analysis of two landscapes in rural Cambodia where conservation and development are in competition. We identify influential actors and suggest ways in which actors can leverage networks to improve natural resource governance and meet goals of sustainable development. Recognizing that landscapes are heterogenous and drivers of change are often exogenous, the network analysis described above is enriched with qualitative information obtained through interviews and observations. Detailed information of institutional arrangements, challenges, and goals from a diverse range of actors ensured we captured complex local realities into our analysis and avoided simplistic assertions (Prell et al., 2009). Organizations interested in utilizing network analysis to strengthen implementation of activities must complement the analysis with in-depth knowledge of the social and ecological characteristics of the landscape, acknowledge dynamic temporal and spatial scales.

In rural Cambodia, meeting goals of sustainable development requires cross-sectoral collaboration among government and non-government actors. Civil society must be adequately represented and engaged in decision making, and information must be transparently shared. To leverage change, actors must utilise their networks to identify charismatic change agents, strengthening productive relationships for collaborative learning. In landscapes exhibiting poor governance, it is vital to nurture change agents within government agencies, providing an enabling environment for institutional learning and building state capability (Andrews et al., 2017). NGOs can play a crucial role in convening and inspiring interorganizational collaboration, working with government to mobilise resources and implement shared agendas. Network analysis targeting smaller or larger scales may further determine localised leverage points and opportunities for policy formulation.

Improving governance systems for sustainable development requires comprehensive understanding of actors driving change at multiple levels and scales. Efforts to evaluate the effective implementation of conservation or development initiatives must take into account the role of social relationships in diffusing information and mobilizing change. Further studies that promote the co-generation of

network analysis with actors *in situ* will continue to enhance methodological techniques for the application and utility of network analysis in strengthening natural resource governance.

Discussion

I began this research with the proposition that meeting global objectives of sustainable development depends on how change is governed in tropical forest landscapes. Focusing on two landscapes in rural Cambodia, I asked (1) How are tropical forest landscapes changing? (2) What strategies exist for nurturing change at the landscape scale? and (3) How can institutions leverage networks for change? To answer these questions, I engaged with different people living in rural forest landscapes who are making decisions over their future. Together, we discussed development trends and their environmental implications, and explored the role of institutions in nurturing these trends for better outcomes. Collectively, the chapters in this thesis show that the future of rural Cambodia will be determined by complex interactions between bio-physical, economic, political, and cultural factors. Geographic location, commodity markets, political leadership, and cultural ties to land affect the pace and direction of landscape change. Managing these changes for better social and environmental outcomes requires coordinated efforts from governing organizations, informed by evidence, long-term thinking, and on-the-ground realities. Transdisciplinary research and external organization can support this process by closing knowledge gaps and facilitating collaboration and commitment for positive change.

As my research is embedded in rural Cambodian landscapes, the research findings discussed in each chapter have the most relevance to the landscapes studied. But sustainable development is a global challenge, and landscapes do not exist in isolation. In Chapter 1, I discuss forest cover trends in Cambodia in relation to neighbouring countries that experienced forest transitions, as defined by Alexander Mather (1992). I examine how research can better contribute to comprehensive analysis of spatial and temporal interactions between governance, forests, and economic development. Place-based studies can help to strategically frame and explore big questions, grounding global policies in local realities. In discussions with local communities and organizations, we spoke about the future of the Northern Plains landscape and Keo Seima Wildlife Sanctuary; the people and nature that were central to that landscape. Through these discussions, I was also addressing underlying questions about the future for smallholders in tropical countries, or how to stop the global illegal flora and fauna trade, or how to end extreme poverty, among others. I did not answer these questions, but they helped to clarify lessons learned from rural Cambodia for other tropical forest landscapes facing similar challenges. These lessons form the overarching discovery of my research and lead to recommendations for future research.

