Integrated landscape approaches for society and environment in the tropics: From premise to practice

A thesis submitted to Lancaster University in fulfilment of the requirements for the degree of Doctor of Philosophy.

By

James Reed

Declaration

I hereby declare that this thesis entitled:

Integrated landscape approaches for society and environment in the tropics: From premise to practice,

is the work of the author, except where otherwise stated, and has not been submitted for the award of a higher degree at any other institution. Inputs from co-authors and collaborators are acknowledged throughout.

James Reed

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Chapter One

Introduction

Food security, poverty alleviation, climate change, and biodiversity loss are persistent global challenges that have been at the forefront of international policy agendas in recent decades (UNCHE, 1972; UNCED, 1992: Laurance et al. 2014; UNFCCC, 2015). In response—and due to—this global momentum there have been a number of sector-specific advances, for example global GDP, crop yield output, and protected area coverage continue to increase (see World Bank & IMF, FAO & UNEP). Nevertheless, these are juxtaposed with ongoing losses that will likely be exacerbated by the impacts of a changing climate. As such, conventional post-war approaches to food production, conservation and development that maintain a sectorial focus are considered insufficient to address these often inter-connected issues that transcend spatial and sectorial scales (Foley et al., 2011a; Godfray et al., 2010; Tscharntke et al., 2012). An alternative approach that involves 'joined-up' thinking between multiple stakeholders to provide integrated solutions for multiple land uses at a landscape scale has been evolving in various forms over recent decades; yet its definition and means of optimal implementation remain somewhat elusive.

In the tropics where agricultural production, forest conservation and natural resource use often occur within complex land use mosaics, a more integrated approach is conceptually appealing (Chia & Sufo, 2015). When effectively implemented, an integrated landscape approach (Sayer et al., 2013) can enhance landscape multi-functionality by accounting for competing land use objectives, thereby delivering more equitable outcomes. Landscape multi-functionality can be described as "the co-existence of ecological, economic, cultural, historical and aesthetic functions" (Tress et al., 2001 p.140) and therefore a landscape approach that encourages periodic dialogue and negotiation amongst multiple stakeholders makes logical sense. As such, conceptually at least, the approach is generating support, however lack of consensus in definition and optimal means of application appear to be stalling practical progress.

Despite the challenges of definition and application, such integrated approaches are increasingly regarded as preferable in attempts to conserve, restore and develop tropical landscapes. The tropics represent a highly relevant focal area where food insecurity, poverty and declines in biodiversity converge with social and political instability, particularly in the context of a changing climate (Wilshusen et al. 2002, Gardner et al. 2009). However, the tropics also host the greatest refuges of biodiversity, threatened species, contiguous forest (Myers et al. 2000) but are juxtaposed with considerable potential for land use intensification, improved crop yield and enhanced social and industrial development. Furthermore, continuing demographic transitions, particularly in sub-Saharan Africa, perpetuate the urgency to develop more sustainable development strategies.

Since at least the early 1980s there have been incremental shifts in scholarship on how to most effectively address linked social and environmental challenges in the tropics. Approaches that focus strictly on environmental protection or social development are in decline as researchers and practitioners recognize the value in attempting to reconcile these previously considered distinct strategies. Integrated approaches have emerged under various guises (McShane et al., 2011; Stucki & Smith, 2011) but converge in their objective to deliver positive outcomes for both society and environment.

The promise to deliver "win-win" or even triple win outcomes makes integrated approaches both compelling and marketable and they have unsurprisingly been widely embraced and embedded within a diversity of global environmental and social policy discourse. For example, the New York declaration on forests (zero deforestation by 2030), the Bonn restoration challenge (150m Ha restored by 2020), the Paris climate accord (stabilizing global temperatures below 2ºC), and the UN Sustainable Development agenda (17 goals and 169 associated targets for global sustainable development) have all acknowledged the need for a more holistic approach to fulfilling global commitments. However, attempts to integrate conservation and development objectives are not without challenge and indeed, for many years were considered antagonistic rather than complementary agendas. Furthermore, the social-ecological system of landscapes encompass technical, environmental, financial, political and institutional challenges that have led to landscape-scale management being referred to as a classic "wicked problem", i.e. one that is resistant to resolution (Balint et al., 2011). Therefore, attempts to integrate conservation and development, while having been many have thus far met with limited success (Agrawal et al.,1997; Clark et al., 2011; Wells & McShane, 2004). As such, there has been an iterative process of re-conceptualizing and refining operational guidelines. Thus we have seen the development of a variety of design principles with the aim of embedding single-sector conservation, agricultural production and other land uses within broader landscape scale management strategies. As developments in landscape scale management strategies continue to emerge, the sheer volume of approaches proposed by numerous research and practitioner organizations has resulted in a rich, yet confusing, terminology that may be inhibiting progress. Organizations are referring to the same concept and are either unknowingly using different terminology to others or choosing to label their approach differently. This has arguably led to fragmentation of knowledge, unnecessary re-invention of ideas and practices, and slow progress in gaining policy traction (Scherr et al. 2013).

The most recent iteration of integrated conservation and development is widely described as a landscape approach (Sayer et al., 2013). A landscape approach can be broadly defined as a concept to integrate policy and practice for multiple land uses, within a given area, to ensure equitable and sustainable use of land while strengthening measures to mitigate and adapt to climate change (Harvey et al., 2014; Milder et al., 2012; Sayer et al., 2013; Scherr et al., 2012). It also aims to balance competing demands on land through the implementation of adaptive and integrated governance systems. These include not only the physical characteristic features of the landscape itself, but also all of the internal and external socio-economic and socio-political drivers that affect land use, particularly related to conservation, forestry and agriculture (Sayer et al., 2013). In short, the landscape approach seeks to address the increasingly complex and widespread environmental, social and political challenges that transcend traditional management boundaries.

Landscape research is inherently challenging; the scale and level of complexity demands that research be conducted inter-, and more often than not, trans-disciplinarily. This therefore requires bridging scientific disciplinary gaps, generating more meaningful and fruitful exchanges between scientists and policymakers, and developing strategies that have the potential to create an environment for equitable knowledge co-production between stakeholders. Adopting a systemic approach that is either problem or goal oriented might offer potential in that a common concern is shared from the outset (Sayer et al., 2013). However, the dynamic nature of tropical landscapes will present significant challenges for monitoring of integrated approaches, and will require regular re-evaluation to account for changing objectives and emergent threats and opportunities.

Nevertheless, the SDGs call for 'holistic and integrated approaches to sustainable development that restore the health and integrity of the Earth's ecosystem' – sentiments that resonate with landscape approach objectives. At least five of the key objectives of the SDGs (end hunger; secure water; promote strong, inclusive and sustainable economic growth; tackle climate change; protect and promote terrestrial resources) display clear overlap with landscape approach desired outputs. There is therefore a timely need to synthesize the current evidence base on landscape approaches in order to guide future attempts at operationalization.

As noted in a recent review by Sayer et al. (2013), a universal definition for a 'landscape approach' remains elusive. This confusion over terminology often stems from landscapes being defined, and perceived, in differing ways. Redford et al. (2003) note that a 'landscape' can refer to either spatial and ecological characteristics that help define conservation and development targets, or it can refer to social interactions and mechanisms that minimize conservation and development tradeoffs. Meanwhile, landscape approaches have been variably described within the literature (Freeman et al. 2015; Hart et al., 2015; Milder et al., 2012; Scherr et al., 2013) while almost 80 integrated approaches have been identified that appear to be largely synonymous with a landscape approach (Scherr et al., 2013). Consequently, despite such a plethora of approaches, researchers and practitioners continue to question what the landscape approach actually is, while its application and practicality are also questioned as a result of the complexity of the associated concepts (Pfund, 2010).

This thesis will disentangle the theory of landscape approaches, establish the current state of the evidence, and investigate what mechanisms and processes contribute to a well-functioning landscape approach. Specifically, the following research questions will be considered (in the following chapters):

1. What is the theoretical development of integrated approaches to conservation and development in the tropics and how has the landscape approach evolved into its current iteration? (Chapter 2)
2. What are the current barriers to implementation or upscaling of landscape approaches? (Chapter 2 and 5)
3. Where have landscape approaches been applied in the tropics? (Chapter 3)

4. Have landscape approaches been effective at integrating conservation and development concerns in the tropics? (Chapter 3)
5. What is the contribution of forests and trees within the landscape to adjacent or embedded agricultural production systems? (Chapter 4)
6. What are the key attributes and action points for landscape approach practitioners to consider for more effective operationalization? (Chapter 5)

This thesis will provide a comprehensive examination of the theoretical development, and practical implementation, of integrated landscape approaches to critically evaluate their utility as a means to reconcile conservation and development in the tropics. In doing so, this thesis contributes to ongoing discussions on how to conceptualize, define and operationalize landscape approaches. The chapters (and supplementary material) within identify where, and how, landscape approaches have been conceived across the tropics documenting important lessons learned and providing valuable insights on potential entry points for implementation, metrics to assess progress, financial support mechanisms, enabling conditions for effectiveness, and the ability to align local needs with global policies. It is therefore hoped that this thesis will provide a valuable resource for stakeholders from across the spectrum of science, policy and practice that cumulatively can contribute to advancing landscape approach rhetoric towards reality. Ultimately, this thesis is for anyone interested in the conservation and sustainable development of tropical landscapes.

The thesis is structured as followed:

Chapter 2 provides a more comprehensive explanation of what is meant by “landscape approach” and documents the trajectories of theoretical concepts that have contributed to the current understanding on how to integrate conservation and development issues at landscape scales. This chapter synthesizes the existing knowledge to infer the key characteristics of landscape approaches and considers how landscape approach principles can contribute towards the fulfilment of recently conceived global conservation and development agendas.

Chapter 3 reviews the implementation, and efficacy, of landscape approaches across the tropics. Despite failing to find a single applied example of a landscape approach that met criteria for reconciling conservation and development with adequate monitoring and reporting, this chapter evaluates 174 interventions with landscape approach characteristics. We identify key factors that may contribute towards more positive outcomes and conclude that landscape approaches, despite being nascent in theory and practice, are distinct from previous joint conservation and development strategies.

Chapter 4 examines the influence of landscape configuration on ecosystem service provision within the tropics. The specific focus was to understand the extent to which forests contributed to agricultural production via the provision of ecosystem services as forests and agriculture could be considered the biophysical representation of conservation and development within many tropical landscapes. Despite an exponential rise in ecosystem service research, this chapter reveals that there are significant gaps in the evidence base, namely a lack of studies that investigate ecosystem service flows from forests to spatially distinct agricultural plots (i.e. across the landscape). However, we evaluate 74 studies at more local scales and conclude that when incorporated within a contextualized management strategy, trees can maintain and in some cases enhance agricultural yields and rural livelihoods.

Chapter 5 takes a more detailed look at the most influential literature on integrating conservation and development of recent decades. By determining where consistency in scholarship exists, the review then offers an improved understanding of the mechanisms of landscape approaches. This chapter highlights the attributes of landscapes that are considered particularly challenging but perhaps are often overlooked, and then identifies the recommended action points that can help to overcome landscape scale challenges. By illustrating some of the main pitfalls to be wary of and opportunities to seek out, this chapter can be considered a "toolkit" of sorts for future attempts at operationalizing landscape approaches.

Chapter 6 is a concluding chapter that summarizes the key findings emerging from this thesis and considers the current state of landscape approaches in the tropics, and what the future holds for efforts to integrate conservation and development agendas. Finally, the chapter offers some recommendations for future research priorities.
The appendix of this thesis contains a list of articles and briefs that I have authored or co-authored throughout the duration of my PhD studies. They are included here as they have direct relevance to the focus of this thesis.

- (1) From global complexity to local reality: Aligning implementation pathways for the SDGs and landscape approaches, CIFOR InfoBrief, (Reed et al. 2015)
- (2) Five challenges to reconcile agricultural land-use and forest ecosystem services in South East Asia (Carrasco et al. 2016)
- (3) Measuring the effectiveness of landscape approaches to conservation and development (Sayer et al. 2016)

- (4) Natural Resource Management Schemes as Entry Points for Integrated Landscape Approaches: Evidence from Ghana and Burkina Faso (Foli et al. 2017)
- (5) From commitment to action: Establishing action points toward operationalizing integrated landscape approaches, CIFOR InfoBrief (Reed et al. 2016)
- (6) Bridging funding gaps for climate and sustainable development: Pitfalls, progress and potential of private finance (Clark et al. under review)
- (7) Clarifying the landscape approach: A response to the Editor (Reed et al. 2017)

Chapter Two

Integrated landscape approaches to managing social and environmental issues in the tropics: learning from the past to guide the future

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Abstract

Poverty, food insecurity, climate change and biodiversity loss continue to persist as the primary environmental and social challenges faced by the global community. As such, there is a growing acknowledgement that conventional sectorial approaches to addressing often inter-connected social, environmental, economic, and political challenges are proving insufficient. An alternative is to focus on integrated solutions at landscape-scales, or "landscape approaches". The appeal of landscape approaches has resulted in the production of a significant body of literature in recent decades, yet confusion over terminology, application and utility persists. Focusing on the tropics, we systematically reviewed the literature to: 1) disentangle the historical development and theory behind the framework of the landscape approach and how it has progressed into its current iteration, 2) establish lessons learned from previous land management strategies, 3) determine the barriers that currently restrict implementation of the landscape approach and 4) provide recommendations for how the landscape approach can contribute towards the fulfilment of the goals of international policy processes. This review shows that despite some barriers to implementation, a landscape approach has considerable potential to meet social and

environmental objectives at local scales while aiding national commitments to ongoing global challenges.

Introduction

Poverty, food insecurity, climate change and biodiversity loss continue to persist as the primary environmental and social challenges faced by the global community (Godfray *et al.*, 2010; Laurance *et al.*, 2014; West *et al.*, 2014). In response to these very different problems, different sectors have had various success: from 1990 – 2015 the number of undernourished people globally has almost halved (Food and Agriculture Organization of the United Nations, 2015); a global network of protected areas has been developed covering over 15% of the terrestrial surface (United Nations Environment Programme (UNEP)/International Union for Conservation of Nature (IUCN)); and between 1990 and 2010 more than one billion people have been lifted out of extreme poverty (United Nations). Yet despite these advances, many challenges remain: approximately 795 million people remain undernourished globally, with 780 million of these people from developing countries (Food and Agriculture Organization of the United Nations, 2015); greenhouse gas emission rates continue to rise (IPCC, 2014); and global poverty remains both high, with almost 900 million people surviving on less than $1.90 per day, and highly concentrated, with 42.6% and 18.8% in Sub-Saharan Africa and South Asia respectively (World Bank & International Monetary fund, 2016). Furthermore, habitat loss due to agricultural expansion (Hansen *et al.*, 2010; Foley *et al.*, 2011; Galluzzi *et al.*, 2011), is widely accepted as a primary contributing factor to what has already been termed the sixth mass extinction event (Ceballos *et al.*, 2015).

As such, there is a growing acknowledgement that conventional sectorial approaches to addressing these often inter-connected challenges are proving insufficient (Godfray *et al.*, 2010; Foley *et al.*, 2011; Tscharntke *et al.*, 2012). While the primary social and environmental challenges—poverty alleviation, food security, biodiversity loss and climate change—are undoubtedly sectorally distinct, the solutions may be more readily devised via an integrated approach. Primarily this is because the perceptions of pressing social or environmental challenges among stakeholder groups are likely to diverge significantly, often being contradictory to each other (Kutter & Westby, 2014). Equally, solely focussing efforts on a single challenge may result in concurrent negative social or environmental outcomes. For example, increased agricultural production could lead to increased biodiversity loss or the creation of a protected area to conserve biodiversity may inhibit the socio-economic development of those communities excluded.

One way to address inter-connected social, environmental, economic, and political challenges is to focus on integrated solutions at landscape-scales. Yet, while international policy dialogues increasingly highlight the potential of integrated landscape approaches, it is also recognised that landscapes evolve in a "more or less chaotic way" (Antrop, 2006; Sayer *et al.*, 2008) and the inherent complexity and problems within them are "in contrast to the disciplinary organization of science" (Tress *et al.*, 2001). Therefore, our understanding and subsequent ability to overcome the 'wicked' problems (Balint *et al.*, 2011; Freeman *et al.*, 2015) apparent within complex systems is dependent on our willingness to work across social, political and scientific disciplinary boundaries (Meinzen-Dick *et al.*, 2002; German *et al.*, 2007; Barlow *et al.*, 2011).

The appeal of integrating systems at the landscape scale has resulted in the production of a significant body of literature in recent decades (See: Scherr and McNeely 2008, Sunderland et al. 2008, Sayer et al. 2013, Minang et al. 2014, Milder et al. 2014). However, a single normative concept of a landscape approach remains elusive. In addition, confusion over terminology, application and utility persists (Redford *et al.*, 2003; Pfund, 2010; Sayer *et* *al.*, 2013; Scherr *et al.*, 2013). While it is accepted that a universally agreed definition has been—and is likely to remain—elusive (Hobbs, 1997; Tress *et al.*, 2001; Musacchio, 2009; Sayer *et al.*, 2013), here we argue for broader consensus on the conceptualization of the landscape approach.

The tropics remain at a confluence of where many of these interlinked global challenges intersect. Integrated management of tropical regions could avert further biodiversity loss, contribute to sustainable rural livelihoods whilst helping to mitigate and adapt to the effects of climate change. Yet these same areas remain the most at risk of habitat conversion and the concomitant impacts of climate change and poverty (Laurance, 1999; Gardner *et al.*, 2009). To that end, by focusing on the tropics, this paper aims to: 1) disentangle the historical development and theory behind the framework of the landscape approach and how it has progressed into its current iteration, 2) establish lessons learned from previous land management strategies, 3) determine the barriers that currently restrict implementation of the landscape approach and 4) document how the landscape approach can contribute towards the fulfilment of the goals of international policy processes.

Methods

This overview of the landscape approach is based upon a robust and thorough review of both the peer-reviewed and grey literature. This process involved analysing more than 13,000 peer-reviewed articles, over 500 grey literature documents and screening the websites of over 30 key research organizations (see: Reed et al. 2015 for a detailed methodology).

Integrated landscape management theory: A brief history

An integrated approach to managing landscapes is not a new concept, but rather one refined through multiple iterations during attempts to integrate social and economic development with biodiversity conservation and climate change mitigation. It is widely acknowledged that traditional communities have for centuries holistically managed natural resources to meet social needs (Feeny *et al.*, 1990; Ostrom, 1990; Lansing, 2006; Sayer *et al.*, 2013; Cairns, 2015). Moreover, some of the key principles of the most recent Landscape Approach iteration (Sayer *et al.*, 2013), such as adaptive management, while widely recognised as being developed in the 1970's (Holling, 1978; Walters, 1986; Light, 2001), has been broadly discussed for almost a century (Leopold, 1933). Furthermore, the emphasis on integrating environment and development agendas has been consistently promoted for over 40 years, both within the literature and at international conferences (Barrett, 1992; O'Riordan, 1998; Sayer & Campbell, 2001; Merrey *et al.*, 2005; Frost *et al.*, 2006; Scherr & McNeely, 2008; Sayer *et al.*, 2013) (UNCHE, 1972; UNCED, 1992).

In the mid-1980's there was something of a paradigm shift with the promotion of more holistic approaches originating from within the conservation community and the emergence of the scientific discipline of landscape ecology (see: Reed et al. 2015). Initiatives such as the WWF "Wildlands and Human Needs program" and policy dialogues such as the Brundtland report, the 1992 Earth Summit and Agenda 21, resulted in a transitioning away from the traditional 'fortress conservation' model that imposed 'fences and fines' in an attempt to restrict human interference. Increasingly prevalent was the emergence of models that sought to account for the needs of rural communities within conservation projects through the recognition and utilisation of multifunctional landscapes (Bellamy & Johnson, 2000; Saxena *et al.*, 2001; Tress *et al.*, 2001; Fischer *et al.*, 2008; O'Farrell & Anderson, 2010; Barlow *et al.*, 2011; Scherr *et al.*, 2012; Harvey *et al.*, 2014). Concurrently, the development discourse began shifting towards the value of safeguarding natural resources to enhance rural development (Ruttan, 1984; Salafsky & Wollenberg, 2000; WRI, 2000; Murphree, 2002; Shackleton & Shackleton, 2004; Belcher *et al.*, 2005; Sunderlin *et al.*, 2005; Sunderland *et al.*, 2008).

These developments spawned a plethora of approaches designed to reconcile conservation and development agendas with the much-heralded objective of delivering "win-win" outcomes that both conserve biodiversity and enhance socio-economic development. However, while such win-win objectives remain desirable, it has been argued that the true value of such approaches lies in their marketability as opposed to their utility in practice (McShane *et al.*, 2011). This marketability has resulted in a strong show of support from donors and policymakers that, as a consequence, has seen a reluctance from the research community to acknowledge the trade-offs that can, and will, occur in targeting joint conservation and development objectives (Faith & Walker, 2002; Wells & McShane, 2004; Sunderland *et al.*, 2008; McShane *et al.*, 2011; Salafsky, 2011).

This win-win rhetoric has formed the basis of a suite of recent conservation and/or development approaches as many global non-governmental organisations (NGO's) that previously had an explicit objective of conserving nature—such as Conservation International (CI), International Union for Conservation of Nature (IUCN), World Wildlife Fund (WWF), amongst others—increasingly developed projects to recognise the needs of people within the landscape. This review identified a number of prominent approaches (for example, Integrated Water Resource Management (IWRM) or Integrated Watershed Management (IWM); Ecosystem Approach (EA); Integrated Rural Development (IRD); Integrated Natural Resource Management (INRM); Integrated Conservation and Development Programs (ICDP's); and Forest Landscape Restoration (FLR) to name a few) that either emerged, or were re-visited, seemingly as a direct result of the Rio Earth summit.

Although these approaches are commonly referred-to within the literature, it should be noted that they merely act as umbrella terms for a very wide variety of similar, or even identical initiatives, albeit under different guises (Table 1). While the one dominant commonality of these initiatives was the aim to optimize conservation and development outcomes by managing more holistically, the much sought win-win outcomes often remained elusive. Despite documented cases that show that win-win or even triple win outcomes are achievable (Barrett & Arcese, 1995; Agrawal *et al.*, 1997; Wells, 1999; Ferraro, 2001; Saxena *et al.*, 2001; Cao *et al.*, 2009; Miller *et al.*, 2011), experience suggests these few examples are the exceptions and are not achieved at larger scales. Instead, most management or policy interventions result in winners and losers (Wunder, 2001; Brown, 2002; Berkes, 2007; Laumonier *et al.*, 2008; Sunderland *et al.*, 2008; Pfund *et al.*, 2011; Castella *et al.*, 2014).

Table 1 Terminology identified throughout this review referring to some form of Integrated Landscape Approach

Lead Author	Year	Terminology Used
Barrett	1992	Agrolandscape ecology
Barrett	1994	Sustainable landscape approach; Landscape approach; Agrolandscape ecology; Noosystem; Holistic management; Sustainable Agrolandscape Management.
Howarth	1999	Lifescape
Bellamy	2000	Integrated Resource Management
Saxena	2001	Integrated Natural Resource Management
Sayer	2001	Integrated Natural Resource Management
Velazquez	2001	Landscape approach; Participatory research approach; Landscape evaluation system.
Browder	2002	Integrated conservation & development project
Younge	2003	Eco-region Based Conservation
Douthwaite	2004	Integrated Natural Resource Management
Keough	2005	Integrative ecosystem management; Collaborative decision making; Integrative collaborative ecosystem management; Collaborative stewardship; Natural Resource Management.
Lllambi	2005	Participatory Conservation
Merry	2005	Integrated Water Resources Management
Sharma	2005	Community Based Natural Resources Management; Participatory Forest Management; Joint forest management; Community forestry; Leasehold forestry; Integrated landscape approach; Livestock Management; Rangeland ecology; Rangeland co-Management
Frost	2006	Integrated Natural Resource Management
Potschin	2006	Landscape Ecology; Sustainability Science; Landscape Approach

Amede	2007	Sustainable land management; Local Level Participatory Planning Approach
Berkes	2007	Community Based Conservation
German	2007	Participatory Integrated Watershed Management
Muhweezi	2007	Transboundary Ecosystem Management Approach
von Kaufmann	2007	Integrated Agricultural Research for Development
Yin	2007	Integrated Assessment Approach
Hall	2008	Payment for Ecosystem Services
Scherr	2008	Ecoagriculture
Shiferaw	2008	Integrated Watershed Management
Cao	2009	Sustainable Environmental Restoration; Sustainable Development; Payment for Ecosystem Services; Poverty Reduction and Environmental Restoration.
Duff	2009	Adaptive Collaborative Landscape Management (ACLM)
Gardner	2009	Adaptive -landscape planning framework
Musacchio	2009	Landscape Ecology; Sustainability Science; Translational Landscape Research and Practice; Holistic Landscape Ecology; Translational Approach
Sayer	2009	Landscape Approach
Termorshuizen	2009	Landscape Services Framework
Ianni	2010	Forest Landscape Restoration; Ecosystems Approach
Pearson	2010	Landscape Ecology; Landscape Ecological Approach; Trans-disciplinary Approach
Sandker	2010	Landscape Approach
Lewis	2011	Community Markets for Conservation
Sellamuttu	2011	Integrated Conservation and Development Project
Stucki	2011	Integrated Water Resources Management; Ecosystem Approach; Integrated Coastal Zone Management; Integrated Natural Resource Management; Forest Landscape Restoration
Haregeweyn	2012	Integrated Watershed Management
Padoch	2012	Landscape Approach
Palsaniya	2012	Integrated Watershed Management
Qiang	2012	Mosaic Agricultural-Forestry-Fishery-Stock Breeding System
Scherr	2012	Ecoagriculture
Sayer	2013	Landscape Approach
Castella	2014	Participatory land use planning
Indrawan	2014	Satoyama
Kutter	2014	Landscape Approach

The acknowledged failings of integrated management approaches have resulted in a number of critiques (Agrawal & Gibson, 1999; Murombedzi, 1999; Adams *et al.*, 2004; Chapin, 2004; Robinson & Redford, 2004; Sayer & Wells, 2004; Wells & McShane, 2004;

Jeffrey & Gearey, 2006; McShane *et al.*, 2011). These suggest that there are three key reasons why it has been difficult to achieve optimal outcomes.

First, these prior approaches have often failed to acknowledge the inevitable trade-offs within the landscape, electing instead to maintain appeal with policy-makers and landscape practitioners by promoting admirable, albeit unrealistic, dual or triple win deliverables (Pfund, 2010). As described above, examples of win-win outcomes are few and far between and at landscape scales the socio-ecological challenges are complex. It will often be the case that optimal solutions for one person, will be sub-optimal for another and as such, accounting for these trade-offs is fundamental to addressing linked social and environmental challenges. Secondly, despite emphasising the importance of integration as an objective, researchers, policymakers, and conservation and development practitioners have struggled to overcome disciplinary boundaries. Stucki and Smith (2011) observe that despite the widespread promotion of integration, aside from the rhetoric, researchers remain embedded within their disciplinary silos: "water resource managers talk about Integrated Water Resource Management (IWRM), ecologists about the Ecosystem Approach (EA), marine professionals about Integrated Coastal Zone Management (ICZM), agricultural scientists about Integrated Natural Resource Management (INRM), and foresters about Forest Landscape Restoration (FLR)". Finally, the research community may be guilty of 'muddying the waters' when offering solutions to pressing scientific questions. As such, an ever-growing lexicon of terminology has evolved in relation to landscape approaches to environmental and developmental challenges (Ewers & Rodrigues, 2006; Mastrangelo *et al.*, 2014; Waylen *et al.*, 2014).

Ironically, this confusion may have been perpetuated through the burgeoning zeal of research organisations aiming to embrace integration, with every new tweaking of a given iteration resulting in a plethora of often florid and confusing terms. Organisations from across the spectrum of sectors are developing their own interpretations of landscape approaches and labelling them differently, either due to unawareness of existing approaches or a desire to develop their ‘own’ brand. However, this may hinder progress as confusion over terms and their application may be impeding donor commitments, slowing policy traction and stalling practitioner uptake. It has also been suggested that researchers, practitioners and development agencies are repeating past mistakes (Castella *et al.*, 2014), and that there remains a large divide between research and practice (Sunderland *et al.*, 2009) and policy (Shackleton *et al.*, 2009; Shanley & López, 2009). It is therefore important to highlight the mechanisms behind these failings and identify how we can best learn to bridge these gaps.

