Sustain Sci (2017) 12:465–476
DOI 10.1007/s11625-016-0415-z

OVERVIEW ARTICLE

Measuring the effectiveness of landscape approaches to conservation and development

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Received: 22 July 2016 / Accepted: 14 November 2016 / Published online: 28 November 2016

Abstract Landscape approaches attempt to achieve balance amongst multiple goals over long time periods and to adapt to changing conditions. We review project reports and the literature on integrated landscape approaches, and found a lack of documented studies of their long-term effectiveness. The combination of multiple and potentially changing goals presents problems for the conventional measures of impact. We propose more critical use of theories of change and measures of process and progress to complement the conventional impact assessments. Theories of change make the links between project deliverables, outputs, outcomes, and impacts explicit, and allow a full exploration of the landscape context. Landscape approaches are long-term engagements, but short-term process metrics are needed to confirm that progress is being made in negotiation of goals, meaningful stakeholder engagement, existence of connections to policy processes, and effectiveness of governance. Long-term impact metrics are needed to assess progress on achieving landscapes that deliver multiple societal benefits, including conservation, production, and livelihood benefits. Generic criteria for process are proposed, but impact metrics will be highly situation specific and must be derived from an effective process and a credible theory of change.

Keywords Conservation and development · Conservation impact assessment · Conservation theories of change · Biodiversity-development trade-offs · Integrated landscape approaches to conservation

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Introduction

Humans have influenced their landscapes both intentionally and unintentionally for millennia. Landscapes are continuously modified to meet aesthetic and functional objectives by the people who live in and use them and they are subject to exogenous influences, such as climate and the economy (Ellis and Ramankutty 2008). However, in the past two decades, the term 'landscape approach' has been used widely to describe a more integrative and trans-disciplinary approach to counter the tendency of dealing with landscape attributes in disciplinary silos (Tress and Tress 2001). Aid agencies, governments, and conservation organizations have increasingly used what they describe as 'landscape approaches' in attempts to reconcile competing claims on land in geographically defined areas. The landscape approach is recognized as a mechanism for achieving the Aichi targets of the UN Convention on Biological Diversity and is widely advocated in measures to achieve climate smart landscapes that mitigate and adapt to climate change (Reed et al. 2016; Harvey et al. 2014; Scherr et al. 2012). This paper focuses on the use of landscape approaches to reconcile production objectives with the need to conserve environmental values. We examine the use of landscape approaches in attempts to conserve environmental assets where it is recognized that conservation cannot be dissociated from socio-economic development (Milder et al. 2012, 2014; Frost et al. 2006). We define the landscape approach as "*a long-term collaborative process bringing together diverse stakeholders aiming to achieve a balance between multiple and sometimes conflicting objectives in a landscape or seascape*". Landscape approaches are commonly proposed for situations where there is ambiguity or disagreement over desirable outcomes. The assumption behind landscape approaches is that by accounting for trade-offs and exploiting potential synergies, they will achieve a better balance between conflicting objectives compared with the conventional spatial planning or sectoral approaches (Görg 2007). A recent review of the literature (Reed et al. 2016) showed widespread support for landscape approaches but a surprising lack of empirical data documenting their effectiveness in delivering social and environmental benefits.

Reed et al. (2016) identified 1500 articles that made reference to an integrated approach to land management. Forty percent of these studies explicitly supported the adoption of landscape approaches (Reed et al. 2015). Major investments are being made in landscape approaches, but accurate estimates of the financial magnitude of these investments are not available. A recent study by Credit Suisse and WWF estimates that US$52.8 billion is invested in conservation annually. Another review of international conservation projects showed that 72% of biodiversity conservation funding—possibly as much as US$13.5 billion between 1980 and 2008—was spent on initiatives that integrated development objectives within conservation projects (Miller 2014). General frameworks for measuring the social, economic, and ecological outcomes of landscape-scale management practices exist (Buck et al. 2006; Buck and Scherr 2009) but do not fully address the issue of trade-offs between conflicting objectives nor the inevitability of modification of objectives over time.

Landscape approaches are now very widely supported by government programs, international development agencies, the private sector, private foundations, and non-governmental organizations, and the need to demonstrate their effectiveness is greater than ever. Corporations are increasingly using landscape approaches when purchasers require reassurance that production processes observe social and environmental standards (Kissinger et al. 2015). Evidence of impact is clearly needed to support these uses of the approach.