The two landscapes in this study were purposefully selected to examine trade-offs between conserving habitat for biodiversity and land-use for economic development. In contrast to some views of poor rural societies living in harmony with nature, the dichotomy between biodiversity

conservation and human development is very real in present day Cambodia. In Chapter 2, I describe rural livelihoods that depend on land expansion for agriculture, logging or hunting, all of which threaten biodiversity conservation. Protected areas with international support have strong, multi-level, adaptive programs to conserve habitat and support local livelihoods. Faced with political barriers for preventing large-scale change, conservation agencies target resources towards stopping illegal logging, hunting, and forest clearance. Intergenerational trends show that **conservation cannot succeed if it seeks only to stop natural resource exploitation**. In poor, rural societies where agriculture is the primary means for moving out of poverty, and agriculture occurs at the expense of natural assets, long term trends show that development will win over conservation (Laurance et al., 2014b; Wunder, 2001). The pace and drivers will vary (Geist & Lambin, 2002), but the conditions of the landscape initially favourable to conservation will be greatly modified when the population is no longer living in poverty.

Accepting that in the long-term, tropical forest landscapes will be mosaic and multi-functional, conservation agencies must reflect on their theory of change (van Noordwijk et al., 2015). Common frameworks for practical conservation identify human activities as threats to conservation targets (Salafsky et al., 2002). Conservation success is then measured by the ability to detect and counter these threats. What if, instead of human activities as threats, they became a means for meeting long term environmental sustainability? Many researchers and practitioners agree with a broad, comprehensive, understanding of conservation that acknowledges human modified landscapes (Schwartzman et al., 2000). Long term trends show that improvements in rural economies can lead to ecological restoration (García-Barrios et al., 2009; Wang et al., 2011). Incorporating development into a theory of change means rigorous exploration of the positive long-term relationship between actions to improve wellbeing and environmental sustainability. For example, Beauchamp et al. (2018c) find that agricultural land is considered most important for wellbeing in villages in the Northern Plains. Rather than portraying smallholder agriculture as a threat and devising ‘alternative livelihoods’, a theory of change might explore how secure ownership of agricultural land can contribute to long term environmental sustainability and potential leverage points to meet that goal. Local decision-makers could discuss the feasibility and impact of zoning or land certificates, informed by community perceptions. With explicit identification of trade-offs and future scenarios, decisions could be made with local organizations on how to allocate resources to meet livelihood goals.

Built collaboratively with landscape actors, a theory of change can generate a common vision for a multifunctional landscape and explicitly identify the barriers for achieving it. Every chapter in this thesis diagnoses institutional barriers that inhibit inclusive sustainable development in Cambodia. While there are many, two key obstacles emerge: the large number of actors that seek to benefit from Cambodia’s forest landscapes, and the political environment that allows for manipulation of policies

and procedure. **Rent seeking slows down development.** Rent seekers act to gain wealth without reciprocal gains to society (Tullock, 1967). It is often described as a form of corruption, which is defined as “the abuse of entrusted power for private gain” (Transparency International, 2018). Corruption can benefit economic growth, but slows down development by “diminishing investment in physical capital and human capital levels, and by enhancing political imbalance” (Ionescu, 2014). In Cambodia, rent seeking causes uncertainty and insecurity in the allocation of land for protection, concessions, communal or private ownership. Local government and non-government organizations lack legitimacy with communities because they cannot protect vulnerable groups from losing against more powerful actors or are seen as part of the problem. Dysfunctional political processes dominate decision-making at all levels, preserving elite control and disincentivising respect for the rule of law. Robust environmental legislation is only valuable if it is upheld and enforced (Gibson et al., 2005). If development is to contribute to long-term environmental sustainability, finding ways to strengthen and respect institutions should be part of the theory of change.

The other institutional barrier, the numerous actors that seek to benefit from natural resources, is frequently identified as a challenge in fostering sustainable landscapes (Kusters et al., 2017; Reed et al., 2016). Landscape approaches specifically seek to reconcile competing land uses by finding a “balance between multiple and sometimes conflicting objectives”, often providing an entry point for natural resource management organizations (Sayer et al., 2016). In Chapter 3, I discover that the main agents with power to influence social and environmental outcomes of road development in Keo Seima are commune and village authorities. The influence of local authorities is consistent with my findings in Chapter 4, which place local authorities at the centre of vertical and horizontal decision-making networks. As such, while multiple actors seek benefits from forest landscapes in Cambodia, it is the responsibility of local government authorities to manage and distribute benefits. At the lower tier of the hierarchy, commune and village authorities do not have decision-making power over large scale change. For example, they cannot reject the presence of a concession or protected area and prevent systemic corruption. But they can influence the social response to landscape change, and in consequence, the environmental repercussions.