Existing criticism of prior approaches that have not sufficiently addressed conservation and development objectives have galvanized efforts to provide a refined approach to landscape design and management (McShane *et al.,* 2011; Milder *et al.,* 2012; Sayer *et al.*, 2013). The challenge for sustainability scientists and practitioners is to sufficiently integrate research efforts from design to practice. By acknowledging conservation and development trade-offs and incorporating them into framework designs, management practices can be developed in order to best account for such trade-offs. This should aim to ensure the delivery of a coherent approach that continues to appeal to donors, policymakers and practitioners.

The landscape approach

A landscape approach can be defined as a framework to integrate policy and practice for multiple competing land uses through the implementation of adaptive and integrated management systems (Reed *et al.*, 2015). The landscape approach seeks to address global challenges of poverty, food security, climate change, and biodiversity loss. Although it can be viewed as a refinement of prior approaches, it is distinct in that it acknowledges that satisfying all stakeholders will often be unachievable. By bringing together the diverse range of stakeholders operating within the landscape and attempting to understand what each of their requirements and expectations are, trade-offs and synergies can be identified. Management plans should then aim to capitalize on the synergies while the trade-offs will enable planners to identify who is losing out and as such appropriate compensation or alternatives can be sought. Therefore, the landscape approach attempts, through participatory, inclusive negotiation and planning to minimize trade-offs and maximise synergies so that there are fewer losers and more winners (Sayer *et al.*, 2014).

Perhaps the greatest distinction of the landscape approach is that it does not follow the traditional unidirectional project cycle approach. Due to the dynamic nature of living landscapes it follows that there should be no defined end point to a landscape approach, rather it should be an iterative process of negotiation, trial and adaptation (Sayer *et al.*, 2013). Adaptive management feedback mechanisms will provide stakeholders the capacity to best account for conservation and development challenges within the landscape (see: Sandker et al. 2010). Below we identify some of the key aspects of a landscape approach, for a more conclusive set of principles, see: Sayer et al. (2013).

Key aspects of an effective landscape approach

Evaluating progress within a landscape is fundamental to determining where gains or losses are being made. Without the—understandable, cost-effective and reliable—tools for measuring landscape outcomes, applying appropriate adaptive management decisions to maximize gains and mitigate losses will become impossible. How such decisions are arrived at will largely depend on the structural arrangements and governance systems in place within and outside the landscape.

Contrary to much of the rhetoric in favour of community-based approaches, experience from the national policies of Brazil and Costa Rica have shown that top-down **governance structures** can be hugely effective in reducing rates of deforestation (Ibrahim *et al.*, 2010; Nepstad *et al.*, 2014). However, such structures have been cited as a major contributor to the lack of success of many integrated conservation and development projects (Browder, 2002; Brown, 2002; Hall, 2008) and go against the basic premise of the landscape approach which calls for multi-scale integration of stakeholders. This does not preclude landscape approaches from utilizing top-down governance, rather there is an increased risk of the implementing partner's objectives being misaligned with the capacities and intentions of practitioners, potentially further marginalising local stakeholders (Browder, 2002). Again, inclusive study design and on-going consultation can help to mitigate such undesired eventualities (Scherr *et al.*, 2012).

Similarly, strictly bottom-up governance structures can also face significant challenges. Issues reported in the literature that can impinge the effectiveness of bottom-up or community-based governance systems include: lack of social capital or strong leadership (Pretty, 2002, 2003; German *et al.*, 2007), weak institutional support (Princen, 2003), lack of capacity or financial resource (Ewing, 1999; Berkes, 2007), inequitable share of benefits (Ostrom *et al.*, 1999), and inability to prevent 'land grabbing' or elite capture of resources (Dietz *et al.*, 2003). A preferable, and perhaps increasingly common, system of governance for landscapes has a hybrid, multi-level and cross-sectoral structure (Ostrom, 1990; Lemos & Agrawal, 2006; Berkes, 2007; Ostrom *et al.*, 2007; Ros-Tonen *et al.*, 2008; Colfer & Pfund, 2011; Torfing, 2012; Kozar *et al.*, 2014) that benefits from the integration of internal traditional knowledge and external institutional and financial support.

Ostrom et al. (2007), Sayer et al. (2013) and others stress the importance of **not subscribing to panaceas** for resolving complex social-ecological landscape challenges. A landscape approach is not a cure-all remedy and will not be appropriate in all contexts. It is therefore necessary to evaluate the different land-use options across the landscape and provide verifiable data to support management plans for optimal environment and development outcomes. As such, the ten principles of the landscape approach (Sayer *et al.*, 2013) provide a framework from which practitioners can select and then adapt to local conditions. The principles should not be considered a prescriptive approach to spatial planning but rather a "menu" from which to select appropriately, depending on specific landscape contexts (Tallis *et al.*, 2008a; Sayer *et al.*, 2013; van Noordwijk *et al.*, 2014).

This need for contextualisation extends beyond the evaluation of spatial and biophysical components. A complete landscape assessment should account for the "sense of place and identity" of landscape inhabitants (van Noordwijk *et al.*, 2014). Careful consideration must be given to the sociocultural needs and desires of rural communities as "often land management is not just an economic activity but also a way of life" (Mishra Panda, 1999). This is well illustrated by the tendency of rural communities to align important community rituals and ceremonies with key events in the agricultural calendar (Posey, 1985).

Inclusive, participatory stakeholder negotiation can help align local socio-cultural and global environmental concerns (Altieri & Masera, 1993; Dewalt, 1994; Saxena *et al.*, 2001; Frost *et al.*, 2006). Without commitment from rural communities, landscape approaches are unlikely to succeed, potentially resulting in community members returning to previous destructive practices (Cao *et al.*, 2009) or circumventing restrictions in favour of high-return, high environmental cost land use practices (Sen *et al.*, 1997; Nautiyal *et al.*, 1998). However, evidence has emerged that communities are willing to trade environmentally costly land-use practices that deliver short-term economic gains for those that deliver long-term social and environmental gains, providing they are adequately informed and convinced of the benefits (Keough & Blahna, 2006; Cao *et al.*, 2009). Finally, the practitioners of the landscape approach must be cognizant of the cross-cutting challenges of gender inequity, food and nutritional security, and climate change that are often manifest in rural landscapes.

Recognising dynamic processes and perverse outcomes: Landscapes are inherently dynamic. The individual components that comprise a landscape, be they biophysical, social or political, never remain static and stochastic changes can, and will, inevitably occur. Furthermore, interventions designed to enhance environmental quality may result in perverse outcomes—unintended negative consequences (see internal/external engagement section below). Given that the landscape approach encourages inclusivity of multiple stakeholders, governed at multiple scales through the application of adaptive management to outcomes without specific objectives, it would be remiss of practitioners not to be as dynamic as the landscape in which they are working. The landscape approach framework, when applied to its full potential, should be resilient and resistant to stochastic, counter-intuitive, or unpredictable changes through well designed and evaluated systems. Such systems have the potential to identify and avoid perverse outcomes (Kinzig, 2001).

Barriers to implementation of the landscape approach

This literature review provided evidence that there is both a need and demand for the widespread adoption of integrated landscape approaches, with 37% of the final suite of studies explicitly stating the need for the approach in one form or another. However, within the peer-reviewed literature very few documented examples of an integrated landscape approach in practice—as we define it—were found. This raises questions as to why there is a large gap between knowledge and implementation, what barriers to implementation currently exist, and to what extent these barriers can be overcome? Somewhat ironically, some of the processes that are required to implement a landscape approach also contribute to the barriers to implementation. As such, there is some overlap between the preceding section—key aspects of a landscape approach—and the subsequent section where we describe some of the key challenges—as identified from the literature—to implementing a landscape approach.

Time lags

The lack of documented landscape approaches may be due to the ongoing theory development process, resulting in a time lag whereby implementing partners are reluctant to commit to initiatives until the theory and conceptualisation is fully established. However, application of the landscape approach is necessary in order to advance progress towards environmental and developmental sustainability. Without application, the landscape approach is vulnerable to the same fate of many other integrated approaches (such as ecosystem approach and integrated conservation and development projects (ICDP's) into which considerable thought, resources and debate, were invested in the design and planning without them ever being fully tested in practice (Wu & Hobbs, 2007; Castella *et al.*, 2014; Waylen *et al.*, 2014). Castella et al. (2014) go as far as recommending fewer resources be invested in planning and more in implementation, as many projects fail to make it past the design stage and as such the precise baseline data collected is never utilised. However, this is contrary to the recommendations of others, who consider efficient design to be integral to closing the knowledge-implementation gap (Nassauer & Opdam, 2008; Wu, 2008; Pearson & Gorman, 2010). Furthermore, there are numerous examples of ICDPs being implemented but sufficient baseline data for monitoring rarely being collected (Sunderland *et al.*, 2012). As with many components of a landscape approach, finding an optimal balance that is context specific will be necessary. With considerate design, application, and monitoring, there is considerable potential to generate feedback mechanisms to develop future guidelines for good practice.

The premise of a holistic approach is the capacity to study the whole system even when not fully cognizant of the precise functioning of the component parts (Naveh, 2001). Furthermore, adaptive management promotes a trial-by-error approach that necessitates learning from prior experience to formulate better established management plans through iterative processes (Holling, 1978). Whilst efforts must be made to strengthen the theory and conceptualization of landscape approaches, there is sufficient knowledge already available to apply the approach in practice. The real value of this knowledge will only be realized through integrated commitments to implement and evaluate the approach over larger spatial and temporal scales.

Terminology

As previously alluded to, a further barrier to implementation could be the proliferation of terms associated with landscape approaches (Table 1). In a recent study, Ecoagriculture Partners identified over 80 terms all alluding broadly to the same concept of integrated approaches to land management (Scherr *et al*>, 2013). It is important that the research community is able to provide a more cohesive argument to better engage with stakeholders and decision-makers. A logical first step could be to look beyond the current labels in use by the various sectors operating within a landscape and instead accept that all are entry points towards a landscape approach (Minang *et al.*, 2014). In this sense, a landscape approach becomes less about a destination, or endpoint, and more about the journey, reiterating the need to have regular, inclusive negotiation between stakeholders that generate feedback mechanisms for adaptive management.

Operating silos

Implementation may also be being impeded because of a reluctance among individuals and institutions to operate outside of their regular realms of operation and expertise, more critically it is only through strategic partnerships that such integration can be effective. Researchers have long promoted the need for integration (Barrett, 1992; O'Riordan, 1998; Sayer & Campbell, 2001; Merrey *et al.*, 2005; Frost *et al.*, 2006; Scherr & McNeely, 2008; Sunderland *et al.*, 2008; Sayer *et al.*, 2013) and yet remain entrenched within their own disciplinary silos (Kinzig, 2001; Barlow *et al.*, 2011; Stucki & Smith, 2011). Likewise, multiple sectors represented within the landscape have traditionally maintained sectoral objectives, whether that be to satisfy agricultural, forestry, tourism, energy, resource extraction, or sociocultural demands. At the national level, ministerial silos also exist with a typical administrative structure containing separate ministries for forests, agriculture and energy, for example. In order to bridge the knowledge-implementation gap, a greater willingness to work across disciplinary, sectoral, and ministerial silos must be displayed. There is, however, considerable cause for optimism in this regard, with the continued support for interdisciplinary research, the emergent field of sustainability science (Kates *et al.*, 2000; Clark, 2007), and the recent convergence of government ministries in Turkey (Ministry of Forest and Environment and Ministry of Public Works and Housing) and Indonesia (Ministries of Forest and Environment).

Finally, donors and project sponsors are also reluctant to break from traditional norms with a tendency to support projects at small spatial and temporal scales. Clearly, to fulfil the objectives of an integrated landscape approach, either longer term commitments from donors must be sought or alternative mechanisms for financing sustainable landscapes be put in place. Established funding donor cycles are inherently maladapted to fully support a truly integrative landscape approach, and a paradigm shift is required to alter how donors see and rate outcomes of implementations. This emphasises the need for some simple and understandable landscape metrics that will enable stakeholders to evaluate progress and make informed decisions for future management (see below).

Internal / external engagement

There are a number of cross-cutting challenges that prevail within many of the articles identified in this review such as: stakeholder participation; local or institutional capacity; governance structures; gender and social equity.

The landscape approach encourages full participatory engagement from the outset (Frost *et al.*, 2006; Harvey *et al.*, 2008; Sayer *et al.*, 2013); by bringing stakeholders together and understanding what their expectations of the landscape are, which ecosystem goods and services it provides and how optimal land use strategies can be formulated. Such participatory engagement—underpinned by negotiation and compromise—is a key tenet of the approach, therefore it is vital that this process is performed with due consideration. All too often, attempts at engaging local stakeholders have merely served as a box-ticking exercise to satisfy the requirements of the project. A German Technical Cooperation Agency (GTZ) study noted that insufficient allocation of resources into project design led to hasty implementation, resulting in local stakeholders lacking the capacity to understand or implement the concepts (Soulivanh *et al.*, 2004). German et al. (2007) describes how community meetings were organised with the intention of engaging stakeholders. However, community members were ill-prepared to attend due to lack of time (insufficient notice) or resources (meetings held in inaccessible locations). Furthermore, those that were able to attend did so only to find the meetings conducted in a language they were unable to understand or that pre-existing demographic or social hierarchies prevented adequate engagement. The authors go on to stress that the conducting of, and attendance at, community fora must not be recognised as an adequate “proxy for true participation”.

A landscape approach must attempt to not only understand the basic needs of local stakeholders but to foster empowerment of community members. By providing local stakeholders an active voice in the design and management of the landscape, it can be determined what people want and expect, rather than what they are prepared to accept (Costanza, 2003). However, caution must be applied as the literature is replete with examples of poorly contextualised interventions with good intentions resulting in outcomes far-removed from the objectives. For example, Cao et al. (2009) describe how reformation of property rights returned 90% of forests to individual farmers with the intention of alleviating forest degradation, only for farmers to exponentially increase transformation of their newly acquired forests; Carpentier et al. (1999) explain how tripling the market value of brazil nuts (a pro-conservation extraction product) does not lead to reduced forest loss, but rather households invest their additional income in cattle ranching with the subsequent result of additional forest loss; finally, the classic acceleration example shows forest dependent communities investing in chainsaws with predictable outcomes (Wunder, 2001).

Inclusive consultation will also assist in aligning the often multi-scale objectives of internal and external land users. External stakeholders often encompass corporate entities whose role in the landscape is one of economic bottom lines that often run counter to rural development and environmental objectives. Commonly, these can include ecotourism, mineral extraction, agri-business, logging or industry. Equally, an external stakeholder may be promoting pro-environmental interventions, which may or may not be appealing to rural communities, such as large-scale reforestation programs; UN REDD+ pilot projects; agroforestry initiatives; climate-smart, organic or sustainably intensive agriculture projects. For external stakeholder driven land-use projects to be achievable and sustainable, a degree of consensus among landscape inhabitants is necessary. Communities will need to be engaged and this will ordinarily take the form of co-operation, co-investment, or compensation. A landscape approach can be applied to address specific landscape challenges, both existing and novel. By selecting appropriate landscape principles, positive synergies can be identified and inevitable trade-offs better accounted for, enabling the identification of the optimal form of engagement for community members.

Aligning external and internal objectives and capacities is a significant challenge for effective implementation of a landscape approach. However, "identifying and managing, rather than avoiding social conflict" can assist in achieving mutually beneficial outcomes (Keough & Blahna, 2006). Recommendations to improve equitable input towards landscape design and sustainable, long term engagement include: participatory land use planning (PLUP) (Pfund *et al.*, 2011; Castella *et al.*, 2014), participatory mapping (Chambers, 1994; Boedhihartono & Sayer, 2012), forum groups (Colfer & Pfund, 2011) and semi-structured interviews (Watts & Colfer, 2011) to name a few already well-established examples. Further, the literature suggests that developing a mechanism to facilitate negotiation between stakeholders aids progress, with numerous examples where committees comprising both internal and external stakeholders have been instrumental in contributing to successful participatory involvement (Curtis & Lockwood, 2000; Lebel & Daniel, 2009; Scherr *et al.*, 2012). In these cases the committee tends not to have any formal authority, rather they advise on basic planning, conflict resolution and budget or decision-making processes (Lebel & Daniel, 2009).

It is now well recognised that landscapes may provide the workable space for addressing inter-connected global challenges (Wu, 2013; Bustamante *et al.*, 2014; Estrada-Carmona *et al.*, 2014; Milder *et al.*, 2014; Mbow *et al.*, 2015). However, without sufficient political and private sector support, landscape approaches may not be fully realised. Should this be the case, the landscape approach may fall into the traps of preceding approaches and fall out of favour before meeting—what the authors here see as— the high potential for tackling global challenges. A 2012 Global Canopy Programme (GCP) report found that from an annual budget of $52 billion committed to conservation efforts, only $10 billion came from the private sector – with over $6.5 billion of this accounted for by 'green commodities', natural products carrying sustainable or fairly traded certification for example (Parker *et al.*, 2010). Clearly there is considerable scope to close the gap between private and public sector investments in landscape initiatives. To this end the research community must persevere with efforts to provide convincing evidence-based research that illustrates the potential for investment in sustainable landscapes.

Monitoring

Monitoring is the least developed area of landscape approach application (Lebel & Daniel, 2009; Sunderland *et al.*, 2012) and the recognised need to establish more effective systems of monitoring is consistent throughout the literature. A number of articles refer to either the lack of efficient monitoring systems (Gruber, 2010) or state the requirement for their development in order for landscape approach interventions to succeed (Tallis *et al.*, 2008b; Scherr *et al.*, 2012). Adaptive management is a key tenet of a landscape approach (Sayer *et al.*, 2013). Fundamental to successful adaptive management is the production of metrics that contribute to feedback mechanisms that inform stakeholders and guide decision-making processes (Holling, 1978; Noss, 1990). Put simply, without quantifiable, and measurable data, evaluation of progress within the landscape would be indeterminable, feedback loops would fail, adaptive management would be unachievable, and landscape approaches would thus be ineffective.

Landscape monitoring is an inherently challenging task. The size and complexity demands significant intellectual willingness, and financial, institutional and human resource commitments (Singh *et al.*, 2014). Despite the general lack of frameworks for data collection and landscape evaluation, a body of theory is beginning to develop. Researchers have developed a number of tools and indices in recent years (Bebbington, 1999; Bond & Mukherjee, 2002; Aldrich & Sayer, 2007; Sayer *et al.*, 2007; Belcher *et al.*, 2013) and the emergence of participatory approaches to landscape monitoring and evaluation are encouraging—as mentioned in the preceding section. Although participatory approaches may lack some credibility with scientists (Sandker *et al.*, 2010), well-applied they have the capacity to cost-effectively generate the necessary data for project implementers to identify impacts and project beneficiaries to be further empowered through increased engagement. Ideally, landscape approaches should be assessed along a minimum of four dimensions—environmental protection and restoration; sustainable production; livelihoods security; and institutional capacity/governance (Sayer et al. unpublished). Efficient management, negotiation and decision-making can then help to identify the sub-level indicators of these four dimensions that will be most applicable to the given landscape context. Achieving the right balance of broadness and specificity is vital to ensuring both stakeholder capacity and sufficient scientific rigour. Meanwhile, a further challenge lies in how to maintain the motivation of local people towards participatory monitoring processes, especially once project cycles and funding streams are concluded.

Linking the landscape approach to global policy dialogues

As a further output of our literature screening we attempted to identify where a landscape approach displayed potential to significantly contribute towards the fulfilment of the goals of existing or forthcoming international policy dialogues. Specifically we have focused on two international commitments: 1. The Aichi targets and 2. The Sustainable Development Goals (SDGs), and mapped where the ten principles of the landscape approach (Sayer *et al.*, 2013) display overlap with the objectives of these commitments.

The Aichi targets are a set of 20 targets, established by the UN Convention on Biological Diversity (CBD), that are central to global efforts to preserve biodiversity with commitments from 193 countries until the year 2020. A key objective of the landscape approach is to ensure landscape resilience (Sayer *et al.*, 2013). Therefore, a landscape approach to biodiversity conservation, applied appropriately and contextually, has the capacity to contribute to all of the 20 Aichi targets (Blackie & Sunderland, 2015). Key to the success of a landscape approach for the Aichi targets would be to align the most suitable landscape principles to each specific target. Table 2 illustrates where the landscape approach overlaps with the Aichi targets by identifying which Aichi goals and targets would benefit most from each of the ten landscape principles.

Table 2 Aichi goals and targets that have been identified as being likely to benefit from utilisation of the 10 principles of the Landscape Approach. For a full list of the specific targets refer to the CBD website (https://www.cbd.int/sp/targets/)

10 Principles of a Landscape Approach	Aichi strategic goal most likely to benefit	Aichi target(s) most likely to benefit
Adaptive management and learning	E	17, 18, 19
Common concern entry point	E	4, 17, 18
Multiple scales	A	2, 4, 11
Multi-functionality	D	4, 14, 15, 16, 19
Multiple stakeholders	E	4, 14, 17, 18
Negotiated, transparent change logic	A	1,4
Clear rights and responsibilities	D	4, 14, 16, 18
Participatory user-friendly monitoring	A, B, D	1, 2, 4, 17, 18
Resilience	C	9, 12, 13, 14, 15
Capacity building	E	1, 17, 19, 20

Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society

Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use

Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity

Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services

Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity building

A key outcome from the Rio+20 conference was a commitment from the member states to produce a set of global goals that—by using Agenda 21 and the Johannesburg Plan of Implementation as a framework—will supersede the Millennium Development Goals. The forthcoming Sustainable Development Goals have recently been agreed upon and will guide the post-2015 development agenda. After many months of speculation and canvassing from various sectors for inclusion of their recommendations within the goals, a set of 17 goals encompassing 169 related targets was provisionally accepted in September of this year (see www.sustainabledevelopment.un.org). It is made explicit in the draft that "holistic and integrated approaches to sustainable development" are required, however, many of the goals retain a sectorial focus. Forests and biodiversity are covered in the "environment" goal (number 15), while hunger and health are covered in goals 2 and 3 respectively. Despite this, there is very clear overlap between the goals identified and the objectives of a landscape approach (Table 3). It is implicit that the majority of the goals are inter-connected and the landscape approach would likely be the most suitable framework for achieving many of the stated goals or at least the targets would benefit by being addressed through a landscape lens.

Table 3 Specific Sustainable Development Goals where the Landscape Approach can be applied to various degrees. Levels of applicability were determined by examining all the drafted sub-goals (169 targets) and applying the same classification. The applicability scores presented here are an average take from the larger list of sub-goals. The full matrix that assesses the applicability of the landscape approach to each of the 169 targets is included in the supplementary material.

Goal Number	Sustainable Development Goal Description	Landscape Approach Applicability
1	End poverty in all its forms everywhere	**Important**
2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	**Important**
3	Ensure healthy lives and promote well-being for all at all ages	**Relevant**

4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	**Relevant**
5	Achieve gender equality and empower all women and girls	**Relevant/Not applicable**
6	Ensure availability and sustainable management of water and sanitation for all	**Vital**
7	Ensure access to affordable, reliable, sustainable and modern energy for all	**Relevant**
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	**Relevant**
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	**Relevant**
10	Reduce inequality within and among countries	**Relevant**
11	Make cities and human settlements inclusive, safe, resilient and sustainable	**Relevant**
12	Ensure sustainable consumption and production patterns	**Relevant**
13	Take urgent action to combat climate change and its impacts	**Important**
14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development	**Important**
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	**Vital**
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	**Not applicable**
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development	**Relevant**

Vital = Goal unlikely to be achieved without a landscape approach
Important = Landscape approach would be a suitable Framework for achieving these goals
Relevant = Goals could benefit from adopting the philosophies of the Landscape Approach
Not applicable = Landscape Approach unlikely to be applicable

Conclusion and recommendations

A landscape approach is a multi-faceted approach to land management that aims to bring together multiple stakeholders from multiple sectors to provide solutions at multiple scales. It can be broadly defined as a framework to address the increasingly widespread and complex environmental, economic, social and political challenges that typically transcend traditional management boundaries (Reed *et al.*, 2015). By ensuring the equitable and sustainable use of land, a landscape approach is a potential mechanism to alleviate poverty in an equitable manner, conserve biodiversity, safeguard forests, sustainably manage natural resources, whilst maintaining food production and mitigating climate change.

By synthesizing the fragmented evidence base on landscape approach theory and conceptualization we reveal that despite significant progress the landscape approach theory remains incomplete and barriers to implementation persist. By learning from past experiences and highlighting the areas that require attention, we hope to provide the basis for the development of an improved landscape management framework. Theoretically, a landscape approach framework that incorporates lessons learnt should be the primary overarching tool, fundamental to achieving global environment and development objectives and overcoming the inherent challenges therein. Implemented to their full potential, landscape approaches should encourage coordinated commitment to a given landscape and bridge disciplinary and sectoral divides. We have shown that the literature is replete with calls for more integrated approaches. Overlaps between landscape approach philosophies, the Aichi targets, and the SDGs should in theory provide a convincing case for donors, policy makers, and researchers to commit to well-funded and well-designed long-term, large-scale implementation of landscape projects.

Further research into the design and application of landscape approaches is still required, with a particular focus in the areas of monitoring and evaluation. Moreover, a greater degree of integration between disciplines and stakeholders operating within landscapes is needed to further the progress made in truly synthesizing the socio-economic and environmental challenges within these complex systems. As such, this paper is both an attempt to clarify the current position of integrated landscape research and an invitation for future collaboration to better align current thinking with future policy and local realities on the ground.

Chapter Three

Have integrated landscape approaches reconciled societal and environmental issues in the tropics?

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Abstract

Landscape approaches to integrated land management have recently gained considerable attention in the scientific literature and international fora. The approach is gaining increasing support at governmental and intergovernmental levels, as well as being embraced by a host of international research and development agencies. In an attempt to determine whether, and how, these approaches compare with previous conservation and development paradigms, we reviewed the implementation of integrated landscape approaches across the tropics. Within the scientific literature we fail to find a single applied example of the landscape approach in the tropics that adequately—that is with reliable, in depth collection and reporting of data—demonstrated the effective balancing of social and environmental trade-offs through multi-scale processes of negotiation for enhanced outcomes. However, we provide an assessment of 150 case studies from unpublished grey literature and 24 peer-reviewed studies that exhibit basic characteristics of landscape approaches. Our findings indicate that landscape approaches show potential as a framework to reconcile conservation and development and improve social capital, enhance community income and employment opportunities as well as reduce land degradation and conserve natural resources. However, comprehensive data on the social and environmental effects of these benefits remain elusive. We identify key contributing factors towards implementation, and progress, of landscape approaches and our findings suggest that multi-level, or polycentric, governance structures relate well with intervention success. We conclude that landscape approaches are a welcome departure from previous unsuccessful attempts at reconciling conservation and development in the tropics but, despite claims to the contrary, remain nascent in both their conceptualization and implementation.

Introduction

Landscape approaches to integrated land management have recently gained considerable attention in the scientific literature and international fora (Sayer et al., 2013; Kusters, 2015; Reed et al., 2016) and represent the latest in a series of attempts to reconcile broad-scale conservation and development objectives (Glamann et al., 2015; Reed et al., 2016). With the aim of enhancing social and environmental outcomes, there is increasing support for the integration of previously distinct sectors such as agriculture, energy, forestry, and industrial supply chains to manage land and resources more sustainably. The landscape approach is appealing as a framework because it explicitly calls for the engagement of multiple stakeholders from across sectors to better negotiate trade-offs and maximize synergies within the landscape (Görg, 2007; Sayer et al., 2013; Chia and Sufo, 2015). The approach has been adopted and recognized at governmental (Indonesia, for example) and intergovernmental levels (Convention on Biological Diversity, United Nations Environment), as well as being embraced by a host of international research and development agencies and non-governmental organizations. Yet despite this growing theoretical support for the landscape approach as a concept, there remains both a lack of consensus on definition and limited attempts to apply these approaches on the ground (Pfund, 2010; Scherr et al., 2013; Chia and Sufo, 2015). Furthermore, it has recently been suggested that the approach remains under-theorized (Reed et al., 2016) and that there is a lack of evidence of the effectiveness of the approach in practice (Sayer et al. 2016a). To determine to what extent landscape approaches differ from previous concepts that sought to reconcile conservation and development agendas, we reviewed their implementation, and maintenance, across the tropics. Essentially, we wanted to consider whether landscape approaches represent an important, novel conceptualization of how conservation and development can be more holistically realized, or are they merely a re-branding of old ideas (Redford et al. 2013)?

Landscape approaches are primarily rooted in conservation and the science of landscape ecology (Forman, 1995; Lindenmayer et al., 2008; Sayer, 2009). Biodiversity conservation in particular has been addressed in a "landscape context" over recent decades (cf. Sunderland et al. 2012). Despite the emphasis on reserves and protected areas in the 1980s, some authors were introducing the concept of landscapes into the conservation narrative (Forman & Godron, 1981; Noss, 1983), and early conservation theory promoted landscape-scale thinking through the principles of island biogeography (Kingsland, 2002), albeit not without criticism (Margules et al., 1982). Concurrently, systems approach thinking was developing new ways to manage common pool resources (Ostrom, 1990). The expanded focus of conservation efforts in the late 1980s and early 90s—driven by international agendas such as the Brundtland report (Brundtland et al., 1987) and the largely universal acceptance of the requirement for sustainable development (Schubert & Láng, 2005)—to move beyond protected areas and integrate broader societal needs and aspirations led to the design of "integrated development and conservation projects" (ICDPs) (Hughes & Flintan, 2001). However, the much anticipated "win-win" outcomes remained hard to achieve (or even measure) and often resulted in win-lose or even lose-lose scenarios for both conservation and development agencies (Wells and McShane, 2004). ICDPs were lamented as being too localized in focus—often targeting buffer zones surrounding protected areas—and heavily biased towards achieving conservation targets alone (Sunderland et al. 2012). Such a focus was regarded as sub-optimal for improving rural economic development (McShane et al., 2011), could lead to unforeseen environmental degradation (Garnett et al., 2007; Wells and McShane, 2004), and failed to take into account the inherent trade-offs between social and environmental concerns (Sunderland et al., 2008).

Recent decades have seen the development of a variety of landscape frameworks by multiple authors (Frost et al., 2006; Fischer et al., 2008; Sayer et al., 2013; Ros-Tonen et al., 2014, Freeman et al. 2015), with the aim of embedding single-sector conservation, agricultural production and other land uses within broader landscape-scale management strategies. Such approaches are epitomized by the “Ecosystem Approach” of the Convention on Biological Diversity, but also include a plethora of landscape-scale initiatives developed by multiple development agencies and conservation NGOs – for example: integrated water resource management, integrated rural development, and forest landscape restoration to name a few. More recently, the emerging interdisciplinary field of sustainability science has strengthened the call for improved integration between research disciplines, policy, and practice to better comprehend the complexities—and connectedness—of interactions between human and environmental systems (Kates et al., 2001; Clark, 2007). As developments in landscape-scale management strategies continue to emerge, the sheer volume of approaches has resulted in a somewhat florid and confusing terminologies, that has been suggested as a contributing factor inhibiting progress on implementation (Scherr et al., 2013; Waylen et al., 2014; Mastrangelo et al., 2014; Reed et al., 2016). This has arguably led to fragmentation of knowledge, unnecessary re-invention of ideas and practices, and slow progress in gaining policy traction (Scherr et al., 2013).

To contribute to a resolution of this confusion, it is seemingly important to define what a landscape approach is, and what it is trying to achieve. This is, however, far from straightforward as landscape approaches, and even the term landscape itself, will mean different things to different actors (Tress et al., 2001). A ‘landscape’ can refer to either spatial and ecological characteristics that help define conservation and development targets, or to governance and other social interactions and mechanisms that minimize conservation and development trade-offs (Redford et al., 2003). A landscape approach can be defined as a framework to integrate policy and practice for multiple competing land uses through the implementation of adaptive and integrated management systems (Reed et al., 2015a). However, as landscapes, their individual components, and the stakeholders within and around them are unique and dynamic, a single management framework applied at the landscape scale cannot be expected to be successfully applied across different landscapes. Such frameworks that are proven to be optimal in one landscape may well be sub-optimal in another and implementers must be cognizant of the context specific nuances of their landscape of interest (Ward & Shackleton, 2016). A landscape approach is best considered as a process—as opposed to a project—but in order to progress towards “outcome” objectives, it is important to recognise what those objectives are, who defines them, and what mechanisms can facilitate progress towards them.

The general overarching objectives of the landscape approach are enhancing sustainability and multi-functionality within the landscape to achieve multiple outcomes. Sustainability should encompass social, economic, environmental, cultural, and often political objectives and relate to the ability of the system of interest to increase resistance to stochastic changes and resilience to future shocks—whether natural or market-induced. Meanwhile multi-functionality can refer to spatial segregation (the configuration of separate land units with different functions); temporal segregation (different functions on the same unit of land over time); or functional integration (multiple concurrent functions operating on the same unit of land) (Brandt, 2003). The landscape approach is more often related to functional integration or “real multi-functionality” and therefore implementation efforts should address the complexity of balancing the objectives of multiple stakeholders—potentially across a range of sectors (e.g. extractive resources to forest conservation) and scales (e.g. indigenous community to multi-national industry or policy) (see also: De Groot, 2006; Scherr and McNeely, 2008; O’Farrell and Anderson, 2010; Freeman et al., 2015). The key to landscape approach effectiveness or progress therefore, is understanding, and balancing, the needs and aspirations of landscape stakeholders, appreciating that perceptions of what defines success will vary amongst stakeholders, and incorporating these into formal or informal decision-making processes. This allows the identification of situations where trade-offs and synergies are likely to occur, facilitating negotiation and the application of appropriate adaptive management mechanisms. Such regular processes of consultation should seek to aid the navigation of landscape change, ideally reducing vulnerability while enhancing resilience (Folke et al. 2010). However, we acknowledge that much of the complexity is likely beyond the realms of management, and a degree of “muddling through” will invariably be necessary (Lindblom, 1959; Sayer et al. 2008a).

Here, we aim to contribute to a better understanding of the practicalities of implementing a landscape approach and the mechanisms required for an effectively functioning process; thereby contributing to the ongoing discourse on reconciling conservation and development by evaluating to what extent landscape approaches represent a departure from the much-criticized prior interventions. To achieve this, we critically reviewed both the scientific peer-reviewed and non-published (grey) literature to determine 1) where terrestrial landscape approaches have been applied in the tropics, 2) whether conservation and development objectives have been integrated with successful outcomes for both, 3) whether landscape approaches have been effective in securing societal and environmental improvements (if any), 4) which components of landscape approaches have contributed towards these improvements, and 5) what are the governance structures in place.

The tropics represent a highly relevant focus area as they contain many globally significant biodiversity hotspots (Myers et al., 2000) but also often exhibit high levels of social and political complexity and dynamism (Wilshusen et al., 2002). While the review process cannot uncover all of the evidence related to integrated landscape approaches, we understand this process to be the first attempt to aggregate the existing published—and grey—scientific knowledge on the subject. As such, this review can complement local knowledge and other reviews that engage more directly with practitioners on the ground (Estrada-Carmona et al., 2014; Milder et al., 2014; Kusters, 2015). Ultimately, we aim to help inform the development of a clear strategy on landscape-scale management, contribute to the integration of conservation, agriculture and other land uses into future land-use policies and identify how landscape approaches can be best implemented to support national commitments towards the Sustainable Development Goals (Van Vianen et al., 2015) (https://sustainabledevelopment.un.org).

Methods

This review of landscape approach case studies in the rural tropics is based upon a robust and thorough systematic assessment of both the peer-reviewed and grey literature. This involved analysing 16,832 peer-reviewed articles retrieved from searches performed in September 2014 and updated in November 2015 using the specialist databases Web of Knowledge, the Centre for Agriculture and Bioscience International (CABI), and Scopus, with Google and Google scholar used to test for completeness. A total of 488 grey literature documents were retrieved via a number of methods: a specific call for grey literature distributed to: key research organisations (see supplementary material for details), the listserv Biodiversity-L, and international conferences (Global Landscapes Forum, Association for

Tropical Biodiversity Conservation, World Forestry Congress); screening the websites of key research organisations (as above) using the search string: site: file:pdf ("landscape approach"|"multifunctional landscapes"|"sustainable agriculture"|"environment and development reconciliation"); identification of documents via the author group and partners (snowballing method); bibliography screening of relevant peer and non-peer-reviewed articles (see: Reed et al., 2015a for a detailed methodology).

At the outset of the review, the inclusion criteria was necessarily rudimentary (see Table 1). However, completing a systematic review is an iterative process and modifications to the protocol may be necessary (Moher et al., 2014). We found this to be the case as due to inconsistencies in use of terminology and a lack of a universal definition for landscape approaches, screening of full text articles became increasingly subjective when limited to the initial criteria. As a result, the review team had multiple consultations throughout the screening process, discussed issues with other experts in the field and ultimately used our collective judgement to determine inclusion. Table 1 presents both the initial (applied to all articles at title and abstract screening) and amended inclusion criteria (applied to all articles at full text screening). It is important to note here that studies that conformed to the initial criteria would be included in the review. The amended criteria was developed more as a guide for the reviewers and to encourage more detailed data extraction at full text screening. While it was hoped for, it was not a requirement that studies must meet all of these amended criteria in order to be included. All studies were reviewed by at least two reviewers and if consensus between the two reviewers was failed to be achieved with regard to study inclusion, a third review would be completed before a consultation to determine inclusion.

Table 1: initial and amended screening criteria for all peer-reviewed studies examined.

Initial inclusion criteria	**Study aims to:** balance competing sectorial or stakeholder demands on land at the landscape scale within the tropics **Study documents:** • evidence of integrating at least two land uses • evidence of integrating at least two stakeholders • outcomes on social, agronomic, environmental, or economic variables
Amended inclusion criteria	**Study details:** an attempt to reconcile social and environmental objectives at the landscape scale. **NB:** We do not provide a set scale, or spectrum of scales, that would define a landscape but rather suggest that the landscape is a socio-ecological system that is large enough to display heterogeneity of land characteristics and small enough to maintain a degree of manageability (Berkes & Folke, 1998; Ostrom, 2009; Torquebiau, 2015; Denier et al., 2015) **Study aims to:** • integrate agriculture and forest conservation or other competing land uses for more optimal, or at least better balanced, outcomes. • assess and refine/reform existing governance structures within the landscape in order to identify the optimal arrangement that encourages inclusive negotiation to maximize participation and manage for potential conflict. • be a long-term commitment to better managing social and environmental concerns within the landscape, typically beyond the 1-3 year project cycle. **Study documents:** evidence of engaging multiple stakeholders from across scales. Such processes should illustrate an effort to assess the needs and aspirations of stakeholders, and therefore be integral to identifying potential trade-offs and synergies. **NB:** Stakeholders can be defined "as people or organizations either affected by the management process or who can affect it" (Glicken, 2000; Hassenforder et al., 2016). **Study identifies** (and ideally implements): a set of metrics to evaluate progress and change within the landscape.

The final suite of studies for analysis comprised of 24 landscape approach examples from the peer-reviewed literature and 150 from the grey literature (see supplementary material). These "landscape approaches" , however, were often labelled differently within the captured documents – for ease of understanding, if they conformed to the criteria they were included and are hereafter referred to as landscape approaches. The initial objectives for this review were to first, identify where within the tropics landscape approaches had been/were being implemented, and second, to determine the characteristics of the interventions. We did not seek to identify a measure of success as landscape approaches are long-term processes and the interventions would likely be ongoing, and landscape approaches are notoriously difficult to evaluate due to their complexity. However, during the screening of the peer-reviewed documents we increasingly encountered articles that were indeed reporting, or alluding to, successful outcomes. Consequently, we became interested in both the "effectiveness" of landscape approaches and also the quality of the reporting of landscape approaches – for example: how, and by whom, is success determined; what attributes of conservation and development are being influenced; and is there sufficient and verifiable data?

In order to further explore these interests, we developed some simple indicators that could represent positive characteristics of a landscape approach in practice. Our previous assessment of the literature (Reed et al., 2016) enabled us to identify a very broad set of guidelines, enabling/pre-conditions, and indicators that—from a theoretical perspective—should facilitate progress on the ground. For the purposes of this review and in the interest of manageability and capacity we condensed these to a few key criteria against which to evaluate the implementation and progress of landscape approaches in the tropics. We consider landscape approaches ought to (at a minimum) display evidence of some or all of the following:

- Good pan-tropical coverage (to establish that uptake of landscape approaches is occurring)
- System of governance (it is anticipated that a multi-scale governance system would be optimal but, at a minimum, some indication that some sort of structure of governance in place)
- Baseline assessment (not limited to biophysical data collection, this might include a negotiated theory of change, identified common concerns, evaluation of tenure/rights, household surveys, use of national inventory data etc.)
- Attempt to integrate conservation and development concerns at a landscape scale
- Regular stakeholder engagement (this might take the form of a multi-stakeholder platform or similar)

- Ongoing assessment (metrics and indicators for regular assessment of conservation and development impacts, mechanisms to account for dynamic processes, use of adaptive management)
- Impact (does the landscape approach report a measure of success/failure/lessons learned)
- Outcome data (robust and verifiable qualitative/quantitative data to support claims of success)

While we did not expect studies to consistently report on all of the criteria detailed above, we developed an Excel database to systematically capture any relevant information observed during the literature screening process. Where possible, within-cell drop-down options were provided to enhance consistency and enable comparative analysis. However, in part to acknowledge the diversity of landscapes, the database was "live" and reviewers were encouraged to develop additional variable columns, or provide further comments of interest beyond the scope of the outlined criteria, as and when required. This process resulted in a final datasheet with a large number of variables of potential interest (n=76) but it was rarely the case that studies sufficiently reported on all or even the majority of these variables and there were numerous empty cells or missing data points which is a recurring issue for systematic reviews within the environmental sciences (J. Oldekop, personal communication). This high percentage of missing data limits our ability in some elements of our analysis (see Results section below).

Literature searches were conducted in September 2014 and captured 13,290 peer-reviewed articles of potential interest. Sequential screening at title, abstract, and full text filtered this number to 82 relevant articles from which we found 22 case studies for inclusion. A total of 488 grey literature documents were retrieved from the following sources: call for grey literature (57 documents); web screening (293 documents); author group and partners (56 documents); bibliographies of key articles (82 documents). From the 488 grey literature documents, 150 were accepted for inclusion. An updated literature search was conducted in November 2015 to capture any literature produced during the screening process. This search produced 3542 articles, from which a further two case studies were included, giving a final figure of 16,832 documents screened with 174 case studies (24 peer-reviewed) included in the final review.

Results

Geographic coverage of landscape approaches

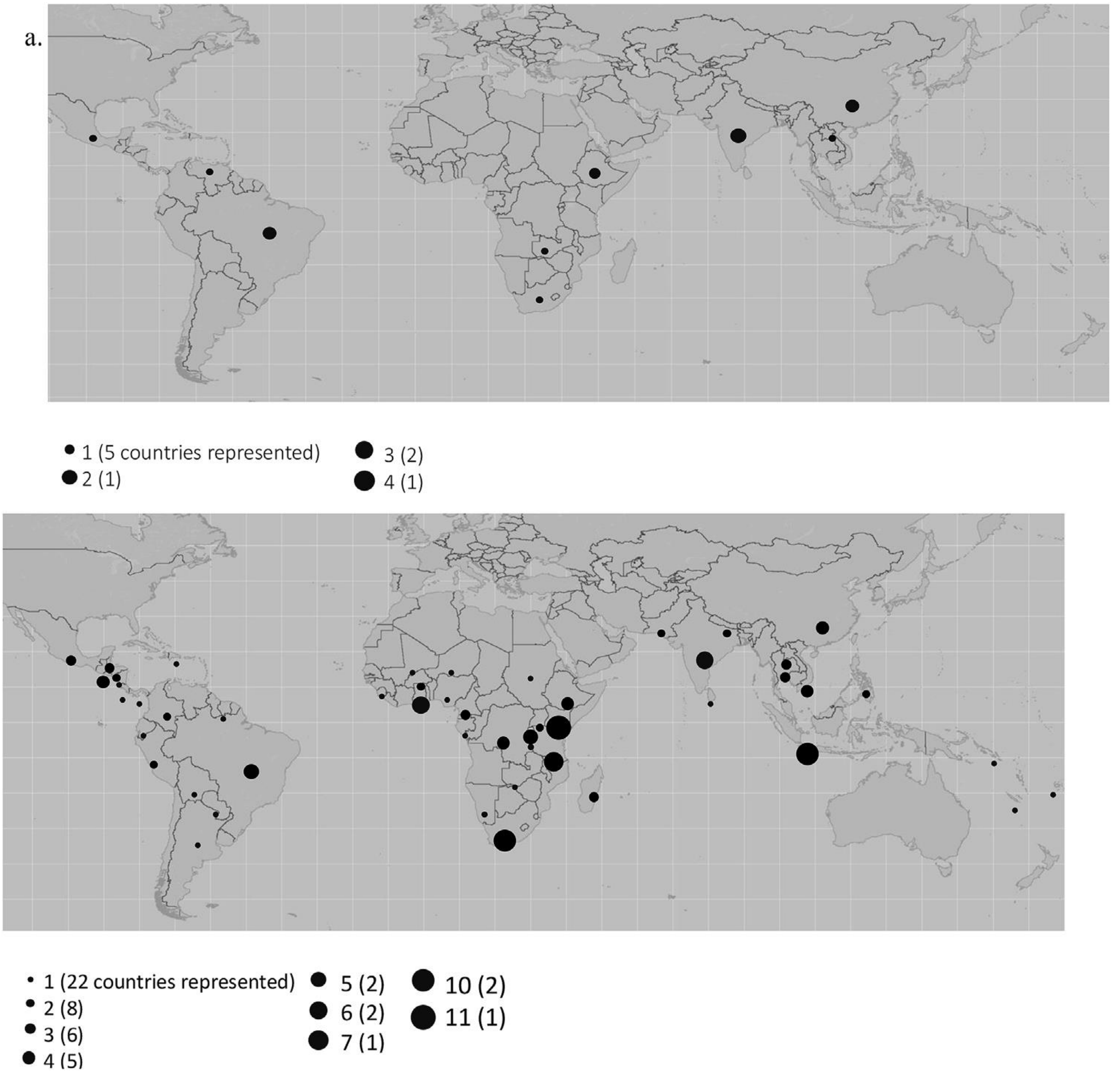

*Figure 1: Geographic distribution showing number of integrated landscape approaches in the tropics. a. peer-reviewed studies b. grey literature studies. The first number indicates the amount of ILAs the point represents, the number in brackets represents the number of countries that have the corresponding amount of ILAs. *Transboundary studies are not indicated (peer-reviewed = 8, grey literature = 14).*

We found evidence of landscape approaches being implemented across the tropics, with 51 of 169 tropical countries represented in the review (Fig. 1). However, reports of landscape approaches were far more prevalent in the grey literature (n=150) than in the peer-reviewed literature (n=24). Furthermore, both the fragmentary and simplified nature of the study details in the grey literature limited our ability to perform comparative analysis between the grey and peer-reviewed for each of our research questions – in such instances analysis was only performed on the peer-reviewed material. For example, information regarding the configuration of land uses within the landscape was largely absent from the grey literature (see supplementary material); reports were often limited to anticipated, pilot, or recently formulated projects; and in many existing projects outcomes were reported but often not supported with the necessary data. As such, it was often the case that our analysis of the data was restricted to just the peer-reviewed material.

Evidence of integrating conservation and development objectives

Due in large part to the focus of the study being on integrated projects, overall, there was consistency across both the peer-reviewed and grey literature in attempting to integrate conservation and development objectives. However, of note, we found, particularly from the peer-reviewed material, that it was often the case (peer reviewed: n=14) that a project initially had a single sector focus and then evolved—often in response to challenges encountered—to incorporate other objectives and thus developed characteristics more closely aligned with a landscape approach (see suppplementary material). We found further consistency in the reporting—or more accurately lack thereof—of baseline assessements. Across the studies, evidence of any form of basline assessment was rarely reported and when there was, this typically consisted of "identifying a common concern" (n=16) as opposed to evidence of any robust social or biophysical baseline data. There was insufficient data and reporting in the grey literatue to develop any further analysis here.

Effectiveness of landscape approaches

A large proportion of both grey literature (44%) and peer-reviewed (54%) documents described successful outcomes, that is claiming—typically within the conclusion of the report—that the landscape approach had been, or was proving to be, successful in the delivery of either, or both, societal or environmental enhancement. However, in the majority of cases the evidence of reliable monitoring and ongoing assessment of landscape approach effectiveness was lacking. We did not identify any unsuccessful examples. However, 8% reported "mixed" outcomes; these were typically interventions that had reported positive socio-economic effects (i.e. improved livelihoods) but negative environmental effects (i.e. increased deforestation) or vice versa.

Evidence of environmental or social change

"Success" was often unsupported with empirical data, relying instead on self-reporting of anecdotal evidence alone. The peer-reviewed material presented numerous issues when it came to the quality of reporting and the presentation of reliable data with only one quarter (n=6) of the studies providing relatively comparable, reliable data (although only nine of the 150 grey literature documents provided similar evidence). From the peer-reviewed literature we were able to determine which attributes of conservation and development had been reported as being positively influenced through these proportedly successful interventions. Despite this analysis only being possible for half of the 24 peer-reviewed studies, the findings indicate that landscape approaches offer potential to positively influence a range of socio-economic and environmental variables (Fig. 2). However, the small sample size—due to a lack of sufficient reporting—should be noted when interpreting the results presented in Figure 2.

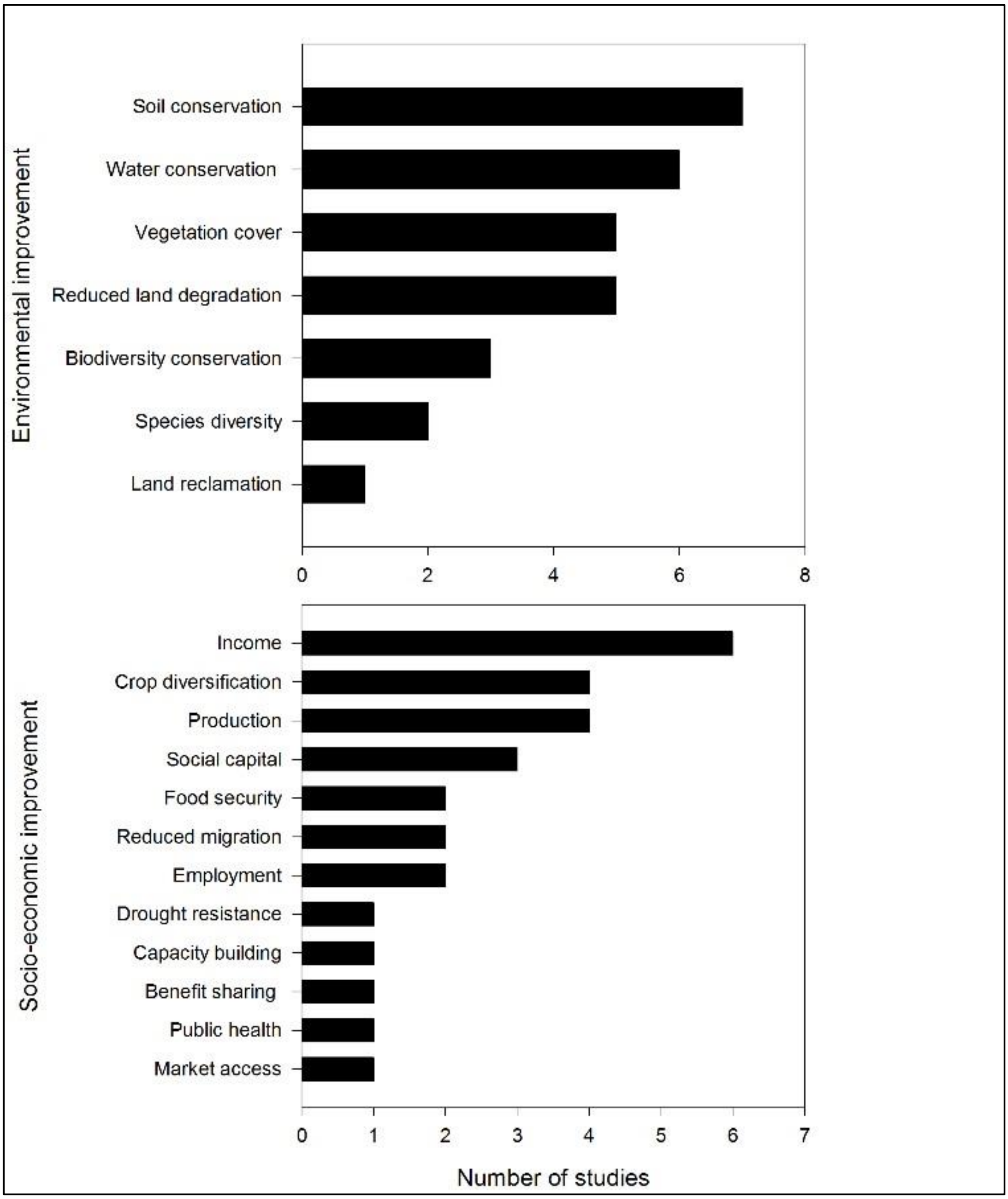

*Figure 2: Reported (a) environmental and (b) socio-economic improvements from peer-reviewed studies (n = 12). *Studies often reported on multiple outcomes and therefore the total number of data points is greater than the number of studies resented here.*

Factors contributing to intervention success

The results suggest that stakeholder engagement, sufficient institutional support, and effective structures of goverance were considered necessary across most case studies that were reported as being sucessful (Fig. 3). However, details of how to effectively enagage stakeholders or utilise institutional support were mostly lacking.

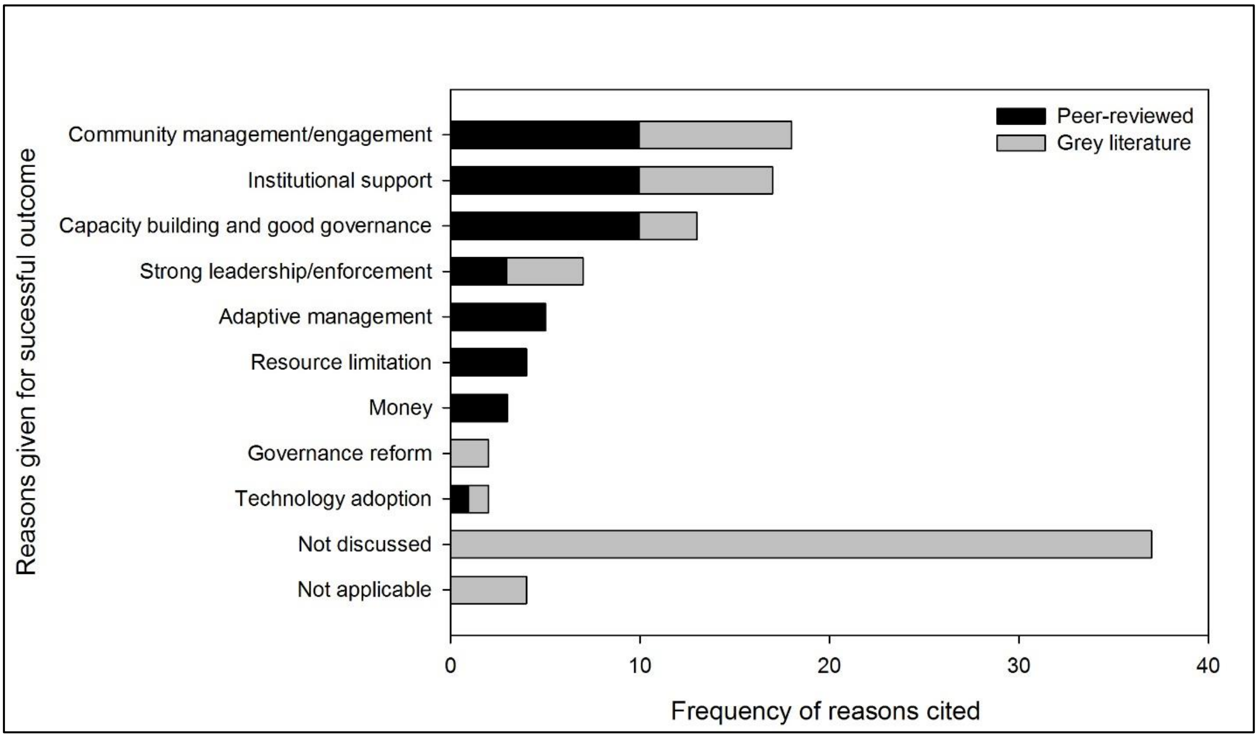

Figure 3: Identified contributing factors towards successful outcomes of peer-reviewed (n=13) and grey literature studies (n = 66).