Managing and reconciling the needs of numerous actors requires a landscape level process for careful and transparent framing and negotiation of trade-offs (Hirsch et al., 2011; McShane et al., 2011). Land use trade-offs unfold at different times and at different spatial scales – strong, capable, legitimate leaders are needed to facilitate engagement in this process (Sayer et al., 2014). In Chapter 4, I discovered how governing organizations in Cambodia face many challenges reconciling different interests, including problems created by the organizations themselves. **Conservation and development trade-offs will only be reconciled if local institutions are willing and able.** In rural Cambodia, there is a lot to be gained from external support in facilitating communication and

collaboration across organizations, strengthening progress towards shared goals. There needs to be stronger emphasis on supporting capable government leaders to strategically manage change at the village, district, and commune level. Strategies will differ depending on the expectations and needs of actors present, and the relationships and spread of power between actors. For example, Chapter 2 shows how in Keo Seima, Indigenous Communal Title is emergent in the landscape, shaping land use decisions from the household level to the international level. In the Northern Plains, the conflict at the Cambodian-Thai border and the strong presence of military in the landscape influences resource allocation and extraction. Leaders must therefore hold attributes and skill sets that encourage accountability, reciprocity, and responsible actions from other landscape actors.

To summarise, nurturing landscapes for sustainable development requires a long-term perspective on the relationship between improvements in wellbeing and environmental sustainability. It requires strong institutions that are respected at all levels, and local government organizations capable of managing multiple and competing land use objectives. Problems do not cease to exist once rural societies shift out of poverty. North Queensland, Australia, my home for most of the duration of this research, is a good example of where vested interests and livelihoods continue to deteriorate the natural environment, despite the presence of strong institutions (Dale et al., 2008). Yet with capable governing agencies, civil society and private actors can actively engage in processes to negotiate competing interests and seek solutions. Sustainable development does not have an end point, and the goal posts are continually moving. It is an adaptive, iterative non-linear process that requires science and evidence, collective action, incentives and punishments. The lessons from the landscapes in this study were developed through rich understandings of the past and present, exploring what these might mean for the future. Further studies that enhance the capacity of governing organizations to develop and implement a theory of change for contested landscapes can help to translate lessons learned into practice.

During my time in Cambodia, the challenges of the present outweighed considerations for the future. While this may always be the case, there is a need to explore the future of contested landscapes in greater depth. Spatially explicit scenario analysis, conducted *in situ*, can contribute to building a common vision for multi-functional shared landscapes. Many tools exist for simulating how decisions might transpire and demonstrating the costs and benefits for outcomes broader than biodiversity conservation (Polasky et al., 2008; Sarkar et al., 2016). The utility of these tools is highly dependent on involvement with decision-makers and local communities throughout the process, creating opportunities for dialogue and building a common understanding of the issues (Sandker et al., 2010). Simple participatory activities such as drawing future landscapes can identify the different expectations for the landscape, and set off a process of negotiation (Boedhihartono, 2012). In my experience conducting participatory scenario modelling in Indonesia, I have learnt that these activities

are equally if not more useful for asking questions than for answering them. Hence, scenario analysis is likely to help identify knowledge gaps and refine research to better target end-users.

Future research needs that emerged throughout my experience in Cambodia were the profitability and productivity of agriculture, and how to secure rights to land and resources. Drivers of agricultural growth in Cambodia include; area expansion, diversification (maize and cassava), technological change, and increased prices received by producers (Birthal et al., 2019). As available land becomes scarce and the effects of deforestation such as soil erosion are felt more acutely, farmers will have to rely less on extensification, and find other means to improve economic returns. Research in other parts of Cambodia with similar bio-physical conditions offer potential solutions for sustainable agriculture (Montgomery et al., 2017) but cannot be simply transferred. As discussed throughout the chapters in this thesis, solutions must be co-generated with actors within the landscapes. Harnessing the potential of income diversification through market accessibility should also be explored more rigorously, such as the prioritization of road rehabilitation discussed in Chapter 3. Improving agricultural benefits to households also involves addressing problems related to the control of, use of, and access to land. As shown by Travers et al. (2015), Indigenous Communal Tenure in Cambodia has the potential to secure social, economic, and environmental benefits of forest landscapes for Indigenous communities. Comprehensive studies that measure social-ecological changes due to increased Indigenous ownership of land could guide strategic development of Indigenous institutions in Cambodia. As communal and private land titling schemes grow in Cambodia, further research can help to determine the ways in which secure property rights enhance sustainable inclusive development.