Evidence of governance structure in place

Where possible to determine (n=126 – peer-reviewed and grey literature combined) we found that a multi-level system of governance—a hybrid system that marries traditional top-down authoritarian structures with bottom-up democractic processes—was both most common (59%) and most highly correlated with reported success (Fig. 4). Despite rhetoric supporting bottom-up governance (see discussion below), we found few examples in practice (3%) and top-down structures remain prevalent throughout the tropics (38%). It is important to note here that studies rarely made explicit reference to the governance structure in place and reviewers often made an informed judgement call. The double screening that was performed helped to achieve consensus between at least two reviewers. If after consultation within the author group, some doubt as to the governance structure remained the study was classified as not determined.

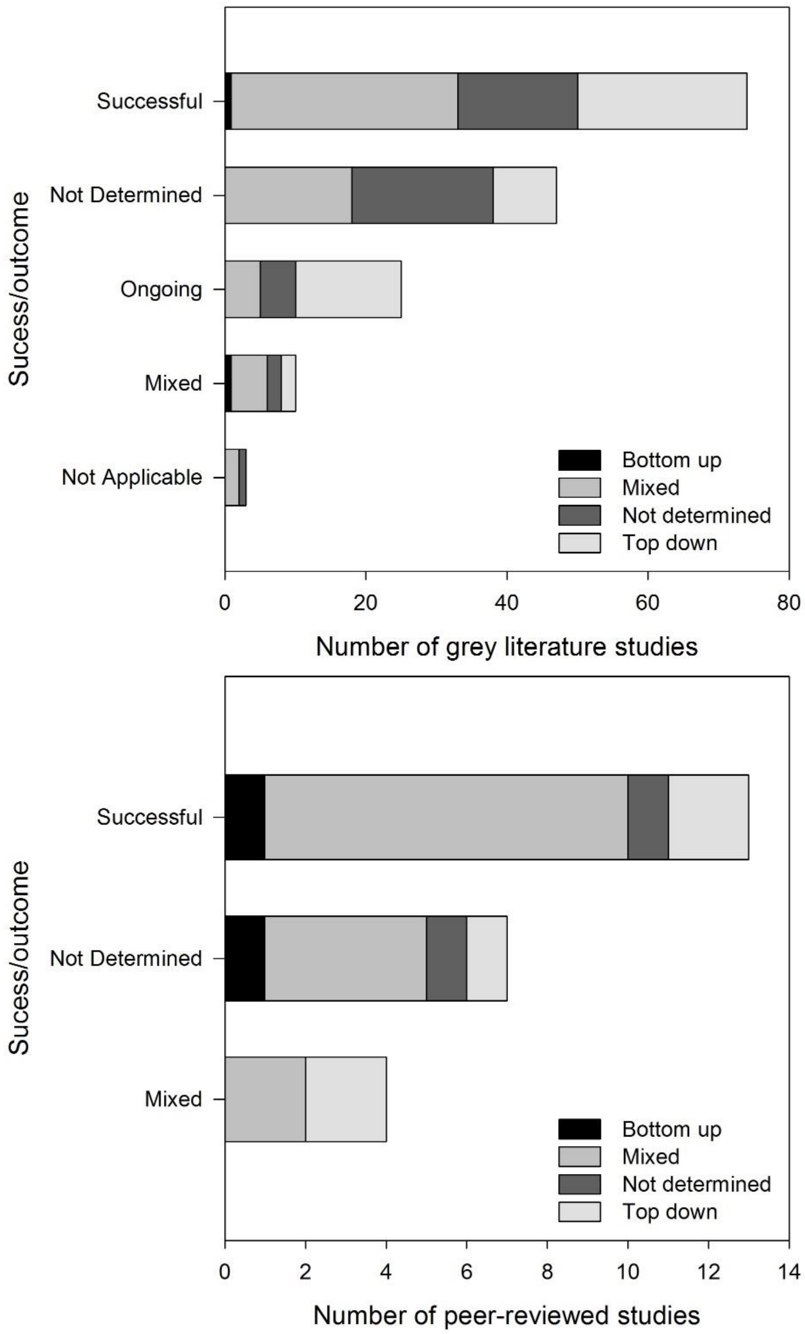

Figure 4: reported successes of all landscape interventions (grey literature and peer-reviewed) and the proportion of governance structure types that the interventions used (n=174)

Discussion

Recent papers present evidence suggesting that integrated landscape approaches that aim to enhance conservation and development are being embraced across the tropics (Estrada-Carmona et al., 2014; Milder et al., 2014). Meanwhile, conservation funding is increasingly targeted at integrating conservation with development (Miller, 2014) and there is burgeoning support for the implementation of landscape approaches from international conservation and development agencies, and within global policy discussion. Despite this, we were unable to identify a single landscape approach that adequately reported—that is with reliable, in depth collection and reporting of data—proven effective balancing of social and environmental trade-offs through multi-scale processes of negotiation for enhanced outcomes. Instead, we recorded a limited number of interventions from the peer-reviewed literature that displayed basic characteristics of the landscape approach—albeit often labeled differently—and a number of grey literature documents that were either in a formative stage or failed to provide a level of reporting necessary for analysis. First, we question why there is a clear lack of evidence of the effectiveness of the landscape approach in the literature. We then consider the significance of scale, structure, and objectives when attempting to integrate conservation and development, and finally we examine the challenges of collecting evidence of the benefits of implementing a landscape approach.

A lack of evidence of the effectiveness of landscape approaches?

Here we identify three key reasons why there is a lack of evidence about the effectiveness of landscape approaches. First, the fact that only 15% of the total number of case studies identified in this review came from the peer-reviewed literature could point to a lack of evidence of implementation. While we captured 150 grey literature documents, these largely comprised of landscape approaches that were still in a developmental stage. We could speculate that landscape approaches—despite gaining support—are as yet, not being widely implemented in the tropics. It could be that integrated landscape approaches are still evolving as a concept and as such, implementing organisations—lacking the sufficient knowledge that enables capacity—retain a certain reluctance to commit. Other concepts and frameworks that attempt to integrate conservation and development have experienced similar "teething problems" (Pahl-Wostl, 2002; Medema et al., 2008), although, perhaps a key difference is that—as yet and to the best of our knowledge—there appears little theoretical resistance to the concept of a landscape approach as a viable implementing framework. Yet it is apparent that barriers to implementation persist (Reed et al., 2016) and strong support for land sparing approaches to conservation remain, which is reflected in this review in the low number of peer-reviewed landscape approach studies captured. The grey literature offers some cause for optimism in this regard however with many of these documents detailing pilot studies, proposals, or implementing agendas suggesting that commitments to implementation may be forthcoming.

The findings from the peer-reviewed literature led us to question further—is there a lack of empirical evidence of effectiveness or is the evidence simply not being effectively reported? The results would suggest that there is support for both of these statements. It has been reported previously that field project implementing agencies may lack either the capacity to report findings of sufficient scientific rigor (Sunderland et al., 2009) or the motivation to report failures in order to not jeopardize future funding opportunities (Knight, 2006; Pullin, 2015). This review found only a small percentage of case studies in the scientific literature that provided robust empirical data (25%)—despite often reporting successful project outcomes (54%). An even greater discrepancy was found in the grey literature, only 6% of which provided robust data while 44% claimed success. Furthermore, we did not find a single study that categorically demonstrated a landscape approach that had failed in its objectives. As a result, while examples of lessons learned do exist, they remain disappointingly few and far between (Browder, 2002; Laumonier et al., 2008; Nyame et al., 2012; Sunderland et al., 2012; Castella et al., 2014). Moreover, the lack of negative outcomes suggests a reporting bias (see: McGauran et al., 2010) that could be partly explained by both the tendency of scientific studies to favour reporting of positive findings and the continued trend of short-term, small-scale projects that rarely demand evidence of monitoring and evaluation of interventions (Pullin, 2015). The typical three year time horizon is sufficient for the production of a summary paper, methods paper, or recommendation for future research but it is perhaps insufficient for documenting and detailing any long-term change induced from the intervention. Conversely, long-term interventions across large landscapes that are difficult to assess will require greater human and financial investment to monitoring and evaluation (M&E) in order to identify outcomes that may not be immediately obvious or available and will likely change over time. In both scenarios, there is a significant disincentive to invest in inclusive monitoring and reporting of results.

This paucity of "scientifically supported" landscape approach case studies could further be attributed to the lack of a universal definition and guiding framework for implementation (Sayer et al., 2013). Although multiple authors have proposed definitions (e.g. Barrett and Peles, 1994; Sandker et al., 2010; Kutter and Westby, 2014; Reed et al., 2015a), they have mostly failed to capture the balance of providing the necessary level of detail with sufficient brevity that will likely be required to garner universal support. Similarly, the scientific literature is replete with examples of guiding frameworks, implementing proposals and recommended future research agendas (Brandon and Wells, 1992; Naveh, 2001; Fischer et al., 2006; Frost et al., 2006; Keough and Blahna, 2006; Chazdon et al., 2009; McShane et al., 2011; Sayer et al., 2013; Milder et al., 2014; Freeman et al., 2015) which despite showing overlaps have failed to instill consensus within the research or practitioner communities. We have previously speculated that the clamour to define, refine, and re-brand seemingly replicate iterations of landscape approaches may ultimately be impeding efforts towards implementation and in fact disengaging policymakers (Redford et al., 2013; Scherr et al., 2013; Reed et al., 2016; Chazdon and Laestadius, 2016). While we accept the need to further develop guiding criteria for implementation, we encourage collaborative efforts that subsequently follow up with commitments to implement. Moreover, the fundamental importance of recognising context-specific nuances (Ward & Shackleton, 2016)—reduces the relevance of an unambiguous definition or universal framework as a degree of pluralism is always likely to exist and should perhaps even be encouraged[1].

The significance of scale, structure, and objectives

Recognising a common concern when implementing a landscape approach links to both the contributing factors to success and project focus findings of this review. An agreed acknowledgement of a resource limitation (common concern) was identified as being a factor towards project success in 38% of peer-reviewed studies. Meanwhile, the project focus findings suggest that integrated approaches may still retain a limited spatial and sectoral focus. For example, from across the 24 peer-reviewed studies, there were 18 landscape features (see supplementary material) documented as being forested areas that were under some form of protection (PAs, NPs, reserves, or exclosures). This raises questions of whether landscape approaches are restricted by administrative boundaries and whether we have learned from the lessons of previous efforts at integrating conservation and development, such as ICDPs for example that were criticized for being too localized in focus (Wells and McShane, 2004; McShane et al., 2011). It has been suggested that maintaining a narrow focus primarily on protected areas for forest/biodiversity conservation or buffer zone management

[1] http://blog.cifor.org/23834/landscape-approach-defies-simple-definition-and-thats-good#.VPgbrzSUdKo

inadequately accounts for local social development and therefore risks further marginalizing vulnerable groups (Adams et al., 2004; Lockwood et al., 2012). We acknowledge that the project focus findings could be conceived as a limitation in the search strategy. For example, had we included REDD/REDD+ in the search strings we would clearly have generated many more projects with an emissions reduction focus. However, when we designed the search stategy it was with the objective of capturing landscape approaches that were distinct from both prior integrated approaches to conservation and development and the REDD discourse, despite some evidence of their potential connectedness (Blom et al., 2010; McCall, 2016).

Implementing a landscape approach requires managing multiple layers of complexity and in all likelihood the ability to align local needs and capacities with regional, national, and global objectives and commitments (Browder, 2002; McShane et al., 2011; Chia and Sufo, 2015; Reed et al., 2015b). Multi-level structures that foster cross-scale and cross-sectoral dialogue may be the most appropriate method for governance of multiple resources (Colfer and Pfund, 2011; Torfing, 2012; Ros-Tonen et al., 2014). It is encouraging that we found a significant proportion of studies reporting a multi-level governance structure. Further, multi-level governance appears to translate well to the delivery of positive conservation and development outcomes. Given the rhetoric in support of bottom-up approaches to landscape management (Ostrom et al., 1999; Pretty, 2003)—which is also supported in part by the factors for success identified in this review below—it is perhaps surprising that we found so few examples of community-based or bottom-up approaches. However, it could be speculated that where bottom-up approaches have been effective there may not be the capacity or motivation to monitor or report on them. Furthermore—although perhaps not so surprising given the ongoing trajectory of development and governance reform within the tropics—we found top-down governance structures maintain a high degree of prevalence. Some of the literature suggests that top-down governance can be effective for addressing sector-specific conservation goals (Ibrahim et al., 2010; Nepstad et al., 2014), and our analysis shows there to be a good relationship with 48% of studies adopting this system reporting successful outcomes. However, landscape approaches that adopt—or are embedded within—a top-down governance structure are counter to its basic premise that promotes open and transparent negotiation processes across all scales from the outset. If the implementing agency enters negotiations with a pre-conceived agenda and list of objectives, it needs to be questioned whether the intervention actually represents a landscape approach – i.e. an approach that attempts to balance trade-offs across multiple actors and scales and in particular recognizes the needs and aspirations of local stakeholders.

Ideally landscape approaches should have continual adjustment with short and mid-term objectives to assess progress (Sayer et al., 2013). Therefore the production of (regular) progress assessment reports that detail both successes and also failings would be useful to enhance understanding of what works and why. Our findings clearly suggest there is a requirement for further evidence of what works, but that there is perhaps a greater need for examples of lessons learned when projects might have failed in their objectives or produced unexpected outcomes (Knight, 2006; Sunderland et al., 2009; Clark et al., 2016). Only trial by experimentation will enable us to measure effectiveness and only by identifying failures will we be able to adapt. While it is important to evaluate the cost-benefit trade-offs when the approach is applied (in terms of balancing social and environmental objectives) we should also acknowledge the cost/benefit trade-off of actually applying the approach (in terms of success and failure). Knowledge will not only be informed by success and so the cost of applying the approach may actually be traded off against the benefit of the knowledge acquired from a “failed” attempt at implementation.

Collecting and reporting the evidence

In light of the difficulties surrounding monitoring of landscape approaches (Sunderland et al., 2012), the number of studies captured in this review that reported project successes was surprising. At conception the review objective was to merely report where and how landscape approaches were being implemented. A measure of success or project outcome was not considered a priority as we anticipated the projects we found would be largely ongoing processes—an acknowledgement of landscape approaches as long-term endeavors. However, we increasingly found projects reporting or alluding to measured outcomes—albeit often not supported by empirical data. While it is encouraging to show that landscape approaches have the capacity to positively influence societal and environmental attributes, the large proportion of successful outcomes demands some scrutiny. There is definite concern of publication and methodological bias here (Dickersin, 1990) - are journals, researchers and organisations more likely to publish positive findings? And if this is the case, should research be judged on its ability to achieve a set of pre-conceived criteria? While for small-scale studies over short time frames this may be an acceptable—although not preferable—model, if a landscape approach is to be accepted as a process and not a project (Reed et al., 2016) then a model that does not explicitly demand outcome results should be considered. While such a model may cause alarm for donors or investors in landscape approaches, we contend that an inclusive and regular process of defining objectives, measuring progress, and re-evaluating will better maintain commitment to the approach (see Sayer et al. 2016b). Longer term outcomes will inevitably change over time as different driver and actor constellations form and should necessarily be revisited and reconsidered.

Options to improve reporting of results have been identified and must continue to be developed to both enhance current understanding and inform future implementation efforts and policy recommendations (Shanley & López, 2009). There is certainly a need to produce sets of reliable metrics and indicators for assessing landscape approaches and there appears to remain an element of an inability to measure restricting the ability to report (Stiglitz et al., 2010). However, the growing body of literature on monitoring tools for integrated approaches (Bond and Mukherjee, 2002; Buck et al., 2006; Kusters et al., 2006; Aldrich and Sayer, 2007; Sayer et al., 2008b; Belcher et al., 2013) ought to provide better means for meeting these requirements and tackling the issues going forward that this review has identified. A further challenge lies in building and maintaining local capacity to commit to long-term monitoring initiatives – particularly beyond the typical project time horizon. However, emerging evidence from REDD+ pilot projects suggests that when such commitment can be achieved, community collected data can contribute significantly to monitoring and reporting efforts (Bellfield et al., 2015). Finally, it may also be the case that insufficient investment in monitoring either historically or currently may have contributed to projects failing to reliably test effectiveness. Certainly if are we to use conservation as a guide, a recent survey supports this assertion with only five percent of projects performing robust monitoring and evaluation (Muir, 2010). Similarly, recent estimates of the financial investment in monitoring have also been estimated as five percent of the total project spend.

From the peer-reviewed articles captured in this review, it was surprising that despite the fact that there are so few papers with examples of landscape approaches in the tropics, there is such inconsistency in reporting. We encountered numerous examples of studies not providing reliable social (qualitative) or biophysical (quantitative) data; not reliably detailing the landscape configuration; and not providing the necessary detail on type of governance structure or reform process (see also Kusters et al. in review). Perhaps this is due to the lack of previous studies and therefore an identifiable "gold standard" or prototype for reporting remains lacking but clearly the monitoring and reporting of such interventions demands greater attention. Again, acknowledging landscape context renders the development and application of a monitoring or reporting blueprint unlikely, and even unwelcome. However, if projects are not being sufficiently analyzed, reported and subjected to the peer-review process, it is difficult to draw conclusions or make meaningful policy recommendations – from the limited, robust, peer-reviewed evidence we have collected we can outline a normative set of recommendations but until these are tested in contextualized situations, we cannot be sure of their effectiveness (see also McCall, 2016).

Conclusion

This review of landscape approaches in the tropics suggests that this latest attempt to reconcile societal and environmental concerns has considerable potential as an implementing framework. While we have failed to provide a series of quintessential examples of the approach in practice, we have identified numerous examples of interventions that show positive characteristics of a landscape approach. Our findings suggest that contextualized landscape approaches can enhance multiple socio-economic and environmental outcomes. This synthesis also makes a significant contribution to future implementation efforts by tentatively identifying which factors are likely to influence social and environmental change. However, we have also identified a number of concerns. Foremost amongst these is that landscape approaches remain an attractive concept in theory but the current evidence base is lacking in the necessary precision to adequately assess the effectiveness in practice. There have been suggestions that the landscape approach might possibly represent the latest conservation/development "fad" (Redford et al., 2013). However, until the concept has been further tested and evaluated this is at best redundant and at worst, an impediment to making real progress towards integrating conservation and development.

Attempts to implement a landscape approach are inherently complex as they are often large-scale and encompass multiple stakeholders from across sectors and therefore are likely to involve marked asymmetries in power and influence. They are also very difficult to assess requiring both biophysical and social data collection and analysis, as well as the analysis of existing governance structure, and understanding the processes of governance reform and possible drivers of change. Landscape approaches are also risky as they are often expensive and yet may fail to deliver tangible social, economic, or environmental outcomes, especially over the short term. However, without innovative and long-term commitments to implement, test, and evaluate, there is a danger of being caught in a cycle of continually defining and re-fining the conceptualization of landscape approaches until interest is lost or the next iteration of integrated resource management and social development is conceived (cf. Redford et al., 2013). Such efforts at implementation should be cognizant of these challenges, have mechanisms embedded that acknowledge the potential for unsatisfactory outcomes, and apply the principles of adaptive management accordingly. While landscape approaches remain epistemologically contentious (Sayer et al. 2016a), researchers must be afforded the time to further develop their conceptualization, and yet all stakeholders must be encouraged to utilize the current body of knowledge to apply and evaluate the approach in practice. If we cannot translate knowledge into practice, how can we ever expect to translate science into policy?

Chapter Four

Trees for life: The ecosystem service contribution of trees to food production and livelihoods in the tropics

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Abstract

Despite expanding interest in ecosystem service research over the past three decades, in-depth understanding of the contribution of forests and trees to food production and livelihoods remains limited. This review synthesizes the current evidence base examining the contribution of forest and trees to agricultural production and livelihoods in the tropics, where production often occurs within complex land use mosaics that are increasingly subjected to concomitant climatic and anthropogenic pressures. Using systematic review methodology we found 74 studies investigating the effect of forest or tree-based ecosystem service provision on a range of outcomes such as crop yield, biomass, soil fertility, and income. Our findings suggest that when incorporating forests and trees within an appropriate and contextualized natural resource management strategy, there is potential to maintain, and in some cases, enhance yields comparable to solely monoculture systems. Furthermore, this review has illustrated the potential of achieving net livelihood gains through integrating trees on farms, providing rural farmers with additional income sources, and greater resilience strategies to adapt to market or climatic shocks. However, we also identify significant gaps in the current

knowledge that demonstrate a need for larger-scale, longer term research to better understand the contribution of forest and trees within the broader landscape and their associated impacts on livelihoods and food production systems.

Introduction

Forests provide a range of ecosystem functions that are fundamental to sustaining terrestrial systems (Abson et al., 2014; Chazdon et al., 2009; MEA, 2005). These functions are thought to contribute vital support to the provisioning of ecosystem goods and services needed to maintain human populations (Foley et al., 2005; Matson, 1997; Mery et al., 2005). The contribution of forests to nutrient cycling (Power, 2010), soil formation (Pimentel & Kounang, 1998), climate (Daily & Matson, 2008), and water regulation (De Groot et al., 2002) is now well established. Forests are also well recognised as important habitats for faunal and floral resources that directly provide vital provisioning services through the production of fuel and fibre (Rojstaczer et al., 2001; Vitousek et al., 1986). Furthermore, they can aid in regulating pest control (Bale et al., 2008; Karp et al., 2013; Klein et al., 2006) and supporting pollinating services (Kremen et al. 2002, Klein et al. 2007). Finally, in Africa at least, the links between tree cover, access to food and improved dietary diversity are also becoming increasingly evident (Ickowitz et al., 2014; Johnson et al., 2013).

The literature on ecosystem services has increased considerably in the last three decades and yet the concept remains contentious (Barnaud & Antona, 2014). Early proponents of the ecosystem service concept (Ehrlich & Mooney, 1983; Westman, 1977) used the term to illustrate the depletion of natural resources through anthropogenic activities that would impede the capacity of ecosystems to provide vital services. These authors and others (Daily 1997, Chapin et al. 2000) assert that such services are provided by nature and significantly contribute to human well-being in numerous ways.

Others contest that it is the environmentally sensitive actions of humans that facilitate the provision of ecosystem services (Gordon et al., 2011; Sunderlin et al., 2005; Wunder, 2005)—discourse that is congruent with the motivation for researchers to develop and apply an economic valuation of ecosystems and the services they provide (Costanza et al., 1998; Woodward & Wui, 2001). Subsequent policy instruments, such as payments for ecosystem services (Wunder, 2005, 2008) have been developed to financially compensate land managers for preserving ecosystem services and refraining from destructive land-use practices. More recently, researchers have posited that ecosystem services are co-produced by socio-ecological processes—that is a mixture of natural, financial, technological, and social capital—typically requiring some degree of human intervention to support appropriation (Biggs et al. 2015, Palomo et al. 2016).

While there remains some disagreement as to how ecosystem functioning translates into the delivery of tangible benefits in the form of ecosystem services (Cardinale et al., 2012), it is now well acknowledged that the preservation of biological diversity and associated habitats can maintain or enhance ecosystem service provision (Hooper et al., 2005; Isbell et al., 2011; Lefcheck et al., 2015). As such, landscape management is increasingly considered to be best conceived through a holistic lens that encourages multi-functionality (O'Farrell et al., 2010; Reed et al., 2016; Scherr & McNeely, 2008; Vandermeer et al., 1998). In this regard, multi-functionality typically refers to either spatial or temporal segregation, or functional integration (Brandt, 2003).

This review is concerned with the latter—the integration of multiple functions within the same landscape—in this case, the contribution of forests and trees, and their associated ecosystem functions, to food production in the tropics. Food production systems globally have been greatly intensified throughout the past century. As a consequence, primary forests, trees, and the associated provision of ecosystem services have suffered sustained and ongoing decline (Foley et al., 2005; Power, 2010). Furthermore, as the social and environmental costs of industrial food production have become better understood, it is increasingly recognised that this model cannot continue to be pursued sustainably (Foley et al., 2011b; Godfray et al., 2010). Therefore, alternative strategies that reconcile biodiversity conservation and food production warrant further consideration (Minang et al., 2014; Sayer et al., 2013; Sunderland et al., 2008). This is particularly pertinent in the tropics, where the majority of global biodiversity hotspots occur (Myers et al., 2000). Yet these hotspots are highly susceptible to the drivers and impacts of global environmental change such as forest conversion, high levels of poverty, and food insecurity (Gardner et al., 2009; Laurance, 1999).

Agriculture and forestry have traditionally been managed as sectorial, and sometimes antagonistic, entities, often contributing to social and environmental conflicts. However, the two are inextricably interlinked. While the drivers of deforestation and forest degradation are complex and vary by region (Lambin et al., 2001), on a global scale agriculture is estimated to be the primary driver of deforestation (Foley et al. 2005, Scherr & McNeely, 2008, Gibbs et al. 2010), responsible for approximately 80% of forest loss (Kissinger & Herold, 2012). These losses account for emissions of 4.3–5.5 Pg CO_2 eq. yr^{-1} (Smith et al., 2014), which represents approximately 11% of total global carbon emissions (Goodman & Herold, 2014), accelerating climate change, and in turn inhibiting forests capacity to provide essential ecosystem services (Laurance et al., 2014). As such, a better understanding of the interactions between forest ecosystem services and agricultural production is fundamental to the sustainable management of terrestrial resources.

This review was conceived around the notion that, despite a rapidly growing body of literature on the role and value of ecosystem services, the contribution of forests and trees—via ecosystem service provision—to adjacent or embedded food production systems in the tropics remains poorly understood. Furthermore, we speculate that the contribution of forests, in terms of ecosystem services provision, to food production systems may often be based on anecdotal evidence or may not be well supported with robust evidence of the "true" functional value. As such, this review assesses the contribution of trees and forests to food production in the tropics, where production often occurs within complex land use mosaics that are increasingly subjected to concomitant climatic and anthropogenic pressures (Gibbs et al., 2010; Steffen et al., 2015). While we acknowledge the value of tropical forests for the direct provisioning of food (i.e. fruits, nuts, leafy vegetables etc.) that contributes to local dietary and nutritional quality (Powell et al., 2015), this review is concerned with the indirect non-provisioning ecosystem service (i.e. regulating and supporting services) contribution of forests and trees, and the effect these have on food production.

This systematic review synthesizes the current evidence base by assessing the contribution of trees and forests to food production through ecosystem services derived from both within agroecosystems and extant natural forests. We anticipate this synthesis will contribute towards efforts that address the current controversies of independently addressing food production and forest/biodiversity conservation and highlight the potential of integrating land uses within multifunctional landscapes to deliver a diverse suite of ecosystem services (Foli et al., 2014; Glamann et al., 2015) .

Methods

We followed standard systematic review methodology, detailed in Foli et al (2014), to identify and screen literature from a number of specialist databases, grey literature sources, and key institutional websites (Foli et al. 2014). All searches were conducted in English and covered publication years from 1950 to July 2015. Preliminary searches were conducted to test the search terms and strategy in Web of Knowledge only. This initially yielded 321 hits. After expanding the number of search terms, the number of hits increased to 63,253. A final search strategy (see: Foli et al. 2014 for protocol including detail on search strings employed) was determined which yielded 9,932, which constituted the set of documents we worked with (see Figure 1). The initial searches were conducted in January 2014. An updated search was performed in July 2015 to account for additional articles produced during the period of the initial literature screening process. All articles were screened sequentially for relevance at title, abstract, and full text stages.

Study inclusion and exclusion criteria

At the title and abstract stage, studies were screened for relevance and accepted for the next stage of assessment if they were studies within the tropics that measured forest or tree-based ecosystem services and agricultural output.

At full text screening, **final study inclusion** was determined if studies met the following three criteria:

Relevant study method/design: studies showed a transparent and repeatable research design.

Relevant study comparator: studies presented comparisons between agricultural systems with and without tree presence (either replicated or longitudinal comparison).

Relevant study outcomes: studies measured and reported outcomes that showed a clear positive, negative or neutral effect of tree or forest presence on ecosystem functions in agricultural systems.

Studies were **excluded** from the review if they met one or more of the following criteria:

- Studied ecosystem services only at global scales.

- Exploratory studies, conceptual frameworks, non-empirical, or methods papers.

- General forestry and agricultural policy briefs.

- Studies solely on the economic evaluation and accounting of ecosystem services.

- Studies outside the tropics.

- Studies solely on the contribution of wind pollination to crop production.

- Studies with relevant results but without transparent methodology or findings.

Those articles accepted at full text were then critically appraised before data extraction. A peer-reviewed protocol provides a detailed account of the research design, methods, and inclusion criteria (Foli et al. 2014).

Data extraction

Data extraction was performed by all authors. Due to differences in reporting and use of terminology across the final suite of articles, ecosystem services derived from forests or trees were grouped according to nine simplified categories for analysis (see Table 1). Similarly, an article often examined multiple ecosystem services and therefore reported multiple study outcomes. For the analysis of this review, outcomes for each ecosystem service reported in each article were grouped in 13 categories (see: Fig. 5) by the presence or absence of trees having a positive, negative, neutral or mixed effect on any reported food production or livelihood component. Unsurprisingly, given the review focus on food production, all included studies reported a direct measure of the effect of tree or forest presence on crop production or farm yields—except in three cases where sufficient proxy measures of yields were explicitly given. These include two pest control studies (Gidoin et al., 2014; Karp et al., 2013) and one pollination study (Blanche et al., 2006).

Further analysis of the system wide effects of trees/forests was performed by aggregating all recorded outcomes for the effects of trees/forests. These system wide effects of tree presence were classified as representative of an overall effect on livelihood outcomes. For example trees may have had no effect on yields when compared to non-tree controls yet had a positive effect on soil fertility within the system, thus having a net positive system wide effect. This would result in the study being documented as an overall (system-wide) positive effect of trees and thus a positive livelihood outcome. Similarly, a negative effect on yield and a positive effect on primary production would result in an overall (system-wide or livelihood) mixed effect of tree presence. Reed et al. (2015) provides a full list of the variables assessed in this review.

Results

Review statistics

The initial 9,932 articles were reduced to 1,054 after title screening, 178 after abstract screening and finally 62 articles for critical appraisal and data extraction after full text screening. Updated searches conducted in July 2015 identified a further 2481 articles, of which 36 were retained after full text screening. Twenty four articles were eliminated during critical appraisal—screened by a second reviewer to assess conformity to the inclusion/exclusion criteria—resulting in a total of 74 articles in the final review. Figure 2 summarizes the screening process. All articles included in this review were published in peer-reviewed journals, with the earliest retrieved published in 1991.

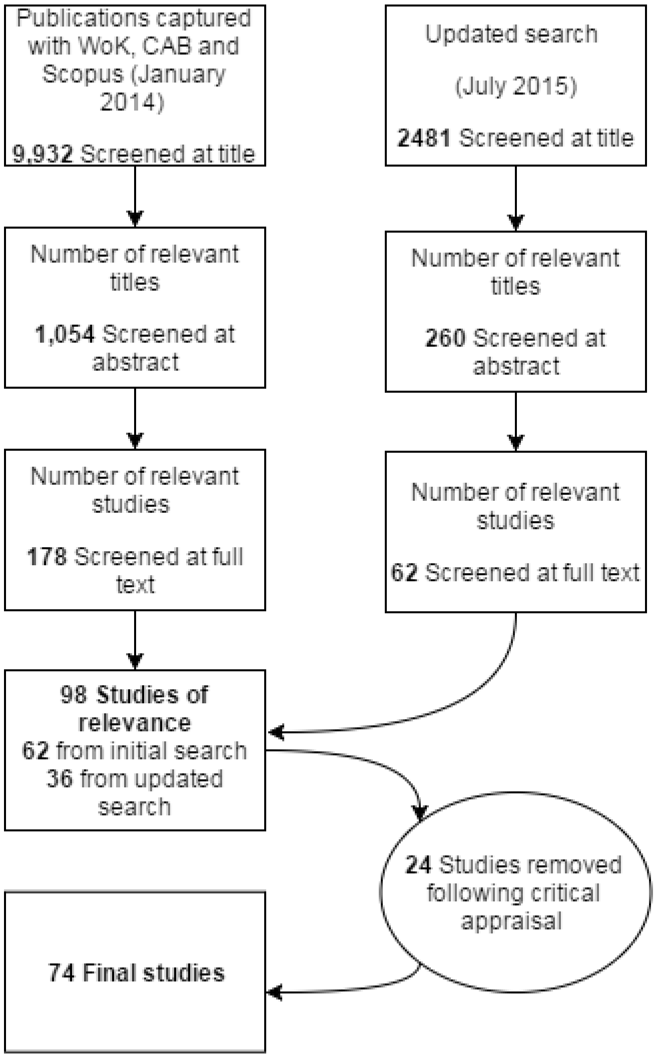

Figure 2 Flow diagram showing the systematic screening process

Geographic distribution and research focus

A broad range of tropical countries were represented in this review. However, research was predominantly located in East and West Africa, South Asia (Indian sub-continent) and South America (Figure 3).

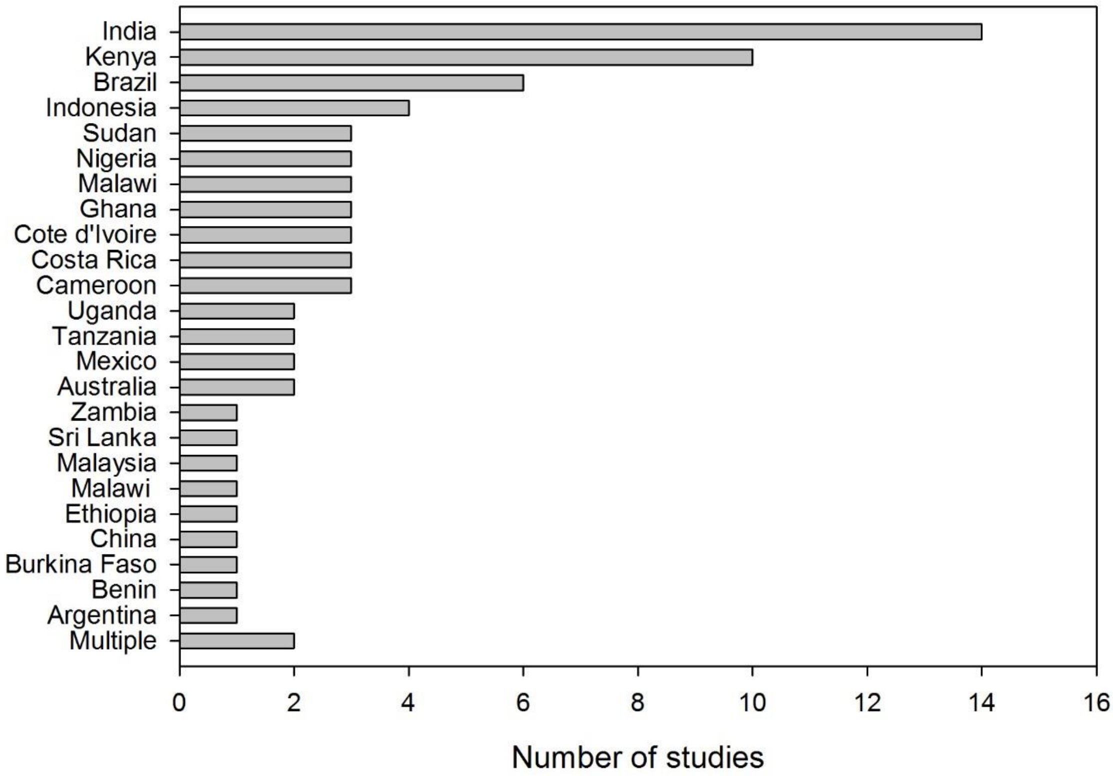

Figure 3: Frequency plot showing study country distribution

The final suite of 74 studies investigated the roles of trees and forests on crop yields across a total of nine ecosystem services. However, the majority (n=58) investigated bundled ecosystem service effects (see: Renard et al. 2015) of trees and forests, resulting in 138 data points (distributed across the nine ecosystem services and 74 studies) (Figure 4). Cumulatively, the most commonly studied ecosystem services were primary production and nutrient cycling, accounting for 29% and 25% of the ecosystem services studied, respectively. These patterns were consistent across the regions with the exception of Australia where both studies focused on pollination. The third most commonly studied ecosystem service varied across the regions – in Africa, resource competition (dis-service) (n=8), in Asia, microclimate (n=9), and in the Americas, pollination (n=4).

Table 2: regional distribution of ecosystem services studied

	Africa (n=39)	Asia (n=12)	Americas (n=21)	Australia (n=2)	Total
Primary production	19	14	7		40
Nutrient cycling	22	9	4		35
Pollination	5	4	3	2	14
Microclimate	7	6	1		14
Resource competition	8	4	1		13
Water retention	4	4			8
Soil formation	3	1	2		6
Pest control	4		1		5
Carbon storage	2	1			3
Total services studied	74	43	19	2	138

The study system characteristics were largely dominated by agroforestry studies (Figure 4). Of the total 74 studies, 58 were agroforestry studies, and only 5 of these were agroforestry systems under the forest canopy – the remaining 53 were trees introduced to the farm (typically alley cropping). Only 12 studies investigated the effect of spatially distinct natural forest patches on agroecosystems, namely off-farm forests and trees – mostly consisting of studies utilizing agroforestry gradients (investigating yield outputs from a range of land use types from canopy agroforestry to monoculture full sun systems) (see Figure 3 & 4). Furthermore, we found that most studies—particularly those with planted trees—were conducted over short timescales (< 3 years, n=58) (Figure 4). As such, of the 54 genera of tree species recorded, the most frequently represented were the common agroforestry taxa of *Acacia, Gliricidia, Leucaena* and *Sesbania* (represented in 12%, 11%, 6%, and 4% of studies respectively—for a full list of tree and crop species studied, see supplementary material). Of the studies that evaluated the contribution of off-farm forests and trees, eleven were researching the impact of forest distance or diversity on pollination or pest control services. While most of these were also within agroforestry systems, these were the few studies that investigated ecosystem service provision within or from natural or semi-natural forest systems—as opposed to food systems that incorporated planted trees. We found only nine long-term studies (≥ 7 years) and these were all on-farm or within research station experimental plots. Whereas studies that assessed off-farm provision of forest ecosystem services were all short term (≤ 3 years). Figure 5 clearly illustrates the lack of long term, landscape-scale evaluations of forest ecosystem service provisioning.

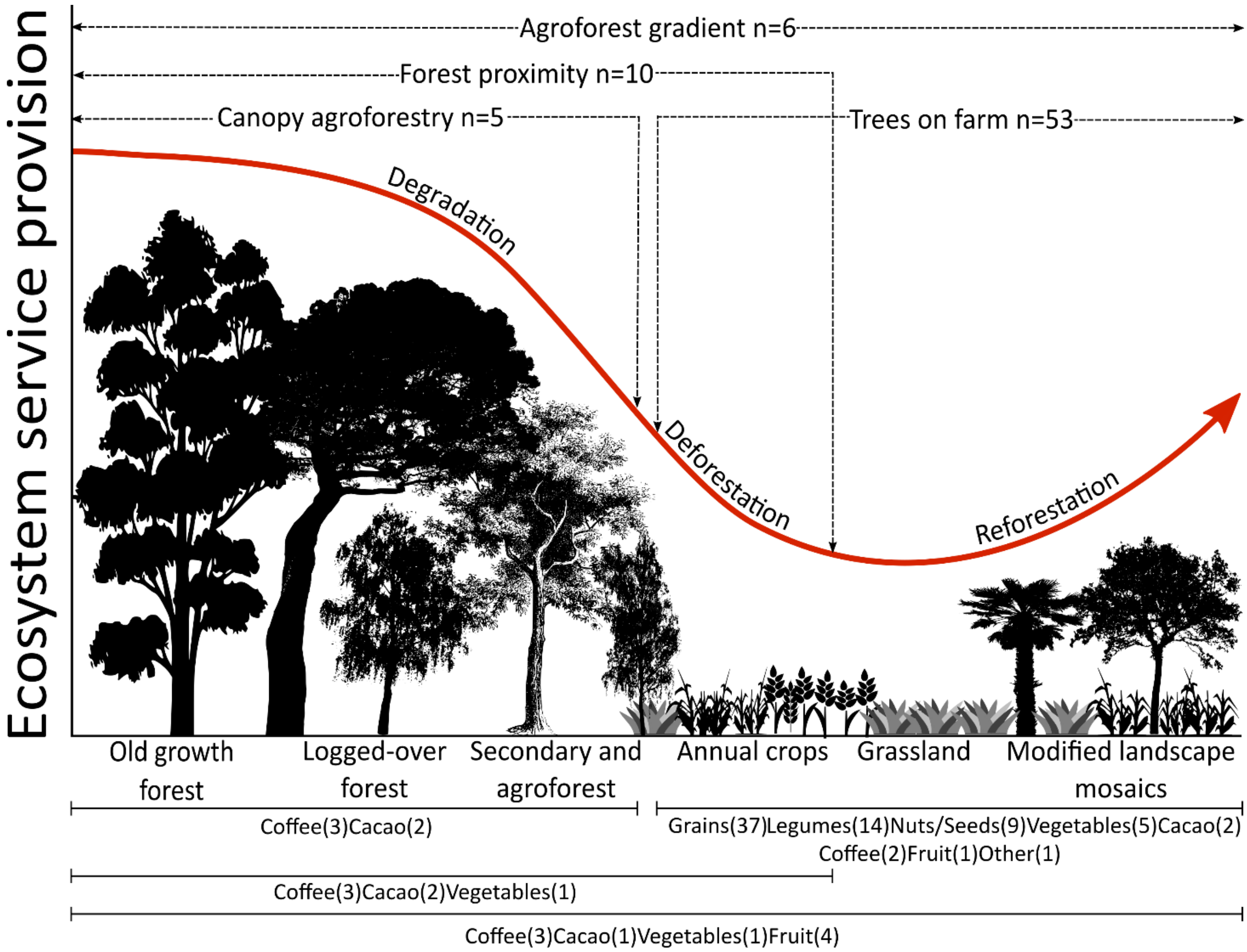

Figure 4: Figure showing a forest transition curve and the position along which the reviewed studies are placed according to their study system characteristics (above the transition curve) and corresponding food produced (below x axis).

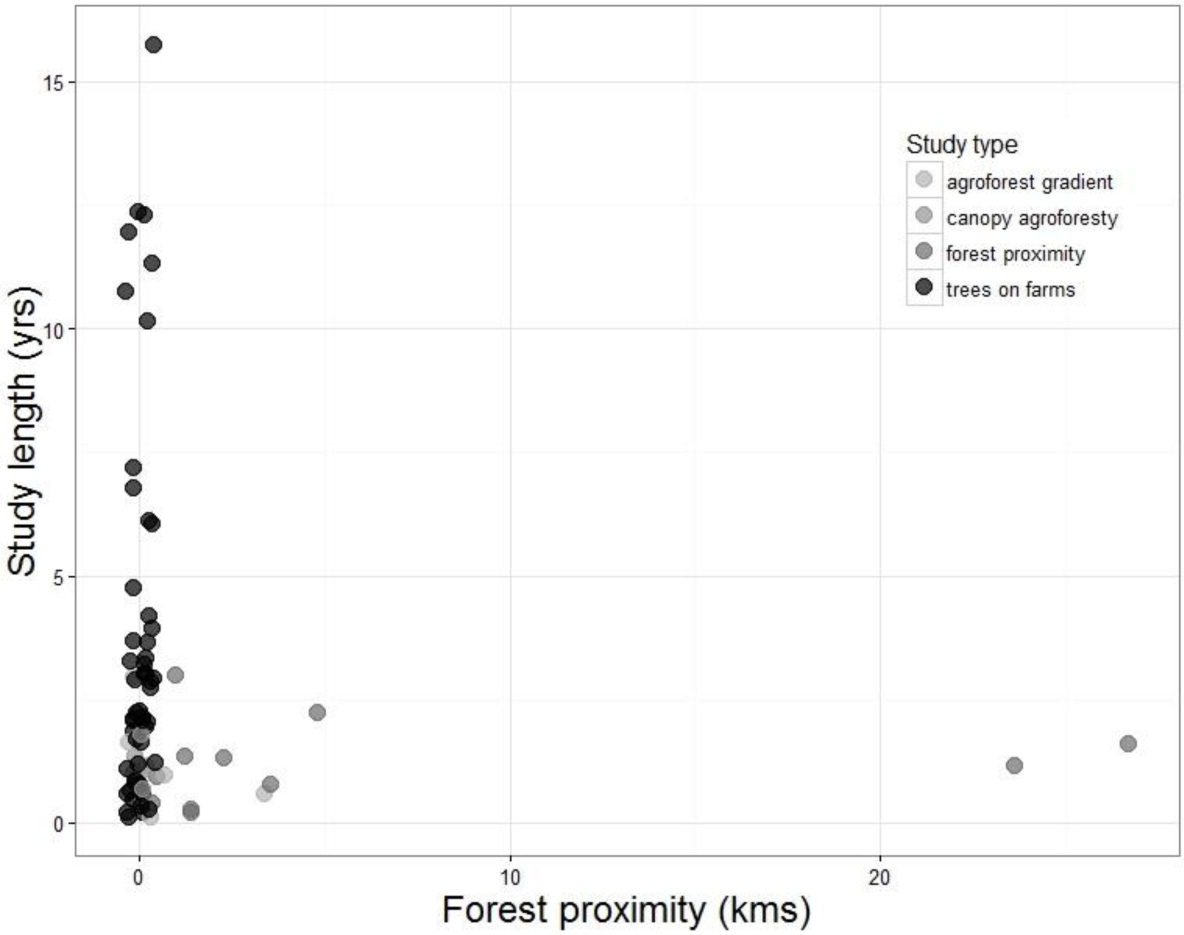

Figure 5: Scatter plot of study durations and forest proximity for different study types

The effect of tree presence on food production in the tropics

The overall trend across the studies shows that in the majority of cases (52%) there was a net positive (47%) or neutral (5%) effect of tree presence on food yields or food yield proxies. However, when the results are disaggregated by region, there is a degree of variability (Figure 6). For example, in the Americas and Africa, tree presence was more likely to enhance food yields with positive effects of trees on yields reported in 58% and 54% of studies for these regions respectively; while in Asia the opposite is the case, with the majority of studies (48%) reporting decreased food yields as a result of tree presence (Figure 6).

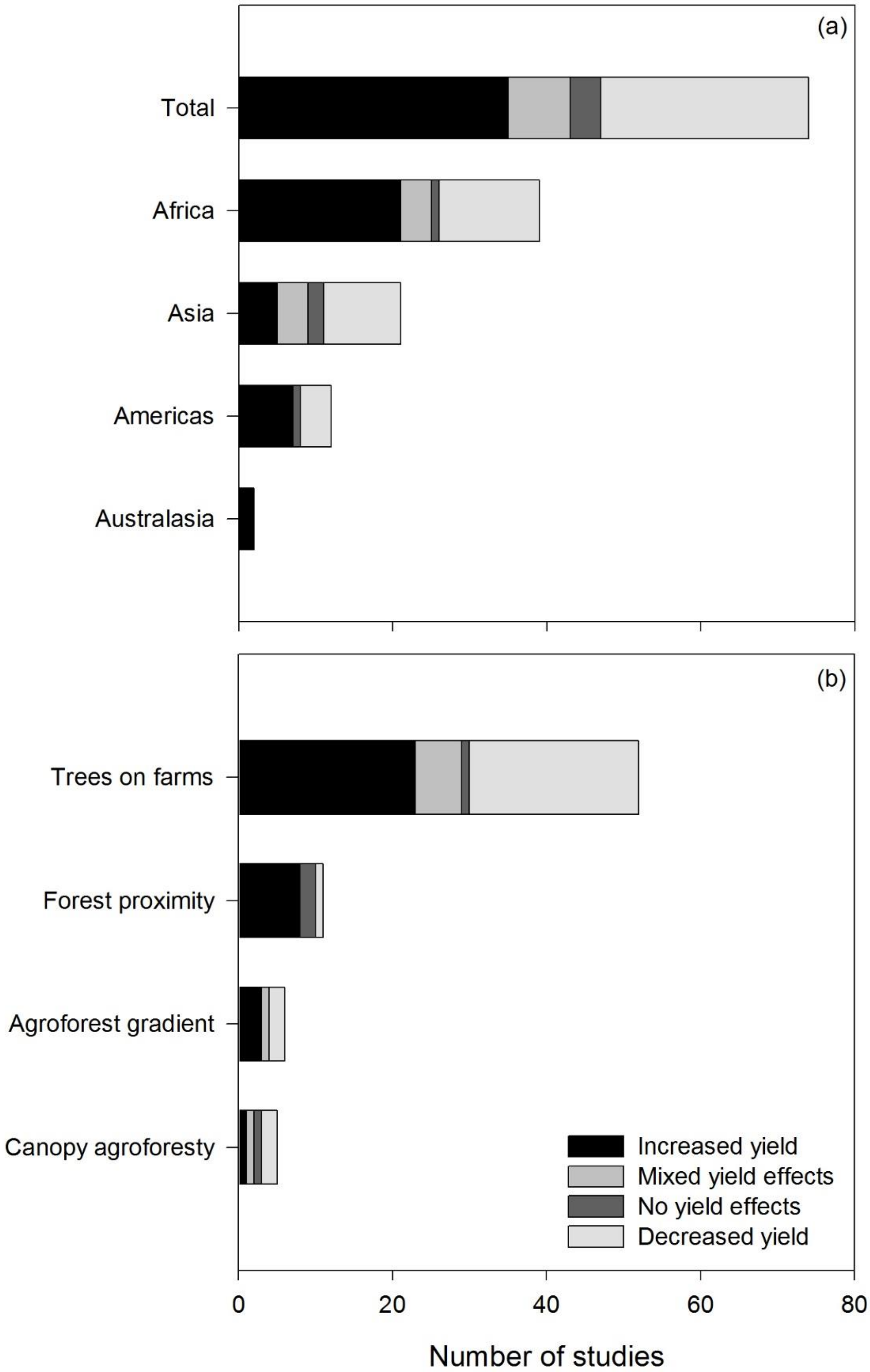

Figure 6: Frequency plot showing tree effects on crop yields by: (a) regional distribution and (b) study system

The "overall livelihood" effect of tree presence in the tropics

Studies often investigated multiple ecosystem services and reported on multiple outcomes – for example, one study may investigate nutrient cycling and primary production and measure effects on differences in crop yield and soil fertility. Consequently, the final set of 74 articles recorded 138 data entries for ecosystem services studied and 164 data entries for measured effects of trees. Due to inconsistencies in terminology used across the studies, we developed thirteen broad categories of effect variables. Given the review's primary focus on food production, some measurement of yield was a prerequisite for inclusion and hence had a recorded outcome for all 74 final studies. Any other effects directly linked to tree/forest presence were also recorded, with the most widely reported effects of trees other than yield being soil fertility and income (Figure 7).

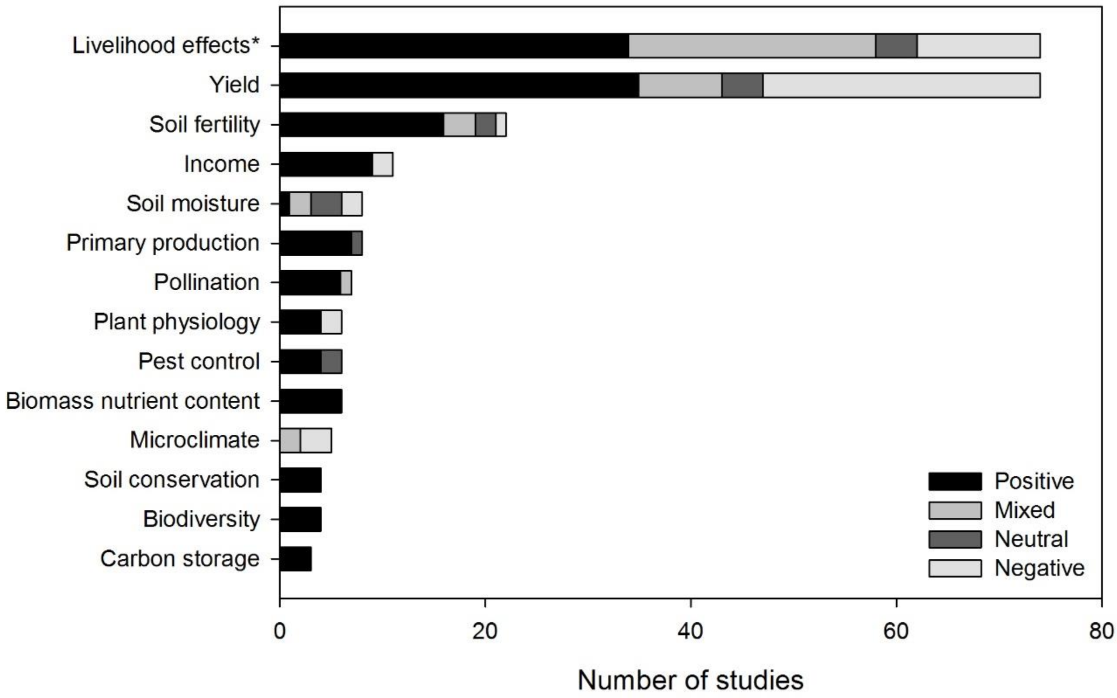

*Figure 7: Frequency plot of the effect of trees/forest on multiple system components across all studies. Non-yield effects were broadly categorised by the authors.*Livelihood effects were categorised by the authors by summing multiple system wide effects of trees.*

By combining the empirical data and the self-reported anecdotal evidence within the articles, the review team was able to broadly establish overall livelihood effects for each of the articles—i.e. whether there is a net positive or negative effect of tree cover on livelihoods. While it has to be noted that this was largely a subjective process and not always supported by empirical data, it was felt that this was a useful exercise as often articles that reported depressed crop yields due to resource competition effects of tree presence also reported (in discussion and conclusions) overall livelihood gains due to other economic benefits derived from trees, such as the provision or sale of fuelwood, mulch, or fodder for example. Hence, when examining the overall livelihood effects of tree presence across the 74 articles in this review, the majority report a positive effect (46%) which closely mirrors the effects on yield (47%) (Figure 6).

The main difference when comparing the effects of trees on yields with the overall livelihood effects of trees across all studies is the reduction in the total negative effects from 36% for yield to 16% for overall livelihood effects, suggesting that a reduction in yields may be compensated by other benefits provided by trees to the farm system (Figure 7). This cost/benefit relationship—where the cost of crop yield losses is compensated by the overall benefits of incorporating trees—is consistent across the study regions with Africa, Asia and the Americas reporting negative effects of trees on crop yields in 33%, 48%, and 33% of studies but negative effects of trees on overall livelihood outcomes in only 15%, 24%, and 8% respectively (Figure 7).