There is ample opportunity for place-based transdisciplinary research to enhance sustainability in tropical forest landscapes. I encourage researchers to seek partnerships with local decision-makers and communities to better understand, explore, and find solutions to global sustainability challenges. Rich understanding of social-ecological conditions shared through decision-making networks can support thoughtful discussions about the future of tropical forest landscapes where biodiversity is rich, people are poor, and institutions are weak. External agencies and researchers can engage in a process of change informed by evidence, scenarios, and consensus building. Tropical landscapes that deliver sustainable inclusive development need strong institutions to govern and nurture change.

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Appendix A

Sample of questions from household survey

Name of respondent:

Sex:

Age:

Krom:

Village:

Commune:

District:

How many members in your household? [Answer in table]

No	Name	Age	Sex	Education [#yr]	Education (Grade)	Function in HH	Family Status	Literate	Ethnicity

What land did your household used to grow crops on last year? [Answer in table]

No	Kind of land	W (m)	L (m)	Land size (m2)	Year land claimed	Land inside ICT	Kind of crop	Access to land	Yrs growing current crop	Previous crop (last season)	Fertility	Other

How many resin trees does your household own?

How many resin trees does your household tap?

Does anyone in your household have a job? [Answer in table]

Name	Job title	With which type of agency?	Where	Salary [rirel/month]	No. of months worked/year

Does anyone in your household sell their labour? [Answer in table]

Name	Purpose of labour	Wage [rirel/day]	No. of days worked /dry season	No. of days worked /wet season	Where do they work?

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What did your household harvest from the forest in the last 12 months (April 2016 – March 2017)?

Does your household operate any services within the village?

What did your household earn from selling agricultural produce in the last 12 months (April 2016 – March 2017)?

No	Kind of Crop	Total production (in Kg)	Price [riel/Kg]	Gross incomes (Riel)	Total costs [riel/ha]	Net incomes	Where did you sell?

Does the forest provide you with any other benefit?

Yes No Don't Know

If yes, please specify:

Has your household's livelihood improved over the last 5 years?

Improved Stayed the same Got worse

What are the main reasons for these changes?

Does cutting trees provide benefits to your household?

Yes No Don't Know

If yes, how?

In general, what do you think about cooperation between people in the village?

Do local leaders consider your concerns when they make decisions that affect you?

yes no Don't know

If yes, how?

Out of the following options, rank the most important infrastructure challenge in your village (1 is most important, 5 is least important)

- Buildings for community
- Sanitary toilet
- Domestic water supply (good drinking water)
- Road improvement
- Electricity

Other

Why did you choose number 1?

What are the positives of good roads?

What are the negatives of good roads?

Do you prefer to have a good road or not?

Yes No

Basic Necessity (Keo Seima Wildlife Sanctuary)

“Basic necessities are the minimum requirement for living that all households of the community should have and no-one should not have.”

No	Type of basic necessity	Is it a necessity?	Does your HH have it?	Quantity
1	Having at least one week holiday per year for all family members for tourist to visit other provinces or tourist site (e.g. Siem Reap) (do not include visiting relative)			
2	Having three meals per day regularly: Breakfast, Lunch and Dinner for all family members			
3	Having gas-cook stove (with two stoves using with large gas containers – 14.7Kg)			
4	Having Cassette Recorder/Player (or VCD)			
5	Having mosquito net for all family members			
6	Having health insurance for all family members			
7	Having ability to participate in all invited wedding in your community			
8	Having car battery 40 A or more (for lighting and/or watching television)			
9	Having at least two big cattle (buffalos or cows) for farming or pulling cart			
10	Having at least one water jar or water tank for keeping water for consumption (at least 120 L Jar)			
11	Having a fan using electricity in the family			
12	Having access to electricity (from public or generator service own generator)			
13	Having thick blanket for all family members			
14	Having at least one long knife			
15	Having a motor-trailer (Kor Yun)			
16	Having a fridge (not cooler box)			
17	Having at least one axe			
18	Having hand pump well at home			
19	Having home-toilet connecting with sewer or septic tank			
20	Having one wooden wardrobe in the family			
21	Having access to a car-taxi service from village to district or provincial town?			
22	Having one motorbike in the family			
23	Having roof with zinc sheet / Tile roof/ fibro house			
24	Having wooden wall house			
25	Having a television			
26	Having a washing machine using electricity			
27	Having a mobile phone			
28	Having homestead land at least 50m x 100 m or 5000m ² (settlement land with home garden around)			
29	Having farming land for rice cultivation or doing Chamkar at least 3 ha?			
30	Having a concrete house			
31	Having access to water supply system (arriving at home)			