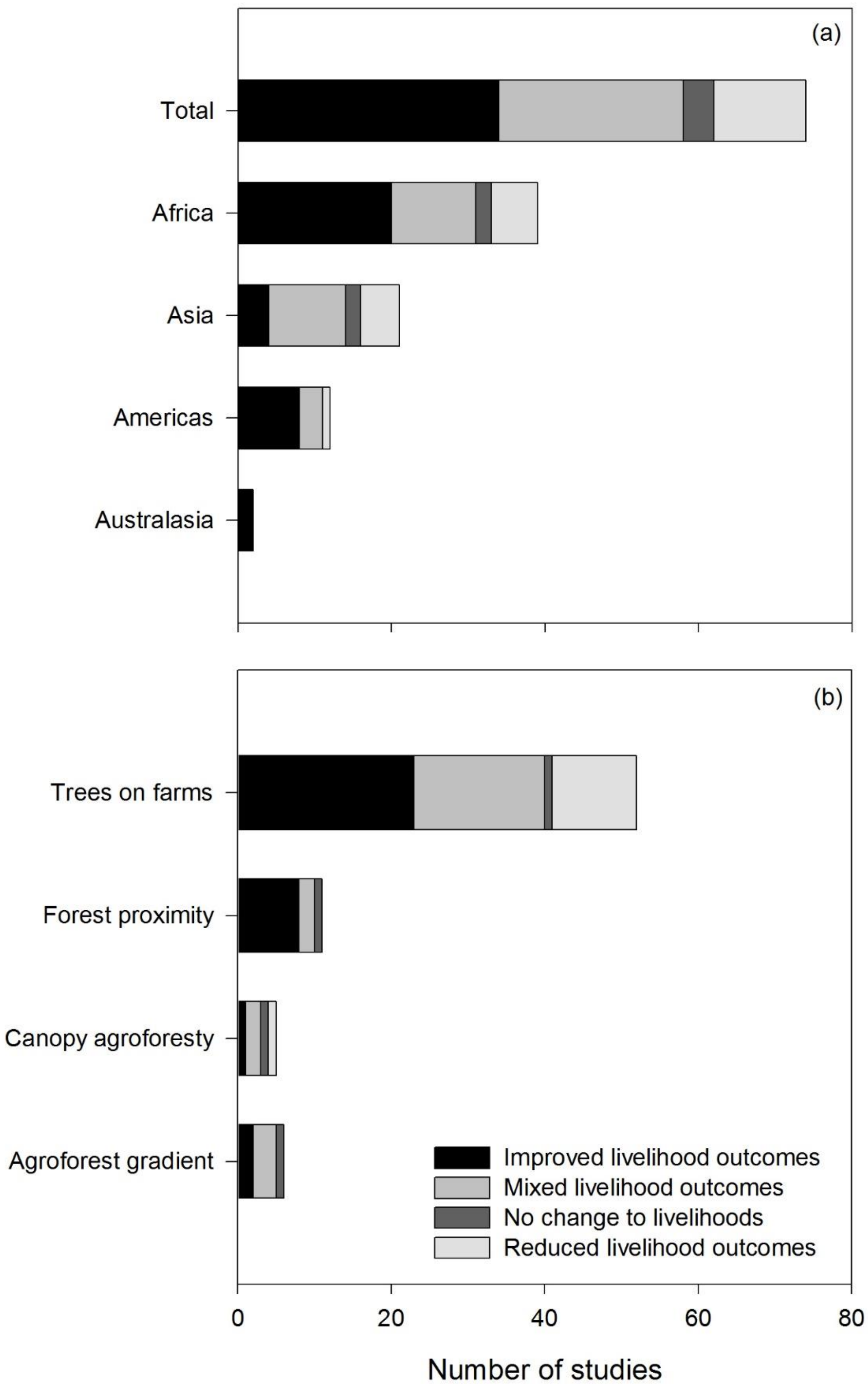

Figure 8: The overall livelihood effects of trees (determined by the authors by summing multiple system wide effects of trees) categorized by region (a) and study system (b).

In studies where trees were shown to have a positive effect on food yield, the overall livelihood effect was also positive (86%) and never returned a negative outcome, although 11% of studies showed a mixed effect i.e. some negative and some positive effects on overall livelihood outcomes. However, in the studies where trees decreased food yields, the overall livelihood effects were varied: in 37% of studies that showed trees having a negative effect on yield, livelihoods were also reduced; 59% of studies showed either a mixed effect or no change in livelihoods, while one study showed that negative yield outcomes were fully compensated by improved overall livelihood outcomes (Figure 8).

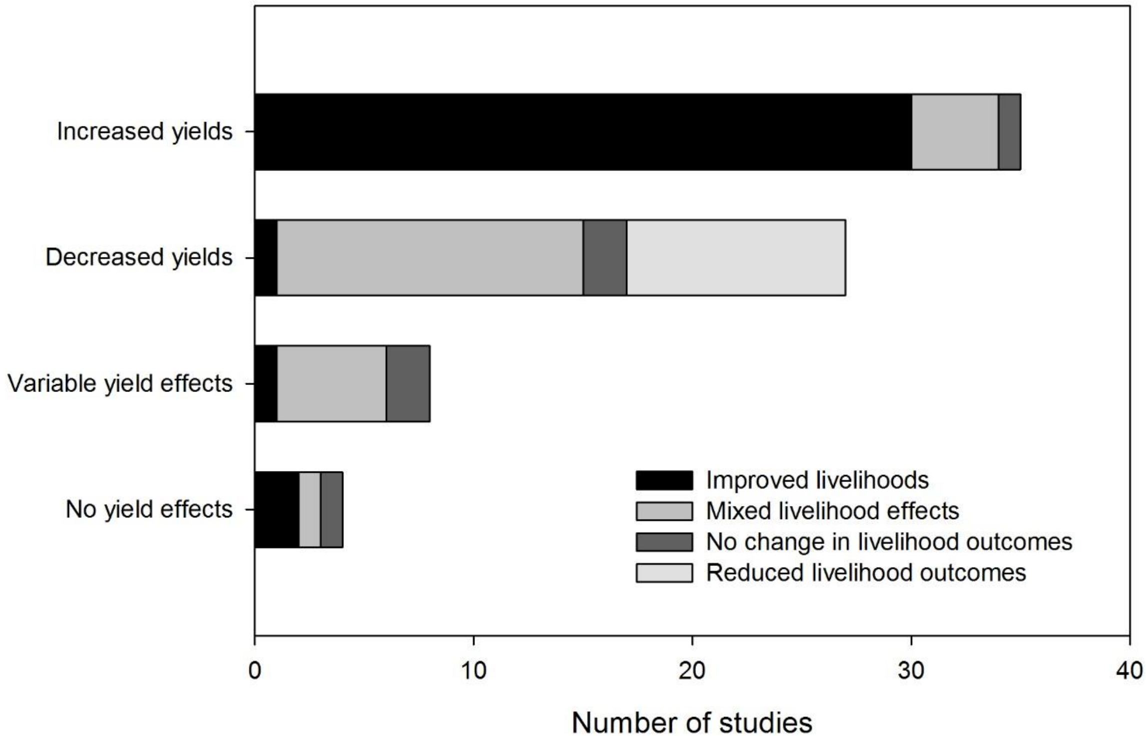

Figure 9: Frequency plot comparing the direct effects of trees on crop yield and the overall livelihood effects reported across the study system as a result of tree/forest presence.

Discussion

Despite a significant increase in ecosystem service-related research in the past two decades (Abson et al., 2014), this review illustrates that there are clear gaps in the literature with regard to the contribution of tropical forest and tree-based ecosystem services to food production. Principal amongst these is the lack of evidence for the contribution of off-farm tropical forest patches to agricultural systems. Of the few studies identified, the majority—such as those conducted by Blanche et al. 2006, Klein 2009, and Sande et al. 2009—used a forest distance gradient to establish the effects and thresholds for pollinator success as a sole focus.

While such studies are useful and clearly illustrate the importance of trees and forests for the delivery of a single ecosystem service, it is well acknowledged that ecosystem services do not act in isolation (Boreux et al., 2013; Renard et al., 2015) and therefore studies that examine the interactions of multiple ecosystem services within multiple land use configurations are much needed. As such, the key finding of this systematic review is that there is little clear evidence of the effect of multiple interacting ecosystem services flowing from forest fragments to food systems. This paucity of studies significantly limits our ability to draw conclusions as to the value of forests and trees within the landscape to proximate agricultural systems. Therefore, despite our original objective of attempting to quantify the contribution of off-farm forests and trees to food production, the results presented in this review principally reflect the contribution of trees to food production and livelihoods at the farm scale only.

The temporal and spatial scales of the studies identified in this review point to further gaps in the current understanding of the longer-term contributions of forest and trees to food production. Although spatial information was not always provided in the studies, the large majority were conducted in either smallholder agroforestry systems (typically 0.5 – 3.0 ha.) or research station small-scale experimental plots (for example 20 x 18m plots), and over a study period of less than three years. Much of the evidence in this review therefore provides a snapshot in time of ecosystem processes, therefore failing to recognise the changes that can occur over space and time (Renard et al., 2015). The assessment of ecosystem services is not easy and complexity will be increased when transitioning from local to landscape scales (Swift et al. 2004), but given the extensive dialogue on ecosystem service provisioning as a contribution to long-term sustainable systems (Jordan, 2013; Scherr & McNeely, 2008; Tilman et al., 2002), it seems clear that further evidence on the spatiotemporal dynamics of ecosystem service provision to support such claims is both necessary and timely.

We strongly recommend that future research efforts attempt to bridge these gaps by moving beyond the farm gate, as it were. Research that investigates the effects that tropical forests and forest patches have on spatially distinct agroecosystems would increase our understanding of complex systems. This level of research is essential in order to further dissolve the dichotomies of biodiversity conservation and food production which often remain viewed as entities to be addressed individually (Glamann et al., 2015). A further requirement to aid our understanding is the testing of such relationships over time. We agree with Pattanayak (2009) and others (Bauch et al., 2014; Renard et al., 2015), that studies that monitor how forests function over periods beyond the traditional project cycle of 1-3 years are vital to assess the contribution of forests to food production, livelihoods, and the long-term sustainability of integrated landscape approaches (Barlow et al., 2011; Reed et al., 2016).

While many tropical countries are represented in this review, there is a clear geographical research bias towards India and East Africa. It may be the case that the climatic and natural resource conditions of these regions make them particularly pertinent for ecosystem service research; it may reflect the interests of donors funding primary research; there may be greater political will or existing national policies that support agroforestry system research; it may be the presence of research organisations in the region (i.e. ICRAF); or it may be a result of other factors of which we are not aware. An important limiting caveat of this review is that searches were conducted only in English. Consequently, it is likely that searches in other languages would reveal more studies from non-English speaking countries, providing a more even geographic distribution. One recommendation would be for future reviews to be performed in non-English languages, to complement and build upon these findings. Furthermore, a review of temperate systems would also complement the findings we have presented here.

This review indicates that the presence of forest and trees has varying effects on food production, but that the majority of studies showed a direct net positive or neutral effect of tree presence on crop yields. When other factors are considered such as environmental impacts or additional income derived from trees through sale of fuelwood for example, the overall livelihood benefit to land managers can buffer costs accrued through crop yield reductions. Even in Asia where a large proportion of studies showed the presence of trees was negatively impacting crop yields (a finding that warrants further investigation), the overall net livelihood effect suggested that farmers could reduce negative impacts and gain a long-term benefit from incorporating trees on their farms as the total negative effects were greatly reduced (48% to 24%). Given the short term nature of the studies examined here, it could be speculated that when examined over longer time scales the broader benefits of maintaining trees would become more evident.

While this is an encouraging result, the evidence presented here is not sufficient to suggest that tree presence or incorporation will always be the optimal management strategy for food and livelihood outcomes, and land managers should be encouraged to pursue a more nuanced approach to managing complex socio-ecological systems. It is important to note that many studies examined the effects of multiple ecosystem services on multiple outcomes, often with contrasting results. For example, a study may reveal environmental gains from trees planted on farms via improved soil fertility, but also report associated production losses in terms of crop yield due to resource competition (Kidanu et al., 2005; Siriri et al., 2010). Similarly, one study reported an overall negative effect but suggested this may be attributed to the fact that the surrounding forest matrix was intact and healthy and therefore the greater abundance of floral resources inhibited pollination success in the agroforestry system of interest (Boreux et al., 2013). A further study reported mixed success: non-intensive systems were optimal in terms of pollination, however, proximity to forest was not significant (Frimpong et al., 2011). A number of studies showed that net losses in crop yield may be compensated by the additional biomass produced from the planted trees, resulting in an overall net gain (Asase et al. 2008, Chauhan et al. 2010, Fadl and El sheikh 2010). Moreover, it is clear from this review that the provisioning of individual forest ecosystem services to food production do not act in isolation. Consequently, the potential socio-environmental costs and benefits need to be contextualized and considered over time and space, with land use management strategies applied and adapted accordingly.

Conclusion

The study of forest and tree-based ecosystem services in the tropics suffers from both a geographic and research focus bias, and is further limited by the propensity for small-scale and short-term evaluations. The relative dearth of studies prevents us from providing a definitive answer to our original research question—to what extent do forests and trees support food production? There is insufficient evidence—most of which is not directly comparable—to assess the contribution of ecosystem services derived from forests to agricultural systems. The findings of this review very much reflect the contribution of trees to food production at the farm scale rather than the broader contribution of forests and trees within the landscape. To this end, we have generated a database of 74 articles that demonstrate both positive and negative effect of trees on food yields and broader livelihood outcomes. Our findings suggest that when incorporating forests and trees within an appropriate and contextualized natural resource management strategy, yields can be maintained or enhanced comparable to intensive monoculture systems. Furthermore, this review has illustrated the potential of achieving net positive gains through integrating trees on farms, providing practitioners with additional income sources and greater resilience strategies to adapt to market or climatic shocks.

Despite this, contemporary development pathways—particularly within the tropics—often tend towards “conventional” approaches to agriculture and food security that deplete the natural resource base (Gibbs et al., 2010; Gibson et al., 2011; Roe et al., 2014; Steffen et al., 2015). Forest conservation rhetoric largely refers to the benefits for the global community. Meanwhile, conservation of forests and trees at the local scale is often sold as generating other tangible benefits to farmers and rural people through the provisioning of ecosystem services. However, this review has highlighted that the current evidence of the latter—particularly with regard to food production outputs—remains unclear. Research efforts are urgently required to strengthen the evidence base and provide clear, robust data in order to support the transitioning to "alternative" approaches to land management. Without strong evidence linking forest derived ecosystem services to food production and livelihood benefits there remains little incentive for food producers to acknowledge the need for forest conservation at the local and landscape scale. Further evidence is required if we are to illustrate the potential local social and environmental benefits that can be achieved through both conserving trees within the landscape and incorporating them within food production systems.

This systematic review (and the accessible accompanying database) provides a valuable resource for policy makers, practitioners, and researchers in countries where efforts to integrate food production, livelihood enhancement, and tree conservation are already underway. However, it has also identified a number of key knowledge gaps, enabling us to provide the following recommendations for future research: Investigate the effect of off-farm trees and forest patches on proximate food production systems; further examine spatiotemporal forest ecosystem service dynamics; assess how these services interact with other system functions; and further develop appropriate instruments for measuring and comparing ecosystem services.

Current evidence on the association between forests, trees and food production systems in the tropics lack the necessary precision to fully inform practice and policy. A future research agenda that attempts to elucidate the above recommendations would enhance our understanding, providing further support for more integrated approaches to land management that seek to sustainably utilize rather than deplete natural resources.

Chapter Five

Means and ends: Identifying attributes and action points to guide landscape approach implementation and progress

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Abstract

Sectorial approaches to land management are inadequately meeting persistent global challenges of poverty, food insecurity, climate change and biodiversity loss. In response, more holistic approaches to resource management are increasingly preferred strategies to reconcile conservation and development at the landscape scale. Such "integrated landscape approaches' have recently been embraced by the research and donor communities, conservation and development agencies, and have been subsumed in international conventions for climate, biodiversity, and development. Despite this traction, implementation efforts and evaluation of progress of landscape approaches remains challenging. Here we review the literature base to identify attributes and action points that have been identified to be of practical use for the implementation, maintenance and evaluation of landscape-scale integrated approaches. We provide a summary of attributes of landscape approaches and action points for implementation that we consider imperative for effectively achieving the approach in practice. We have documented these within attribute categories of: (i) navigating complexity, (ii) engaging multiple stakeholders, (iii) landscape monitoring, (iv) incentivizing behavioral change, and action points categories of: (i) building networks (ii) developments in landscape monitoring (iii) towards meaningful engagement (iv) modeling and scenario building (v) advances in spatial data. This article provides a valuable resource for actors operating across the spectrum of research, policy and practice as we continue to develop the means by which we will fulfill such globally conceived commitments as the New York declaration on forests, the Aichi biodiversity targets, the global restoration agenda, and the goals of the climate and development initiatives. The evidence synthesis provides a useful starting point for overcoming implementation and evaluation challenges, identifies where further research is required and can also serve to reduce future duplication of research effort.

Introduction

Why are attempts to integrate conservation and development so often unsuccessful? This question was originally posed fifteen years ago (Brown, 2003), yet the question remains highly —and some would argue increasingly—relevant today. Despite countless efforts and investment, tractable and sustainable solutions remain elusive. Both natural and social scientists have considered how to better integrate conservation and development through a variety of—often overlapping—analytical lenses, including: systems dynamics (Meadows, 1998), political economy (Lemos & Agrawal, 2006; Ostrom, 1990), political ecology (Blaikie, 1999; Robbins, 2011; Zimmerer & Bassett, 2003), landscape ecology (Forman & Godron, 1986; Wu & Hobbs, 2002), sustainability science (Kates et al., 2000), resilience science (Berkes et al., 2003; Folke, 2006), and conservation social science (Bennett et al., 2017) to name a few. This led to the development of numerous conceptual frameworks and guiding principles that are designed to embed development objectives within pro-environmental agendas (or vice versa), therefore delivering positive outcomes for both conservation and development. Various associated concepts have gained—and lost—appeal with the research and practitioner communities, particularly post-Rio Earth Summit 1992, where there has been a noticeable increase in the diversity of integrated approaches to land use management and planning (Reed et al., 2016). The theorized best practice for integrating conservation and development and the associated nomenclature have evolved, but the objective (to deliver win-win outcomes) has remained consistent.

Contemporary efforts to reconcile conservation and development at the landscape scale have recognized the importance of context-specific nuances (Ward & Shackleton, 2016) and acknowledge complex cross-scale interactions (Folke et al., 2005). Climate change, poverty, and biodiversity loss are global phenomena and must be tackled with global commitments (Koomen et al., 2012). However, implementation strategies for conservation and development agendas will often be nationally formulated (Forman, 1995; Ling et al., 2009). Furthermore, the outcomes of such strategies will often be realized, and influenced, by actions at the individual level, while long-term success will be largely dependent on landscape scale processes and interactions. Implementation strategies should therefore not only acknowledge both the bio-physical and socio-economic processes that comprise social-ecological systems, but also not underestimate the significance of cross-scale interlinkages and the unique challenges and opportunities therein. Transformational shifts away from the 'business as usual' approach of recent decades should avoid sectorial focus, where multiple agencies within the landscape push conflicting mandates that often result in strategies that are at cross-purposes. However, while a more integrated approach is conceptually appealing, the application on the ground is not without challenge - whether assessing peatland management and fire in Indonesia (Carmenta et al., 2017), bush-meat extraction in Cameroon (Sandker et al., 2009), or rates of deforestation in the Amazon (Aguiar et al., 2016), evidence from across the tropics shows that tensions between conservation and development objectives at the landscape scale remain pervasive.

Integrated landscape approaches represent the latest in a long series of attempts to reconcile challenges facing conservation and development initiatives (Reed et al., 2016). Although variably defined (Erbaugh & Agrawal, 2017; Reed et al., 2016; Scherr et al., 2013), a landscape approach is essentially a governance strategy that brings together multiple stakeholders to identify synergies and balance trade-offs that manifest across scales and sectoral boundaries. Such holistic approaches are increasingly regarded as preferable to single sector alternatives to tackling pervasive local-global challenges of climate change, poverty, food security, and biodiversity loss (Berkes et al., 2003; Olsson et al., 2006; Sayer et al., 2013). However, despite burgeoning support for a landscape approach conceptually, there is thus far limited empirical evidence of either the operationalization or effectiveness of the approach in practice (Reed et al., 2017; Sayer et al., 2016).

The seemingly slow uptake of landscape approaches by policy makers and practitioners may be driven by the suggestion that landscape approaches remain largely conceptual and that implementation is lagging as practitioners grapple with the ongoing development of the theory (Knight et al., 2006; O'Farrell & Anderson, 2010b; Reed et al., 2015). Furthermore it has been reported that the scarcity of tools available to implementers has inhibited efforts on the ground. Finally, several authors have speculated that the lack of both a universally agreed definition and a guiding framework further impedes policy traction and implementation, serving to widen the gap between science, policy, and practice (Nassauer & Opdam, 2008; Scherr et al., 2013; Sunderland et al., 2009). As such, it is vital to synthesize existing knowledge and learn from both the successes and failures of previous attempts at integrating conservation and development to better understand why integration remains problematic and inform future implementation initiatives.

Here we contribute towards efforts at bridging knowledge-practice gaps by: (1) highlighting attributes of landscapes and approaches to reconcile conservation and development that will present challenges and opportunities and (2) elaborating on lessons learned from landscape practitioners and identifying action points for overcoming challenges and avoiding duplicating future research effort or repeating past underperformance.

Methods

This paper is a further output from an extensive data collection exercise carried out by the authors to evaluate the theory and application of integrated landscape approaches in the tropics (Reed et al., 2016, 2017). We searched a number of specialist databases (Web of Knowledge, the Centre for Agriculture and Bioscience International (CABI), and Scopus), web search engines, research organizations and grey literature sources to capture 16,832 relevant documents. The full detailed methodology can be found in Reed et al. 2015 (Reed et al., 2015). The reviews of the theory and application of landscape approaches provided a comprehensive, but (necessarily) coarse overview of the available evidence across the tropics. For this paper, we delve deeper into the dataset resulting from the prior review processes in order to generate a more refined understanding of the conditions that enable—or obstruct—implementation of landscape approaches and the mechanisms that can facilitate the monitoring and maintenance of progress.

A brief summary of key landscape attributes

In this section we identify some key landscape attributes—positive and negative—that will present both challenges and opportunities to practitioners of landscape approaches. While this is not an exhaustive list, the attributes highlighted have consistently surfaced within our reviews of the literature and regular consultation workshops.

Navigating complexity

Acknowledging social-ecological system complexity and the application of associated frameworks for their management is a surprisingly recent development (Cash et al., 2006; Cox & Arnold, 2010). Considering the myriad variables within landscapes and how they interact might be likened to Newton's third law of physics—every action has an equal or opposite reaction—with the not insignificant caveat that the reaction will likely be neither equal nor opposite. Within natural landscapes ecological interactions are complex and encompass both fast, and slow, drivers of change (Fischer et al., 2015) – in itself a challenge to management. In landscapes where natural processes co-exist with the multiple, and often contradictory, socio-economic institutions and their interactions—whether they be political, environmental, social, or commercial—the level of complexity (and therefore the degree of difficulty for investigation, management and disentanglement) is significantly enhanced (Demek, 1978; Mollinga, 2010). Furthermore, the spatial scales at which contemporary socio-economic interactions take place are increasingly expanded due to the accelerating processes of urbanization, globalization and telecommunication, leading to the phenomena of telecoupled landscapes (Carrasco et al., 2017; Liu et al., 2013).

Social-ecological system governance and management is thus often referred to as a "wicked problem" (Balint et al., 2011; Defries & Nagendra, 2017). A wicked problem in this context recognizes system complexity, accepting that proposed solutions will neither be true nor false as a satisfactory conclusion is unattainable for all, and any current "solution" will invariably generate new challenges (Rittel & Webber, 1973). It is simply the case that solutions should be developed that ideally result in overall better, and certainly not worse, outcomes, and should then be periodically revisited. This should not however discourage current research and scholarship that attempts to provide solutions that are "better" than what existed previously – although "better" will of course be variably interpreted. Prior research suggests that disentangling natural resource decision-making at local or landscape scales should not necessarily be a state-driven initiative due to local communities capacity to self-organize and recognize thresholds of use (Agrawal & Gibson, 1999; Hardin, 1968). Increasingly, centralized management is considered a poor fit for complex systems where issues need to be addressed simultaneously at various scales (Berkes, 2004; Hodge, 2007; Kremen et al., 2000). The question then becomes more than simply at what scale land-use decision-making, policies and management should be conceived and implemented. Research and practice must consider how institutions, sectors and policies intersect across the system and determine the processes that will enhance cognizance of shared—or conflicted—intentions.

The increased acknowledgement of a need for a systemic approach to dealing with complexity has raised the question of whether management is a realistic, or even desirable objective. Research suggests that perhaps we need to accept that navigating—as opposed to strict managing or planning—complexity may be, not only more appropriate, but preferable (Armitage et al., 2009; Sayer et al., 2016). Such discourse calls for moving beyond disciplinary confinement and in to "transdisciplinary modes of inquiry" (Brown et al., 2010 p.4) that encourage adaptive co-governance and polycentric structures. Nevertheless, developing institutions that can accommodate diverse stakeholders with conflicting solutions is challenging and hints at what Brown (2003) termed a case of institutional misfit. Multi-stakeholder interactions across scales implies institutional linkages horizontally (across space), vertically (across levels of organisations) (Berkes, 2002) and also diagonally (Torfing, 2012). Developing greater fluidity of actors and institutional interplay across sectors and scales, in many contexts, may require changes to both top-down and bottom-up structures in order to minimize scale conflicts (Foli et al., 2017; Olsson et al., 2006; Young, 2002).

Maintaining engagement in landscape decision-making processes is challenging (Balint et al., 2011); unsurprisingly, transforming to alternative governance arrangements is equally challenging, problematized by entrenched power structures, and both time and labour intensive. Governance transformations will often require enhanced political will and a political "window of opportunity" (Folke et al., 2005). Such a window will open when there is either a pressing environmental concern (problem-driven) or an administration seeks a problem that will justify change (politically-driven) (Kingdon & Thurber, 1984). Olsson et al. (2006) suggest that "key leaders and shadow networks can prepare a system for change by exploring alternative system configurations and developing strategies for choosing from among possible futures" (Olsson et al., 2006). This is somewhat consistent with the views of Ostrom and colleagues who recommend deliberate institution building to facilitate the emergence of adaptive co-management of SES (Ostrom, 1990; Ostrom et al., 1999, Barrett et al., 2001). Although Olsson et al. (2006) stress that transitions within SES "can only be navigated, not planned" - rhetoric that is well supported by a number of scholars (Berkes et al., 2003; Folke et al., 2005; Sayer et al., 2008) who favour a less prescriptive approach, arguing that the inherent complexity of landscapes renders formal management and planning problematic and therefore an element of "muddling through" will always be necessary (Lindblom, 1959; Sayer et al., 2008). However, all are proponents of building networks that integrate expert and community experiences to "increase the knowledge pool for decision-making" (Olsson et al., 2006 p.21) therefore averting an over-reliance on, or suppression of, either.

Engagement of multiple stakeholders

Greater engagement of stakeholders to enhance participation in decision-making and management is a fundamental organizing principle of a landscape approach (Sayer et al., 2013). The importance of effective, and ongoing, stakeholder engagement cannot be overstated. The impacts—both positive and negative—of political, environmental and economic decision-making at the landscape scale will be absorbed by multiple stakeholders. As such, participatory approaches that provide a forum for stakeholders from across a range of sectors operating within—and also external to—the landscape provide an opportunity to better reconcile ideological differences, including through triple loop learning (Biggs et al., 2011) and seek consensus on defining problems, objectives, and solutions (Blackstock, 2007).

A recent review of landscape approaches found community engagement in decision-making to be the most significant contributing factor to successful outcomes (Reed et al., 2017). Similarly, an assessment of a long-term landscape approach in the Sangha tri-national landscape found that the "maintenance of multi-stakeholder processes is vital to any landscape approach" (Sayer et al., 2016 p.137). Despite mixed results—in terms of reconciling conservation and development—within the Sangha landscape, participants recognized the value of multi-stakeholder engagement, particularly in terms of enhancing the capacity to share and comprehend complex challenges. Furthermore, evidence from the commons and social-ecological systems literature further stresses the value of community engagement and empowerment to the long-term sustainability of joint conservation and development interventions (Ostrom, 1990; Persha et al., 2011).

However, while the need to more effectively—and equitably—engage stakeholders in decision-making dialogue for natural resource use and social development has long been conceptually recognized, practical progress remains slow (Agrawal & Gibson, 1999; Lund, 2015; Ribot et al., 2010); and reporting on the means of implementation—or methods for evaluation—remains scarce (Stenseke, 2009; Bixler et al., 2016). Moreover, practical attempts to balance the objectives of multiple stakeholders are often hindered due to "the political process of decision-making, differing values and norms, and power imbalances" (Defries & Nagendra, 2017)

The literature is replete with examples of stakeholder engagement being delivered as a mere box-ticking exercise to satisfy project or donor demands (Enengel et al., 2011; German et al., 2007; Castella et al., 2012). Perhaps the participatory forest management (PFM) programs in Kenya epitomize this challenge– a recent assessment of which found that in practice, the P for participation was all too often lacking (Mutune & Lund, 2016). While there is abundant evidence of the failure of implementers to adequately engage local stakeholders, it can equally be the case that participation fails due to the reluctance of local stakeholders themselves (Cheng et al., 2006). Multi-stakeholder engagement processes have high transaction costs (Enengel et al., 2011) and these costs will, of course, also be borne by local stakeholders. As such, effective engagement is only likely to occur if the long-term rewards are perceived as having potential to outweigh the initial short-term investment – whether that be monetary or otherwise (see section on incentives).

Engaging multiple stakeholders should be recognized as more than a function to simply support or empower local communities. When confronting problems that cross disciplines and sectors, adequately engaging stakeholders from across scales and levels is not only commendable but also likely to influence outcome pathways, build consensus and enhance sustainability potential. Increasingly, the concept of knowledge co-production that integrates communities of knowledge with communities of action is recognized as offering significant potential in confronting the kinds of "wicked problems" presented by social-ecological systems (Cash et al., 2003) (see also section on building networks). However, despite this recognition, the problem persists that groups or individuals will often have conflicting agendas, motivations, and levels of trust/mis-trust; issues that are likely compounded by top-down or strictly "expert" driven agendas.

Monitoring and evaluation

Due to the complexity, chaos and variability of social-ecological systems, monitoring and evaluation (M&E) is inherently challenging (Antrop, 2000; Lebel & Daniel, 2009) and largely inadequate (Milder et al., 2012). Beyond the challenge of identifying which indicators to monitor within the landscape, there are myriad further questions that must be considered such as: who develops the M&E framework, who performs the monitoring, who finances the process, for who is the monitoring for, who conducts the impact evaluation etc. Landscapes are unique and strategies to influence change must be highly contextualized (Ward & Shackleton, 2016), thus presenting challenges for the development of M&E systems - it is unreasonable to expect the development of a generic M&E framework that can be meaningfully applied across context specific systems. Irrespective, M&E of landscape-scale interventions is essential to both make effective use of the limited resources available (Ferraro & Pattanayak, 2006) and also as a pre-requisite for the application of adaptive management (Wicander & Coad, 2015).

A consistent narrative in landscape approach discourse is that the process of developing and conducting M&E should encourage the participation of multiple stakeholders (Sayer et al., 2016; Sayer & Campbell, 2004). An approach that seeks to overcome disciplinary barriers and encourages sustained stakeholder interaction offers a number of practical and technical advantages. Incorporating local stakeholders, and particularly local farmers in monitoring processes, offers important cost-reduction potential and is considered fundamental to enhancing local biodiversity conservation and sustainable development (Norris, 2008; Mcneely, 2006). Furthermore, a history of learning-by-doing renders local and indigenous communities well positioned to identify appropriate indicators for ecosystem change – knowledge that should be recognized rather than repressed by conservation and development interventions (Lebel, 2013). Finally, landscape initiatives should incorporate capacity development to enhance the probability of local stakeholders having engagement in, and commitment to, the ongoing monitoring and maintenance of initiatives beyond the project duration – ultimately local participants need to be able to take ownership of the process such that they can evaluate progress towards the goals that they themselves have helped to establish (M. Ros-Tonen, personal communication).

Singularly within the discipline of biodiversity conservation, monitoring and evaluation is challenging and costly to perform. These challenges are not ameliorated by the fact that M&E has typically been under-funded and under-considered in project proposals – and by its nature is typically tailored to specific project needs and incorporated at scales far below the landscape. Further, much project and donor funding is not conditional on performance (Wertz-kanounniko et al., 2008). Comprehensive landscape monitoring will likely depend on aggregate systems that encompass multiple variables of interest – ideally with one indicator being able to satisfy multiple objectives. While aggregate systems offer potential (albeit not without their own challenges), a rigorous assessment of a landscape system is contingent on an evaluation of not just the individual components but also how these components interact to influence the whole (Levin, 1992; Ostrom, 2009). Therefore, monitoring frameworks for landscape-scale initiatives must go beyond simply measuring progress against a set of pre-determined indicators and attempt to determine how change in one (or multiple) area(s) impacts progress in another. Identifying where synergies might exist or trade-offs occur is fundamental to informing processes of adaptive management allowing governance structures to periodically re-evaluate objectives and then adapt accordingly.

Incentivizing behavioral change

Effective landscape approaches will likely be influenced by the application of appropriate incentive structures designed to reduce the exploitation of natural resources. As previously commented, "there is little debate over whether incentives for conservation are important – they are" (Berkes, 2004 p.626). However, determining the "right" or "best" incentives will be largely dependent on the socio-economic, cultural and political context. Simply put, what is perceived as an adequate incentive in one landscape may be considered inappropriate or insufficient in another and will depend on the form the incentives take and the manner in which they are distributed. For example, market-based incentives rely on market forces to incentivize behavioral change and may therefore be biased towards middle income actors with good market access. Furthermore, incentive structures targeted at either the individual (i.e. direct cash payments) or community level (i.e. investment in health services or education) will generate variable responses depending on context specificities. This raises questions over the equitable distribution and appropriateness of incentive structures (Dietz et al., 2003; Ostrom et al., 1999). Consequently, questions must be posed not just at, but also below, the scale of landscape – is the proposed incentive and means of benefit sharing perceived equally across and within stakeholder groups? Oftentimes, the likely answer is almost certainly not (Cooney et al., 2017; Naidoo et al., 2016).

Incentives for pro-conservation behavior can take many forms, from providing financial compensation or clarifying property or access rights to addressing issues of equity, health, infrastructure, or power asymmetries of class or gender. Yet, within these broad classifications, there will be differences in application and perception. For example, if an objective is to engage and empower marginalized groups, there are multiple potential approaches that will have differential outcomes and even empowerment itself will be perceived variably. As "perceptions often condition behavior, compliance and engagement" (Carmenta et al., 2017), it is therefore critical that sufficient consideration is given to the potential environmental and societal pathways that may result from a given incentive. Research has illustrated the peril of perverse incentives – that is, well-intended pro-conservation incentives that have the paradoxical effect of accelerating natural resource depletion. (Ferraro & Kramer, 1995; Langholz, 1999; Wunder, 2001). Perverse incentives are often realized when the opportunity costs of ecosystem conservation are underappreciated and the financial returns from ecosystem conversion are greater (or even perceived as being greater) than those generated from conservation to the end users. Such rudimentary cost-benefit analysis also fails to account for the broader implications resulting from the action to conserve, or convert. The challenge is to develop a more nuanced understanding of the complex interactions between people, nature and institutions and then identify which incentive structure will deliver the optimal outcome for the optimal number of stakeholders, within the specific context of interest.

A related but distinct incentive strategy that has been increasingly employed is that of providing alternative livelihood options that reduce threats to the local natural resource base. Despite the relatively wide uptake of this approach, the effectiveness in delivering positive conservation impacts remains poorly understood. This is largely due to the fact that the impact of such projects is rarely evaluated (Ferraro & Pattanayak, 2006; Sainsbury et al., 2015). Indeed, a recent review of alternative livelihood projects found that less than 20% of the studies analyzed sufficiently evaluated project impacts, while fewer than 10% resulted in positive conservation outcomes (Roe et al., 2015). A similar lack of evidence of effectiveness is found when examining the impact of alternative livelihood projects on socio-economic outcomes in Ghana (Hilson & Banchirigah, 2009) and Africa more broadly (Wicander & Coad, 2015). What the available evidence does show however is that like compensatory incentives, alternative livelihood strategies need to be carefully contextualized. For example, when considering livelihood options for a bush meat hunter, it will often be more than simply a financial or environmental consideration as a hunter may command a certain social respect within the community that he is reluctant to relinquish (John Fa, personal communication). Nevertheless, when applied effectively, alternative livelihood programs can be effective in empowering local communities, enhancing local agency and reducing threats to local biodiversity (Lotter & Clark, 2014; Roe, 2015).

Table 3: Summary of landscape attributes, challenges and key source references

Attribute	**Challenges**	**References**
Navigating complexity	Landscape dynamism, moving and emergent challenges Governance analysis and reform	Lindblom 1959, Rittel & Webber, 1973, Ostrom 1990, Berkes et al. 2003, Brown 2003, Folke, 2006, Olsson et al. 2006, Sayer et al. 2008, Balint et al. 2011
Multiple stakeholders	Conflicting agendas/mandates Differing levels of (mis)trust Power imbalances Legacy of ineffectiveness	Cheng et al. 2006, German et al. 2007, Ribot 2010, Persha et al. 2011, Sayer et al. 2013, Lund 2015
Monitoring	Underfunded, under-considered Who decides, performs, evaluates? High transaction costs	Levin 1992, Antrop 2000, Ferraro & Pattanayak 2006, Lebel & Daniel 2009, Milder et al. 2012

Incentivizing behavioral change	Varied perceptions Avoiding perverse incentives Achieving (cost) effective and equitable distribution	Ferraro & Kramer 1995, Langholz 1999, Wunder 2001, Sainsbury et al. 2015, Roe et al. 2015

Action points for reconciling conservation and development

In this section we identify what we consider to be some of the key action points for addressing the challenges above and for reconciling conservation and development more broadly within the tropics. In doing so, we summarize some of the current tools in use, strategies that have proved effective and areas of development.

Building networks to navigate complexity

Effective network building that integrates actors from across disciplines and sectors can improve our understanding of system wide dynamics and enhance our "ability to exploit economies of scale in shared resources and technical expertise" (Barlow et al., 2011 p.4). Despite recent endorsement of this sentiment from across the spectrum of scientific disciplines operating within sustainable development, the ability of researchers to effectively bridge disciplinary divides and link science with action has, at best, been only partially successful (Brown, 2003; Clark et al., 2011). Building networks with a shared thematic or geographic focus can help to bridge disciplinary divides (Gardner et al., 2013), however, overcoming entrenched philosophical and ideological differences will require careful facilitation. A potentially powerful—though by no means novel (Star & Griesemer, 1989)—means to facilitate dialogue and enhance links between disciplines and also bridge science, policy, and action gaps is the incorporation of boundary, or bridging, organizations (Cash et al., 2006; Cash & Moser, 2000; Clark et al., 2011; Guston, 2001). Boundary organizations fulfill the difficult task of considering the objectives of, and being accountable to, actors from across social-ecological system boundaries, while remaining impartial to other influencing forces (Guston, 2001), therefore facilitating co-production of knowledge and social order (Jasonoff, 1996a, 1996b). A common example of the role fulfilled by a bridging organization is to provide global-local level links between research and policy that reconcile global environmental objectives with national commitments and local realities. Such boundary organizations are characterized by the ability to link experts and decision-makers through facilitating open communication, aiding mutual comprehension of problems and proposed solutions, and mediating conflicts (Cash et al., 2003). The value of boundary organizations therefore depends upon the production of salient, credible and legitimate 'boundary objects' (i.e. maps, reports, protocols) that are sufficiently adaptable (to different viewpoints) and robust (to maintain identity) to satisfy the intentions of multiple parties (Cash et al., 2003; Star & Griesemer, 1989) Recent evidence has demonstrated the incorporation of boundary organizations across a range of countries and contexts (Clark et al., 2011; Mollinga, 2010; Pohl et al., 2010; Polsky & Cash, 2005; Reyers et al., 2015), however ascertaining effectiveness remains challenging (Clark et al., 2011) and therefore the credibility and legitimacy of boundary organizations themselves must also be given due consideration (Graham & Mitchell, 2016).

Developments in landscape monitoring

A number of landscape M&E frameworks have been developed in recent years, although their subsequent lack of repeat use or exposure suggests that they have not been widely embraced by the research or practitioner communities. However, they provide useful insights into how monitoring programs might be developed, implemented and maintained, and at a minimum offer a starting point for a discussion on how to refine and further develop landscape-scale M&E. In recognition of a general lack of robust data, Kellert et al. (2000) (Kellert et al., 2000) developed a set of six variables—equity, empowerment, conflict resolution, knowledge and awareness, biodiversity protection, and sustainable resource utilization—to evaluate the effectiveness of community-based natural resource management (CBNRM) programs. These variables were then applied post hoc to empirical evidence from Kenya, Nepal and the US. The findings revealed persistent institutional and organizational barriers preventing integration of societal and environmental objectives, particularly in Kenya and Nepal. Such post hoc evaluation is important to illustrate the gap between rhetoric and reality – a gap that the study authors felt might be bridged by making explicit the implementation challenges facing CBNRM, acknowledging disparities between the needs of people and environment, and building strong institutions that enhance stakeholder engagement.

The landscape measures framework (Buck et al., 2006; Milder et al., 2012) attempts to reconcile local stakeholder requirements with broader environmental objectives by incorporating local involvement in the development of metrics to measure landscape performance. The framework adopts a hierarchical approach of four overarching goals—conservation, production, livelihoods, and institutions with twenty sub-criteria—essentially 20 questions that serve as indicators to evaluate social and biophysical change. The questions themselves are—perhaps necessarily considering the scale and diversity of landscapes—somewhat vague but encourage users to refine, adapt or elaborate as required to best suit the landscape context and challenges.

A framework that offers potential in its ability to capture both the dynamism of landscapes and the contrasting perceptions of multiple stakeholders is the capital assets framework developed by Sayer et al. (2006) (Sayer et al., 2006) which builds upon the earlier work of Scoones (1998) (Scoones, 1998) and Carney et al. (1999) (Carney, 1998). Similar to the landscape measures framework above, this approach advocates the use of social learning in a participatory process of developing simple indicator sets in key asset categories of: financial, social, physical, human, and natural capital. In an explicit attempt to sustain stakeholder engagement—and presumably alleviate high transaction costs—the capital assets framework encourages continued and open stakeholder dialogue (as opposed to an over-reliance on expert opinion) throughout the process of conceptualizing, monitoring, and analyzing indicator sets. Analysis of the performance of "individual" assets relative to other assets allows for identification of trade-offs and can stimulate further stakeholder negotiation.

While there are a number of potential frameworks for landscape monitoring available, the specific context will of course largely determine what needs to be measured. Practitioners of landscape approaches should be encouraged to investigate the existing publicly available data sources for their landscape of interest. Technological advances have greatly enhanced the ability to monitor land use cover and change (see section below), and recent research also shows the potential for incorporating census data, mobile phone usage and even gas stove conversion figures to interpret the social implications of environmental decision-making (Jagger & Rana, 2017).

Towards meaningful engagement

Effective engagement will require the ability to facilitate dialogue between the diverse range of stakeholders that represent a variety of sectors, in order to influence or assist a range of systems (Clark et al., 2016). Engagement processes should therefore be encouraged that are adapted to specific contexts, structured in a manner that is commonly accessible and are cognizant of historic or potential conflict and power hierarchies. Furthermore, the dynamism of complex ecosystems and the associated stakeholders means that system shocks and fluctuations will inevitably occur, increasing the susceptibility to uncertainty and risk over time (Cooke & Kothari, 2001; Smith, 2008). As such, engagement structures need to be an iterative process of periodically informing, evaluating and updating knowledge and objectives to stimulate feedbacks for principles of adaptive governance (Carpenter &

Gunderson, 2001; Folke et al., 2005; Gunderson et al., 2001) with methods to assess both the satisfaction of participants (Enengel et al., 2011) and the effectiveness of governance platforms (Bixler et al., 2016; Hassenforder et al., 2016; Kusters et al., 2017).

While there is evidence to show that effectively engaging multiple stakeholders is fraught with difficulty, previous experience has provided valuable lessons suggesting that engagement can be enhanced via multiple pathways. Generating a shared understanding amongst stakeholders of their respective requirements or objectives and the implications of actions can help to highlight potential areas of synergy and also enhance empathy and trust amongst participants. Collectives can then potentially form that are built upon an acknowledgement of the interdependency of actions (i.e. that the actions of one group will likely influence the outcomes of another group and therefore in order to achieve goals it is desirable to take in to account the needs of others) (Steyaert & Jiggins, 2007).

Effectiveness of engagement should not be measured simply in terms of numbers of people in attendance. Increased attendance is an insufficient proxy for meaningful engagement if the discussion is consistently dominated by a specific group or individual (German et al., 2007). Therefore, multi-stakeholder platforms must consider ways to confront issues of inequity, such that a more deliberative form of co-governance might ensue. However, the importance of context must again be acknowledged; it is often considered that imbalances of power are detrimental to multi-stakeholder dialogue, but there may be instances when asymmetrical power relationships will actually facilitate the promotion of the agendas of marginalized groups (Hendriks, 2009; Moeliono et al., 2014); for example, if the power-holder champions the cause of those marginalized. Where this is not the case, attempts must be made to dissolve power asymmetries to encourage the co-production of governance arrangements and consideration must be given to issues such as: ensuring venues for public consultation are accessible to all stakeholders (or legitimate representatives) with an interest in participation, and that stakeholders are duly well informed (Sessin-dilascio et al., 2016), ensuring negotiation processes are conducted in a common language (Bennett & Dearden, 2014), developing strategies to enable equitable participation of all concerned stakeholders, including women and marginalized groups (Ling et al., 2009). Independent facilitation and support from external agencies—whether political, technical, or financial—has been demonstrated to inspire more effective stakeholder engagement processes (Balint & Mashinya, 2006; Sayer et al., 2016). However, capacity building can be a lengthy process, at times requiring external support for up to 20 years before fruition[2,3]. Furthermore, a recent study illustrated that external support does not guarantee enhanced equity; in this case internal capacity for cohesive collective action towards sustainable development already existed and externally induced programs disrupted rather than accelerated equitable stakeholder engagement (Guillaume, 2017). A robust baseline study to determine contextual nuance and social norms and behaviors can therefore be valuable.

Modelling and scenario building

The proposed use of simulation models has long been a feature of joint conservation and development discourse (Holling & Chambers, 1973; Sayer & Campbell, 2004; Walters, 1986; Wu & Hobbs, 2002). Rather than a predictive tool, their value is in generating potential outcomes that enable better comprehension of complex social-ecological systems and outcomes. Using participatory modeling can make explicit the assumptions and preferences

[2] https://forestsnews.cifor.org/51411/a-promising-but-uncertain-future-for-tenure-rights-devolution?fnl=en

[3] Jennie Barron (IWMI/SLU) presentation: Feasibility of green water management and rainwater harvesting in drylands. Falkenmark Symposium – Achieving SDG in Africa: Scaling green-blue revolution. World Water Week 2017.

of a diversity of participants, thereby enabling more transparent decision-making processes (Holling & Chambers, 1973; Sayer et al., 2016; Wu & Hobbs, 2002). Importantly they can help to develop a better understanding of the bio-physical and socio-economic processes within the landscape, and how they interact (Musacchio, 2009; O'Farrell & Anderson, 2010b). Coupled with participatory historical trend analysis – the practice of consulting inhabitants to collect historical landscape information—can be particularly effective for identifying patterns of change. Understanding both ecological processes derived from landscape configuration and function, as well as structural hierarchies, social conflicts, and political agendas can strengthen measures for safeguarding natural resources and enhance the efficacy of collaborative decision-making. Application of modelling techniques can enable stakeholders to consider the current social-ecological system and negotiate desired future alternative states (Fischer et al., 2017). Furthermore, models can be revisited and evaluated against to facilitate the process of adaptive management.

There do remain a number of shortfalls in the modeling approaches, with projections characterized by a high degree of uncertainty (Prestele et al., 2016). Most models retain a large number of assumptions and the parameters are subject to modeler bias and—particularly for long-term projections—are limited to the known or anticipated variables of the time. For example, a model designed today to forecast future forest cover in Indonesia over the next 30 years would certainly include oil palm production as an independent variable – something that might not have been the case 30 years previously and would (as we now know) have represented a significant oversight. However, participatory modelling has been shown to be extremely effective in enhancing stakeholder discussion, helping to illustrate potential synergies or trade-offs and stimulating the development of innovative solutions. For example, Castella et al. (Castella et al., 2014) describe the use of a boundary object (in the form of a 3D model representing a Laotian village landscape) to encourage local stakeholder participation in land use planning. The model enabled those stakeholders lacking the capacity to adequately convey landscape features or interpret GIS maps to maintain an active role in scenario visualizing. Model outputs (as GIS maps) were then coupled with simple cost-benefit analyses (with locally determined parameters) so that community members could iteratively negotiate potential outcomes and ultimately influence decision-making processes (Sayer et al., 2006)

When considering the impacts of biophysical changes on landscape dynamics, the application of ecosystem service mapping tools offers potential. The online, open access tool InVEST (Integrated tool to Value Ecosystem Services and their Trade-offs) is an integrated and spatially distributed model that enables users to analyze the impacts of land cover change on the provision of ecosystem services. Developed by the Natural Capital Project[4] the tool predicts future ecosystem service provision in biophysical or monetary value outputs (Crossman et al., 2013) and has been widely applied in varying contexts (Swetnam & Willcock, 2011). Importantly, the tool can be used to assess potential future ecological trade-offs. Nelson et al. (Nelson et al., 2009) used InVEST to assess three stakeholder-defined scenarios of future land use.. By combining model outputs for ecosystem services, biodiversity conservation and commodity market values, they were able to quantify potential future trade-offs arising from increasing one or other of the outputs. Furthermore, they were able to speculate the degree to which potential trade-offs might be moderated by future policy interventions – particularly payments for ecosystem services.

While InVEST is especially useful for biophysical mapping and evaluating socioeconomic and ecological trade-offs, it fails to account for social (particularly non-monetary) values of ecosystem services, or "cultural services". A new tool, SOLVES (Social Values for

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[4] /http://www.naturalcapitalproject.org/InVEST.htmlS

Ecosystem Services) enables quantified and spatially explicit measures of social values to be incorporated into ecosystem service assessments. The publicly available GIS tool developed by the US Geological Survey uses a 12 point index to allow users to assess and map social values in relation to landscape metrics such as topography, distance to roads or water, and land cover – therefore improving the ability to assess trade-offs amongst ecosystem services and the social perception of their value (Sherrouse et al., 2011). Bagstad et al. (2016) used SOLVES in collaboration with another biophysical modelling tool, ARIES (Artificial Intelligence for Ecosystem Services) to map ecosystem service hot/cold spots in the Southern Rocky mountains with public perceptions of areas of natural value (using the SOLVES 12 point index). The analysis enabled the identification of areas of potential synergy or conflict between locations of ecosystem service value and those valued by local residents, thus benefitting resource managers, land planners and policy makers.

Modelling and scenario building has developed rapidly in recent years and now take various forms (Enfors et al., 2008; Palomo et al., 2011; Watts & Colfer, 2011). While not all outcomes can be anticipated, planned, or predicted (Folke et al., 2005), it is increasingly acknowledged that the process of developing models and alternative future scenarios—particularly when performed in a participatory manner—can help stakeholders to recognize and respond to social and biophysical fluctuations, trade-offs and synergies; thus enhancing the capacity to buffer against future environmental and social disturbance (Trosper, 2003). Finally, both the models produced, and analyses of the subsequent stakeholder discussions can provide important decision support for policy making processes.

Advances in spatial data and mapping

Inputs to modelling (both for scenario building and informing trajectories analysis), monitoring and evaluation and resource management allocation and planning at multiple scales, has been facilitated in recent years by advances in spatial data and mapping. These advances include new data sources at increasingly fine spatial and temporal resolutions, improved algorithms that increase the accuracy of remote sensed detection (e.g. of fire or rainfall) (Aragao et al., 2008) and the large open access platforms that make available prepared data that can be incorporated in to new analyses (i.e. Borneo Atlas and Global Forest Watch). Added to the burgeoning suite of processed remote sensed data and their repositories (e.g. Maryland's Global Forest Change, NASAs Wed Fire Mapper) are additional sources of georeferenced data across the social, ecological (from biodiversity and carbon, to agricultural yields and soil quality) and economic domains (e.g. YieldGapMap; WCMC; LMSM; IDH);. These data enable assessments of globally significant processes such as those related to carbon and fire against a suite of tenure regimes or intervention types (Baccini et al., 2012; Jagger & Rana, 2017; Soares-Filho et al., 2012) and assessments of social outcomes solicited by interventions for sustainability (Ferraro & Hanauer, 2014; Fisher & Christopher, 2006). Furthermore, these data allow for relationships between context and outcomes to be assessed and provide a tool to enable resource managers and additional stakeholders to visualize outcomes among a number of competing scenarios, and provide an evidence base for resource planning (Gray et al., 2016; Joppa & Pfaff, 2010). Therefore, monitoring frameworks for landscape-scale initiatives are increasingly able to go beyond simply measuring progress against a set of pre-determined indicators and attempt to determine how change in one (or multiple) area(s) are related to progress in another. Further new techniques for analyzing spatial data range from the quantitative orientations to the qualitative sciences. For example, new scholarship has dealt with important caveats in geospatial anlaysis, such as 'matching' which enables similar non-treatment sites to be compared against treatment sites and infer information about causality in to previously under-evaluated domains (Ferraro & Hanauer, 2014) and at global scales (Eklund & Cabeza, 2017), while on the qualitative tendency are new methods for participatory GIS and embedding multiple understandings of the landscape and its attributes in to an analysis.

Table 4: Summary of landscape action points, opportunities and key source references

Action point	**Opportunity**	**References**
Building networks	Geographically/thematically specific Incorporating boundary partners Bridging science-policy-practice gaps	Jasonoff, 1996, Guston 2001, Pohl et al. 2010, Barlow et al. 2011, Clark et al. 2011, Gardner et al. 2013
Developments in monitoring	Existing frameworks for integrated analysis Publicly available data sources Participatory approaches	Kellert et al. 2000, Buck et al. 2006, Sayer et al. 2006, Jagger & Rana 2017
Towards meaningful engagement	Knowledge co-production Formation of multi-stakeholder platforms or collectives Overcoming power and equity issues Capacity development	Cooke & Kothari, 2001; Ribot et al. 2010; Persha et al. 2011; Moeliono et al. 2014; Bennett & Dearden 2014; Clark et al. 2016; Sessin-Dilascio et al. 2016; Sayer et al. 2016
Modeling and scenario building	Improved understanding of potential outcomes Availability of public sources Increased stakeholder engagement/trust	Nelson et al. 2009; Watts & Colfer, 2011; Palomo et al. 2011; Sherrouse et al. 2011; Crossman et al. 2013; Bagstad et al. 2016
Advances in spatial data	Near real time monitoring of land use change and related processes (e.g. roads and fire), Open access platforms, links to social media and telecommunications enabling broad usability. Broad temporal and spatial breadth to inform future planning and conduct performance assessments.	Jagger & Rana, 2017; PGIS; Aragao et al, 2008; Fire and GFW Popkin 2016; Latawiec et al, 2015

Discussion

Decision-making for, and implementation and assessment of, landscape scale land-use management is inherently complex (Furst et al., 2010; Game et al., 2014). There are a number of overlapping and interacting issues that account for this complexity (Game et al., 2014; Mollinga, 2010). The environmental parameters of the landscape itself as well as the institutions operating within those parameters are typically complex, and always dynamic. That is, the processes, both social and biophysical, are rarely static, and over time new threats and opportunities will emerge (Sayer et al., 2016) – whether they be the introduction of mining, poaching or foreign investment for example. Within the tropics, such kicks can be particularly unsettling to systems that are often already socially or politically unstable. This complexity is further compounded by issues of scale and sectorial objectives. Commitments made by international conventions often reflect global level objectives that might not be well aligned with local or even national, realities (Kremen et al., 2000; Reed et al., 2015; van Vianen et al., 2015). Meanwhile, sectors operating within landscapes (e.g. energy, agriculture, forestry, water etc.) will likely place multiple, and often conflicting, demands on land-use and tend to maintain sectorial objectives that they set out to achieve with a lack of attention to, or even disregard of, the objectives of other competing sectors.

It is nonetheless encouraging that global environmental and development policy has widely acknowledged that integrated approaches are required if we are to fulfill global commitments. However, landscape practitioners ought to look beyond the timescales of global commitments and the research community must take care not be hamstrung by the lofty ambitions. A landscape approach must be recognized as long term endeavor, a process, and yet current systems in place are inherently maladapted to this philosophy. Profound policy change could take up to 30 years (Cairney, 2011; Stokstad, 2017), environmental process can take considerably longer to fully manifest, and if sustainable development is truly considered in the manner in which it was originally conceived (i.e. the Brundtland report) the impacts of interventions ought to be evaluated across generations. And yet typically policy terms are restricted to four or so years, donor commitments and project life-cycles rarely extend beyond 2-3 years (Rasmussen et al., 2017), and global sustainable development, climate and de/reforestation commitments are bound to arbitrary time horizons. Allied with ongoing difficulties in bridging disciplinary divides to achieve stakeholder integration, evaluating landscape approaches and even in defining the concept itself (Erbaugh & Agrawal, 2017), it is clear to see why attempts to implement and maintain integrated landscape approaches remain fraught with difficulty. A wicked problem can be described as one that is resistant to resolution (Rittel & Webber, 1973) and practitioners of landscape-scale approaches that attempt to reconcile conservation and development are likely to face multiple, and often conflicting, wicked problems throughout the process. However, an acknowledgement of the difficulties in application should not be a justification for inaction.