No	Type of basic necessity	Is it a necessity?	Does your HH have it?	Quantity
32	Having ability to send children to school at least grade 9			
33	Having ability to contribute in all traditional ceremonies in community			
34	Having an electric rice cooker			
35	Having capacity to buy two sets of new clothes for all family members each year			
36	Having plastic tent			
37	Having a hammock with mosquito net			
38	Having an ox-cart for carrying agricultural products and fire wood...etc.			
39	Having a grass cutting machine			
40	Having a kettle for boiling water in the family			
41	Having at least 1 water container to keep water for domestic use (at least 120 litres – can be a plastic container or metal container)			
42	Having a family car			

Appendix B

Author Consent to Include Publications as Part of PhD Thesis

Thesis Title:	Governing Landscape Transitions in Cambodia		
Name of Candidate:	Rebecca Anne Riggs		
Chapter no.	Details of publication(s) on which chapter is based	Nature and extent of the intellectual input of each author, including the candidate	I confirm the candidate's contribution to this paper and consent to the inclusion of the paper in this thesis
1	Riggs, RA, Langston, JD, Sayer, J, (2018), <i>Incorporating governance into forest transition frameworks to understand and influence Cambodia's forest landscapes</i> , Forest Policy and Economics 96:19-27	The authors co-developed the research question. Riggs collected and analysed the data. Riggs wrote the first draft which was revised with editorial input from Langston and Sayer.	<p>Name: Jeffrey Sayer Signature:</p> <p>16 September 2019</p> <p>Name: James Langston Signature:</p> <p>12 September 2019</p>
2	Riggs, RA, Langston, JD, Beauchamp, E, Travers, H, Sereyrotha, K, Margules, C (In Press) <i>Examining trajectories of change for prosperous forest landscapes in Cambodia</i> , Environmental Management	Riggs, Langston, and Margules co-developed the research question. Riggs designed the study and Riggs and Langston collected the data. Riggs analysed the data and wrote the first draft of the paper. Langston, Margules, Beauchamp, Travers, and Sereyrotha provided conceptual and editorial input to subsequent drafts.	<p>Name: James Langston Signature:</p> <p>12 September 2019</p> <p>Name: Emilie Beauchamp Signature:</p> <p>4th September 2019</p>

			<p>Name: Henry Travers Signature:</p> <p>4th September 2019</p> <p>Name: Ken Sereyrotha Signature:</p> <p>4^t September 2019</p> <p>Name: Chris Margules Signature:</p> <p>3rd September 2019</p>
3	<p>Riggs, RA., Langston, JD., Sayer, J, Sloan, S, & Laurance, WF (2020). <i>Learning from Local Perceptions for Strategic Road Development in Cambodia's Protected Forests</i>, Tropical Conservation Science, 13</p>	<p>Riggs developed the research question and designed the study. Riggs collected and analysed the data. Riggs wrote the first draft of the paper with conceptual and editorial input from Sayer, Langston, Sloan and Laurance.</p>	<p>Name: James Langston Signature:</p> <p>12 September 2019</p> <p>Name: Jeff Sayer Signature:</p> <p>16 September 2019</p> <p>Name: Sean Sloan Signature:</p> <p>3rd September 2019</p> <p>Name: William Laurance Signature:</p>

			7 October 2018
4	Riggs RA, Langston JD, Phann S (submitted), <i>Actor network analysis to leverage improvements in conservation and development outcomes in Cambodia</i> , Ecology and Society	Riggs and Langston co-developed the research question. Riggs collected and analysed the data. Phann facilitated field activities. Riggs wrote the first draft of the paper with conceptual direction from Langston. Phann and Langston provided editorial input on subsequent drafts.	Name: Sithan Phann Signature: 4 th September 2019 Name: James Langston Signature: 12 September 2019