While, of course, there are a multitude of other factors to consider when initiating landscape approaches, within this article we have identified some of the most influential joint conservation and development literature of recent decades and highlighted key factors to consider for integration. In doing so we have demonstrated where convergence of thought amongst scholars occurs and, this alone, goes some way to understanding landscape processes, landscape approach functionality and the challenges related to integrating conservation and development in the tropics. By considering the sum of the attributes and action points detailed within this article, we are able to make some assumptions as to what we consider, based on the literature, are some of the persistent challenges and key areas of opportunity for making future attempts to reconcile conservation and development more effective. We have also highlighted some of the well-recognized but often ignored general themes that as well as being important points in themselves are also woven within every other aspect of landscape approach theory i.e. complexity, context and dynamism.

- Challenges: M&E underfunded and specific to project objectives; Inconsistency in methods; Short time horizons for both projects and policy; Governance failings, lack of institutional capacity, weak links between levels; Landscape complexity/dynamism, moving targets, increased climate instability; High transaction costs, poor understanding of resource allocation and cost-effectiveness; Difficult to provide evidence of effectiveness.
- Opportunities: Technological advancement; Increased recognition of the need to integrate to achieve global policy objectives; Recent global policy process (SDGs, Paris climate accord) provide a global framework against which to assess local-national progress; Body of evidence emerging to show how to navigate landscape complexity and encourage 'good governance'; Abundance of tools available to facilitate the monitoring of progress towards conservation and development objectives; Emergence of multi-stakeholder platforms and boundary organizations to facilitate bridging research-policy-action gaps.

The landscape attributes and action points here provide opportunities for integrating conservation and development in the tropics and overcoming some of the difficulties. However, each also acknowledges challenges, and practitioners will typically have to incorporate a combination of tools and mixed methods (Agrawal & Varughese, 2000). Perhaps most consistent throughout our research has been the need for practitioners to acknowledge the importance of context, encourage multi-stakeholder dialogue and practice principles of adaptive management (Reed et al., 2016, 2017). This paper relates to these components of landscape approaches and offers a synthesis of experience that we hope highlights important pitfalls to be aware of and opportunities to seek out. As such, this paper can be considered a "toolkit" of sorts and the elements within if considered, selected and applied with particular reference to the context of the landscape of interest should be of practical use to researchers and practitioners and technical support to policy and landscape decision making.

Conclusion

We have performed a thorough review of the literature on integrating conservation and development in the tropics. This has enabled us to provide landscape attributes and action points that identify consistency in thought on processes and functions that can aid future implementation efforts. While complexity, engagement, monitoring and behavioral change are significant challenges to progress, the action points suggest that these need not be insurmountable challenges. This article provides a valuable resource for actors operating across the spectrum of research, policy and practice as we continue to develop the means by which we will fulfill such globally conceived commitments as the New York declaration on forests, the Aichi biodiversity targets, the global restoration agenda, and the goals of the climate and development initiatives. The evidence synthesis provides a useful starting point for overcoming implementation and evaluation challenges, identifies where further research is required and can also serve to reduce future duplication of research effort.

However, while the tools and action points identified here may have independent and collective value in terms of moving towards operationalizing landscape approaches and closing knowledge-practice gaps, obstacles to progress remain and new challenges will undoubtedly arise. Innovations in theory, new—and further development of existing—tools, and greater understanding of the precise functioning of landscape approaches must be encouraged. Crucially, the evidence base must continue to be developed with robust monitoring of the biophysical and social processes within the landscape in order to assess change and determine the effectiveness, and cost-effectiveness, of landscape-scale initiatives.

Chapter Six

Conclusion

This thesis has provided a comprehensive evaluation of the current evidence on landscape approaches in the tropics. In doing so, it has identified key attributes for landscape approach efficacy, current impediments to progress, future research areas of importance and some critical gaps in our current understanding. This concluding chapter summarizes the key findings by revisiting the research questions outlined in the introductory chapter, identifying where there are consistencies between the chapters of the thesis, highlighting current gaps in the understanding of landscape approaches, and providing recommendations for future research priorities.

What is the theoretical development of integrated approaches to conservation and development in the tropics and how has the landscape approach evolved into its current iteration?

Chapter two of this thesis provides a reasonably comprehensive overview of how the theory related to integrating conservation and development in the tropics has evolved. Despite recognizing the 1972 United Nations Conference on the Human Environment (UNCHE, 1972) as an important milestone, it was really post-Rio 1992 (UNCED, 1992) that momentum for integrated approaches gathered pace. Perhaps coincidentally it was also in 1992 that this research identified the first use of 'landscape approach' within the scientific literature (Barrett, 1992) – although it bears limited resemblance to the more recent conceptualization of landscape approaches (Sayer et al., 2013). During the two decades subsequent to 1992 a proliferation of approaches were developed that sought to reconcile conservation and development challenges in order to provide outcomes that would benefit both humans and the environment. Despite falling under a number of different guises, many of these approaches were criticized for retaining an overly sectorial objective; for example integrated water management, integrated rural development or integrated natural resource management that respectively placed water, development and natural resources as the central focus.

The integrated conservation and development projects (ICDPs) of the late 1980s and 1990s attracted widespread support, although ultimately these were deemed too localized in focus and often failed to deliver the much sought win-win outcomes (Robinson & Redford, 2004; Wells & McShane, 2004). Perhaps borne out of the inability to deliver win-wins, scholars were then incentivized to develop approaches that readily acknowledged the inherent trade-offs that exist in attempts to integrate conservation and development (McShane et al., 2011; Sunderland et al. 2008). As such, landscape approaches (and their many synonymous approaches, see for example Scherr et al. 2013; Waylen et al., 2014) that attempt to concomitantly address multiple landscape challenges by integrating multiple stakeholders in iterative dialogue processes have been developing in recent years (Milder et al. 2012; Sayer et al., 2013). From our evaluation of the landscape approach literature we were able to distinguish five key elements (the five Es) that would enhance the effectiveness of landscape approaches: evaluating progress, establishing good governance, evolving from panacea solutions, engaging multiple stakeholders, and embracing dynamic processes. We concluded that landscape approaches are distinct from previous attempts at integration in that they acknowledge that trade-offs can and will occur but by identifying who loses, or where losses are occurring—and then acting upon these—landscape approaches can deliver more winners and less losers (Sayer et al., 2014).

What are the current barriers to implementation or upscaling of landscape approaches?

Despite widespread acknowledgement of the need to transition towards more integrated approaches to land use in the tropics (Barlow et al., 2011; Mbow et al., 2015; Meinzen-Dick et al., 2002), there remains a gap between the conceptual attractiveness of landscape approaches (Chia & Sufo, 2015) and their implementation in practice or uptake in policy (Reed et al. 2017). As such, this thesis has identified what are some of the persistent barriers to implementing, upscaling or maintaining landscape approaches. Within chapter two we evaluated a vast body of literature and were able to identify broad-scale challenges facing landscape approach implementation. First, it appears that landscape approaches may be suffering from a time lag effect as efforts at implementation catch up to the fairly rapid development of the theory. On reflection, I would suggest there is some support for this assertion as, certainly within Indonesia, evidence is emerging of private sector, donor agency and NGO commitments to implementation efforts[5,6,7,8]. Second, it is considered that the lack of a coherent terminology for landscape approaches might be inhibiting practical progress and policy traction (Scherr et al., 2013; Waylen et al., 2014). It is difficult to determine the validity of this argument but I sense that increasingly there is a greater understanding of what is meant by adopting a landscape approach, even if a universally agreed definition is not forthcoming. Third, operating silos continue to persist, whether between the social and natural sciences, political ministries or sectors operating within the landscape. There is little doubt this remains one of the fundamental challenges of operationalizing landscape approaches. Fourth, processes to engage internal and external stakeholders were deemed largely insufficient. While there appears to be some progress in this regard with an increase in

[5] https://www.businessgreen.com/bg/interview/2419598/app-embraces-landscape-approach-to-end-deforestation
[6] http://www.inside-rge.com/APRIL-Landscape-Approach-Conserving
[7] https://www.climatelinks.org/resources/usaid-lestari-project
[8] https://www.zsl.org/conservation/regions/asia/kelola-sendang-%E2%80%93-protecting-sumatran-tiger-habitat

the application of multi-stakeholder platforms, I believe there remains a long way to go in terms of establishing equitable engagement that seeks to empower marginalized stakeholders in decision-making processes. Fifth, landscape monitoring is inherently challenging, the size and complexity of landscapes demands human resources and willingness combined with significant financial investment that is all too rarely available.

To further consider the challenges of implementing landscape approaches chapter five takes a deeper look at the literature to ascertain where consistency amongst scholars exists. This investigation confirmed the findings of chapter two in that monitoring was found to be both under-funded and under-performed while there was also a legacy of ineffectively engaging multiple stakeholders. Chapter five also revealed the complexity of landscapes and the associated institutions to be a persistent challenge for practitioners; in order to implement a landscape approach a full analysis of the institutional arrangements in place is recommended and it might be the case that the current arrangements do not well-lend themselves to the adoption of a landscape approach and governance reform is then required. Finally, chapter five highlighted the importance of providing appropriate means to incentivize behavioral change. It is consistently acknowledged that not just the equitable distribution of incentives to be of importance (Berkes et al., 2003) but also how the incentives are perceived by those in receipt (Carmenta et al., 2017). The literature is replete with examples of well-intended pro-conservation incentive policies that have the paradoxical effect of accelerating environmental degradation (Carpentier et al., 1999; Wunder, 2001). These suggest that market-based solutions alone are insufficient to address joint social-ecological obstacles. Somewhat similarly, the advent of alternative livelihood strategies developed to alleviate pressure on natural resources via the provision of new revenue activities have largely failed to exhibit efficacy (Roe et al., 2015). It is therefore important to consider to what extent top-down externally conceived interventions are appropriate for landscape approaches. The available evidence certainly supports a move towards more co-productive systems – rather than imposing what we think will work, we should be co-designing locally appropriate solutions.

Where have landscape approaches been applied in the tropics and how effectively have they managed to reconcile conservation and development concerns?

Chapter three provided perhaps the most insightful, and controversial, finding within this entire thesis – the failure to identify a single example of a landscape approach—as we envision it—within the tropics. It is important to note here that landscape approaches may be present in the tropics but are not being reported in the literature (peer reviewed or grey). This speculation is valid as it has previously been reported that grass-root initiatives may lack either the scientific capacity or motivation to collect and report results (Sunderland et al., 2009). Further, it might be that the terms applied to search the literature were in fact inadequate – given the lengthy process involving multiple expert consultations this seems doubtful. Finally, it could be the case that our expectation of how a landscape approach ought to be operationalized is overly idealistic – it could well be argued that expecting to engage stakeholders with previously conflicting agendas in meaningful dialogue to elicit equitable land use solutions is at best ambitious and at worst naïve or misguided. Nonetheless, I feel that to curb ongoing poverty, loss of biodiversity and environmental destruction in the tropics, somewhat radical solutions must be sought.

Despite not capturing a quintessential example of a landscape approach in practice, the review identified 174 case studies that demonstrated good characteristics of landscape approaches - 150 from the grey literature, with only 24 peer-reviewed examples. From these, 44% (66/150) and 54% (13/24) reported to have been successful with the remainder reporting mixed effects or not determining a level of success; there was not a single report of an unsuccessful landscape approach. While these findings are encouraging, there were concerns over the quality of the evidence and more often than not successful interventions failed to provide sufficient and robust data to support the claim. Nevertheless, the evaluation of the 174 examples, enabled us to determine what were considered to be the key contributing factors to successful outcomes. Community management and engagement, institutional support, capacity building and good governance were deemed particularly influential while there was good evidence to suggest that a mixed or polycentric governance structure would increase the likelihood of success. Interestingly, these results are very consistent with the findings of chapter two in which the literature conceptualizing landscape approaches recognizes good governance and engagement of stakeholders as fundamental to success.

What is the contribution of forests and trees within the landscape to adjacent or embedded agricultural production systems?

The initial objective for chapter four was to determine how forests and forest patches contributed to agricultural production across the landscape via the provision of ecosystem services. Due to a dearth in studies investigating such processes, we were unable to establish the ecosystem service flows across distinct forest and agricultural land units. However, we identified 74 studies that assessed ecosystem service provision from trees to agriculture over more local scales – typically within farm or on experimental plots, with 58 of the 74 being agroforestry systems.

In the majority of cases there was a net positive effect of proximate trees on food yields, although it is worth noting that in Asia there was a net negative effect – the only study region to show such a finding. Moreover, incorporating trees within agricultural systems was shown to have an overall net positive effect on livelihoods as trees provide a secondary source of revenue through for example, the sale of fuelwood or mulch. The enhanced income diversity can be an important safety net for farmers in times of drought, crop failure or other natural or market disturbance.

Perhaps the most intriguing finding of chapter four is the relative lack of studies that investigated ecosystem service provision from trees over long temporal or large spatial scales. As noted above most studies were mixed tree and crop systems. Those studies that did assess the impact of off-farm trees were conducted in agricultural systems located no more than one kilometer from the forest edge and were all short term studies of less than three years focusing on the single ecosystem service of pollination. Given the acknowledgement that ecosystem services do not act in isolation (Boreux et al., 2013) and support for the notion that ecosystem services provision from forests are essential for long-term agricultural sustainability (Scherr & McNeely, 2008), there is an urgent need for long-term research and monitoring that can enhance our empirical understanding of these processes.

What are the key attributes and action points for landscape approach practitioners to consider for more effective operationalization?

Many of the key landscape attributes to consider have already been documented above, particularly in the 'current barriers' section. However, it is worth reiterating here that the significance of context cannot be overstated. Throughout this research and within the many stakeholder and consultation workshops I have attended in the last two years, it has been consistently recognized that all landscapes are distinct and as such practitioners will encounter different challenges and conflicts. While some generalizable patterns may emerge—as exhibited in chapters two and three—progress within landscape approaches will be dependent on the iterative negotiation and dialogue of interested stakeholders that can reveal the context specific challenges and opportunities. Similarly, while our reviews of landscapes and landscape approaches across the tropics highlight important features, they do so at a necessarily coarse scale and therefore potentially fail to recognize the more subtle aspects of landscape approaches. With this in mind, the objective of chapter five was to dive deeper into the data collected for chapters two and three and attempt to develop a more nuanced understanding of the mechanics of landscape approaches and the innovations that might facilitate future implementation and effectiveness.

The deeper analysis of the data enabled the identification of five broadly categorized landscape action points: building networks, developments in monitoring, towards meaningful engagement, modeling and scenario building, and advances in spatial data, which are summarized in table two, chapter five. Chapter five is not a comprehensive account of all landscape attributes and action points - for example it does not cover issues such as sanctions or regulations for implementing landscape approaches, the emergence of green climate and other financial innovations that may support implementation, and only briefly discusses the importance of policy formulation and political will. However, this chapter provides an important, and first of its kind, synthesis of perpetual landscape challenges and offers insights in to the innovations that can enable these challenges to be overcome.

Are there consistencies in findings across the chapters?

In some instances it was encouraging to note the consistencies among the various chapters of this thesis. For example, each of the chapters acknowledge the importance of context when applying landscape-scale approaches and each also recognizes the potential for multifunctional land use. Furthermore, there was particular consistency between the findings of chapters two and three, and three and five, with regard to the significance of engaging multiple stakeholders and developing effective governance arrangements, respectively. However, other consistencies found between the chapters are less encouraging, as they highlight the current gaps in evidence and understanding. Each of the chapters refer at some point to the challenges related to monitoring socio-economic and environmental variables across large landscapes. This challenge is well-acknowledged in the theoretical literature (chapters two and five), and then confirmed in practice (chapters three and four) where monitoring is consistently under-performed or reported.

Two further consistencies of concern relate to the lack of sufficient monitoring. Firstly, the issue of short-termism features throughout this thesis, that is short-term projects, policies and funding cycles that are maladapted to the long-term objectives of landscape sustainability. Secondly, there is the concern that there is a lack of evidence for the effectiveness of landscape approaches specifically or integrated land management more broadly. As we have speculated, a lack of evidence of effectiveness need not indicate a lack of effectiveness. Rather, it may be that the application of landscape approaches is not yet wide-spread or that there is a lack of capacity or motivation to monitor and report findings (the relatively low numbers within this thesis provide some support for, at least, the first part of this statement). Regardless, there is certainly a concern that implementation and monitoring of landscape approaches requires further effort and investigation. These concerns are well-illustrated by the quotes below that represent some of the conclusions from each of the chapters:

"Despite some barriers to implementation, a landscape approach has considerable potential to meet social and environmental objectives at local scales while aiding national commitments to addressing ongoing global challenges." (Reed et al. 2016; chapter two)

"*We conclude that landscape approaches are a welcome departure from previous unsuccessful attempts at reconciling conservation and development in the tropics but, despite claims to the contrary, remain nascent in both their conceptualization and implementation*". (Reed et al. 2017; chapter three)

"*When incorporating forests and trees within an appropriate and contextualized natural resource management strategy, there is potential to maintain, and in some cases, enhance agricultural yields comparable to solely monoculture systems. However, we also identify significant gaps in the current knowledge that demonstrate a need for larger-scale, longer term research to better understand the contribution of forest and trees within the broader landscape and their associated impacts on livelihoods and food production systems".* (Reed et al. 2017; chapter four)

"Allied with ongoing difficulties in bridging disciplinary divides to achieve stakeholder integration, evaluating landscape approaches and even in defining the concept itself, it is clear to see why attempts to implement and maintain integrated landscape approaches remain fraught with difficulty. A wicked problem can be described as one that is resistant to resolution and practitioners of landscape-scale approaches that attempt to reconcile conservation and development are likely to face multiple, and often conflicting, wicked problems throughout the process. However, an acknowledgement of the difficulties in application should not be a justification for inaction". (Reed et al. unpublished; chapter five)

Of course, the issues related to monitoring, short-termism, and a perceived lack of evidence are very much related. This then begs the question (and it has been asked elsewhere), why do we need robust monitoring and evidence of effectiveness? There are a multitude of reasons to build the evidence base for landscape approaches and I will briefly provide just a few here.

First, the axiom "what gets measured, gets managed" (Stiglitz, 2010) carries weight. There is good evidence, for example from deforestation rates in the Brazilian amazon, that when reliable and publicly accessible monitoring systems are in place, environmental degradation is more easily traced and therefore managed. Furthermore, as previously mentioned measurements of progress are fundamental for applying principles of adaptive management – without which landscape approaches are redundant.

Second, we must consider the issues of time lags and fads. The findings of this thesis suggest that we may be witnessing a time lag as implementation catches up with the theory of landscape approaches. Historically, there is a tradition of concepts related to conservation (and development) fluctuating in popularity over time (Redford et al., 2013). It is therefore not inconceivable that landscape approaches are indeed experiencing a time lag and will one day be considered a fad, despite claims to the contrary[9]. However, the negative connotations associated with either of these speculations must be put to one side – indeed a time lag can equally be perceived as a window of opportunity for innovation. There has never been a more pressing urgency for sustainable solutions to land management. Recent increases in global protected areas and decreases in global rate of deforestation (FAO, 2015) are juxtaposed with one third of land now being degraded and 15 billion trees still falling each year (UNCCD, 2017). If time does prove landscape approaches to be fads, it is important that science learns from the experience (much in the same way that landscape approaches have learnt from previous endeavors) and incorporates this knowledge in to future iterations of joint social-ecological strategies.

Third, in order to achieve buy-in from across sectors and enable up- and out-scaling of landscape approaches, evidence of effectiveness is surely required. In many tropical landscapes, political will is essential to affect change. Policy making is not entirely dependent on available evidence but certainly policy-facing evidence-based research can stimulate the formulation of (evidence-based) policy. Meanwhile, private sector actors operating within the

[9] http://ecoagriculture.org/blog/landscape-approaches-are-not-at-risk-of-becoming-a-fad-no-matter-the-absence-of-peer-review/

landscape will be far more incentivized to engage (and invest) in landscape approaches if there is available evidence of effectiveness. The private sector is often touted as a potential source to ‘unlock’ financing for landscape approaches, but without evidence we are unable to forecast rates of return and levels of risks – essential determinants to mobilizing private finance. Finally, but by no means least, evidence of monitoring and effectiveness will be key to gaining local level support and commitment to sustainable landscape practices beyond project durations.

Fourth, and finally (and perhaps most importantly), it is essential to assess both the effectiveness, and cost-effectiveness, of landscape approaches in order to determine if these are (the most) appropriate strategies for integrating conservation and development in the tropics. While funding for conservation and development is insufficient (UN, Clark et al. in appendix), there has nonetheless been significant recent investment in landscape approaches (Sayer et al. in appendix). We need to be sure that this investment is well-targeted or we risk further inhibiting the potential of already stretched resources. Simply, there is a matter of urgency to realize sustainable landscapes and if landscape approaches are not (cost) effective, then resources (both human and financial) must be focused on best alternative solutions.

While there are challenges to producing, and evaluating, the science (and not least the peer-review process) that will provide the evidence base for landscape approaches, I suggest that until an appropriate alternative is conceived, scientific evaluation with peer-review is undoubtedly the most reliable source of information currently available.

Recommendations

Here, based on the cumulative findings of this thesis, I briefly present some recommendations for future research and action that can further the landscape approach discourse. There is some unavoidable overlap with the preceding sections.

- There is an urgent need for research that considers both socioeconomic and biophysical processes over larger spatial and longer temporal scales. The studies of landscape approaches revealed relatively few examples overall and very few long-term, large-scale initiatives. Similarly, the review on forest ecosystem service provision was originally intended to provide a better understanding of how configuration of land uses influences ecosystem processes, and in particular how ecosystem services from forests or forest patches were supporting proximate agricultural systems. However, other than some studies that examined pollinating services over a gradient of forest distance, there was not really any research that investigated these seemingly important questions of how forests and trees within the landscape support or inhibit agricultural production. Furthermore, the case studies within this review that did consider larger scale dynamics were conducted over study periods of one to three years (see Fig. 4, chapter 4), when it is well understood that the impacts of ecosystem processes may only fully manifest over considerably longer periods (Renard et al., 2015). Of course, there are a number of inhibiting factors to longer term, larger scale research and many of the current structures in place to support research are maladapted to such endeavors, however, this should not quell the ambition to fill this gap.

- Studies that investigate both the effectiveness, and cost-effectiveness, of landscape approaches are required. Until we can demonstrate effectiveness, the suggestion that landscape approaches are more marketable than practical (McShane et al., 2011) can always be levied. However, determining effectiveness of landscape approaches is particularly challenging. Due to the widely held belief that acknowledging that context is fundamentally important to progress, it is problematic, if not impossible, to provide an adequate counterfactual against which to measure effectiveness – although matching with large remotely sensed datasets offers potential. Furthermore, implementing agents often have a set of criteria highly specific to their intervention that make it difficult to 1. Consider broader (or more nuanced) questions related to reconciling conservation and development, and 2. Compare across different contexts.

- There remains a lack of emphasis on monitoring and evaluation. Some justification for enhanced monitoring is provided above, but particularly relevant to landscape approaches is that monitoring of progress generates feedback loops that can inform multi-stakeholder reflection and re-evaluation. Such feedback is essential to enable adaptive governance to develop. In particular, the data provided through monitoring should be used to perform trade-off analysis, identifying where trade-offs are occurring within the landscape and amongst stakeholders and is therefore invaluable for developing solutions or alternatives for those who are losing out. However, monitoring is expensive and typically underfunded, we therefore need to develop—and utilize the existing—methods for monitoring in the most cost-effective, but reliable, manner – chapters two and five provide more detailed recommendations for enabling this. Further suggestions for improving monitoring include a comprehensive synthesis of monitoring tools and proposed indicators from across the range of sectors engaged in landscape activities – such an analysis could also evaluate the value of participatory monitoring and how to find the right balance that would satisfy scientists and participants. Finally, use of existing publicly available data sources can aid monitoring and reduce costs. For example matching data collection efforts with private sector or national/global data inventories – this thesis found little evidence of this happening but it seems a huge opportunity to both calibrate findings and reduce costs of monitoring.

- We need to develop more fruitful exchanges of communication between research, policy and practice. While recent international commitments are certainly encouraging, they tend to gloss over the trade-offs that occur between conservation and development objectives. Evidence-based research can inform policy-makers to formulate robust (evidence-based) policy and also contribute to improved practitioner decision-making. Similarly, the way in which landscape research is conducted and communicated can often be improved. There is increasing acknowledgement of the value of knowledge co-production for landscape approaches, but consideration must be given to how dialogue for such production is conveyed. For example, referring to ecosystem service frameworks or trade-off analysis may well be misunderstood or dis-incentivizing at the local level. Meanwhile, the research community is often guilty of being too disciplinarily focused – even with the advent of the SDGs and a call for holism, it is all too common to hear how a particular sector (water, forest, agriculture) is essential to fulfilling all the other SDGs (and therefore failing to embrace true trans-disciplinarity). Such siloed thinking is further exacerbated by the formulation of national plans to fulfill their commitments being dispersed amongst distinct ministries pushing conflicting mandates and therefore potentially working at cross-purposes. Independent facilitation of landscape approaches and brokerage between sectors and levels offers potential solutions to developing more integrated dialogue (see chapter five).

- While there seems to be a better understanding of what it means to take a 'landscape approach', there remains a need to develop a better understanding of how landscape approaches function in practice. A greater understanding can certainly be expedited through improvements in monitoring and reporting of landscape approaches. This thesis found weaknesses in both the social (for example, a lack of good information on landscape governance) and natural (a lack of information on landscape configuration and interactions amongst landscape features) science literature. A suggestion for future improvements is simply to provide better, and more honest, assessments of landscape initiatives. The failure to identify a single unsuccessful landscape approach is a concern and we need to consider further why it is the case that literature is consistently reporting successful outcomes (despite often lacking robust associated data). The motivations for not reporting failings have previously been speculated as the need to avoid jeopardizing future funding opportunities (Knight et al., 2006; Pullin, 2015). However, it must be understood that learning from mistakes is implicit to the design and maintenance of landscape approaches; transparent reporting is therefore fundamental to progress. Similarly, improvements can be made in how results and findings are interpreted and translated in to recommendations for future landscape agendas or policy. For example, there is a tendency to provide unsubstantiated or intangible recommendations for integrating conservation and development i.e. we need policy reform (how?), we need good governance (what?) or we need to empower marginalized groups (how?). Indeed, this thesis is not immune to this accusation. While elements of this thesis have enhanced the landscape approach discourse, one of the shortcomings in pan-tropical evaluation is the inability to fully consider and comprehend the minutiae within the context-specific landscape functions. Improved reporting, informed by empirical experience, can therefore aid the development of a more nuanced understanding of the precise functioning of landscape approaches.

Concluding remarks

Landscape approaches offer considerable potential as a mechanism to address conservation and development challenges. Multi-stakeholder engagement is increasingly recognized as a fundamental component of such endeavors and the virtues of such collaboration are plain to see. By bringing stakeholders together in facilitated and transparent negotiation spaces, there is potential to not just identify ongoing conflicts or trade-offs, but also recognize key areas of synergy. For example, the combined efforts of stakeholders from across the spectrum pf research, policy, and practice can provide the necessary scientific, institutional and practical knowledge that could help identify where future land use efforts are most appropriately targeted. Landscapes (as a feature or scale of enquiry) and landscape approaches (as a concept or process) encompass so many components that implementation will require a mixed methods approach likely increasing complexity and protracted-ness. However, the long-term potential of such approaches to contribute towards pressing challenges such as poverty, health, climate change and ecosystem integrity should justify the investment. Landscape approaches must therefore be considered a process and practitioners must be encouraged to look beyond the typical uni-directional project approach. While sustainable development must remain the ultimate objective, more insights will be gained during the process than after the result (see Sandker et al., 2010).

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Appendix

The following papers are contributions that I have authored or co-authored during my PhD studies and have direct relevance to this thesis.

- (1) From global complexity to local reality: Aligning implementation pathways for the SDGs and landscape approaches, CIFOR InfoBrief, (Reed et al. 2015)
- (2) Five challenges to reconcile agricultural land-use and forest ecosystem services in South East Asia (Carrasco et al. 2016)
- (3) Measuring the effectiveness of landscape approaches to conservation and development (Sayer et al. 2016)
- (4) Natural resource management schemes as entry points for integrated landscape approaches: evidence from Ghana and Burkina Faso (Foli et al. 2017)
- (5) From commitment to action: Establishing action points toward operationalizing integrated landscape approaches, CIFOR InfoBrief (Reed et al. 2016)
- (6) Bridging funding gaps for climate and sustainable development: Pitfalls, progress and potential of private finance (Clark et al. in press)
- (7) Clarifying the landscape approach: A response to the Editor (Reed et al. 2017)