A conceptual framework for landscape approaches

Landscape approaches aspire to make long-term improvements to conservation, production, and livelihoods (Estrada-Carmona et al. 2014) and to achieve these improvements by engaging and empowering the people who are affected. Capacity building, local empowerment, improving governance, and providing transparency in resource management negotiations are widely regarded as central components of landscape approaches (Smith et al. 2009; Pfund 2010; Milder et al. 2014). Moreover, landscape approaches recognize the importance of learning, flexibility, adaptation, and the need for a holistic view of outcomes and impacts in a constantly changing context (Sayer 2009). The immediate outcomes of landscape approaches are short-term changes in the condition of affected people or their environment. Impacts are longer term achievements in attaining goals set for the landscape. The problem persists that many attributes of landscapes are difficult to measure, evolve slowly over time, and are influenced by multiple drivers of change (Pfund 2010). Landscape approaches are assessed against deliverables, outputs, or outcomes of individual attributes, but we found that monitoring and evaluation seldom provided data on the overall performance of the landscape in achieving long-term improvements in livelihoods and the environment (Reed et al. 2015, 2016). Other studies have noted the absence of formal systems for assessing the impact of landscape-scale projects (Sandker et al. 2009; Milder et al. 2014; Sayer et al. 2016).

Landscape approach interventions are initiated, because there are competing claims for land or because the distribution and management of components of the landscape mosaic can be improved to achieve multi-functionality. We postulate that there are fundamental requirements for an institution or coalition of stakeholders to govern and lead the landscape initiative (Sayer et al. 2014; Mansourian 2016). It is the role of the management coalition, through negotiation and feedback with stakeholders to construct a rigorous theory of change (Weiss 1997). Theories of change are conceptual models that are modified as the process proceeds and provide feedback to stakeholders. In some cases, an institution has a clear mandate, legitimacy, and resources to lead a landscape process, and has the ability to enforce decisions (Balint et al. 2011). In many other cases, civil society, private sector actors, or international conservation NGOs convene informal institutions or coalitions that seek to achieve impact by influencing decisions of actors. The legitimacy of the group that leads the process is a fundamental requirement for success.

A spatially explicit inventory of natural, human, physical, social, and financial assets should be fundamental to any landscape approach. The execution of this inventory may be an important step in building the alliance of actors who will take the process forward. The inventory must identify the most suitable institutions and individuals able to establish a platform where negotiations amongst landscape stakeholders can legitimately take place. The management coalition must facilitate and contribute to governance of the process. The role of local governments should be central and provide legitimacy, but landscape approaches are often adopted where local governments and their agencies are failing to address the need to work across sectors and scales. Governance arrangements for landscape approaches are inevitably complex, since they have to satisfy the requirements of multiple actors and institutions (Mansourian 2016).

Spectrum of landscape approaches

Landscape approaches may be used for any geographically defined intervention where multiple objectives are being sought. In the past decade, they have widely been used in dealing with problems of tropical deforestation and more recently to achieve landscape-scale forest restoration (APRIL Group 2015; Mansourian 2016). Landscape approaches are used by conservation organizations in attempts to mediate large-scale changes in land cover, especially where forest conversion is underway (Sayer et al. 2008). These changes occur when forest areas are opened up at the early stages of development and are on the downward trajectory of the forest transition curve (Rudel et al. 2005; Angelsen and Rudel 2013; Sloan 2015). Landscape approaches are also used in the reforestation period, where both development and conservation organizations attempt to rebuild forest assets in deforested landscapes (Fig. 1) (Boedhihartono and Sayer 2012; Milder et al. 2012). The scope of situations where landscape approaches are used includes landscapes or seascapes where land claims are contested, where objectives diverge and where there is a need to optimize production and minimize environmental degradation and the loss of biodiversity. Figure 1 focuses on forest transitions, but integrated landscape approaches are also being used in agricultural production landscapes (Milder et al. 2014; Buck et al. 2006), to balance marine conservation and food security (Grober-Dunsmore et al. 2009; Agostini et al. 2012; Bensted-Smith and Kirkman 2010), for catchment scale natural resources management (Dale et al. 2014), and in other cross sectoral contexts (Álvarez-Romero et al. 2015; Riggs et al. 2016).

Methods

This paper reports on the outcomes of a workshop of landscape approach practitioners held at Lake Eacham in Far North Queensland, Australia, in June 2015. Eighteen landscape practitioners based in six countries working in natural resource management and research and development organizations attended the workshop. Participants all had experience of attempts to reconcile conservation and development trade-offs in landscape-scale initiatives across the tropics, mostly in developing regions and Australia. The participants had their institutional bases in various sectors, including extractive and agribusiness industries, international conservation and development research organizations, and academia. The group consulted the results of a recent systematic review of literature on landscape approaches (Reed et al. 2016). We presented and discussed case studies of landscape conservation efforts in Far North Australia, Mt. Elgon National Park in Uganda, the Congo Basin, and Riau, West Kalimantan and West Papua provinces in Indonesia. Participants worked in groups to compile a list of traits of landscape approaches that differentiated them from spatial planning. Groups presented this information to build our common understanding of the assessment of the effectiveness of integrated landscape management. We used the literature review and the broad experience of participants to reflect upon options for developing metrics useful for measuring effectiveness of landscape approaches.

The challenge of impact assessment

Like most conservation and development investments, monitoring and evaluation of landscape approaches are

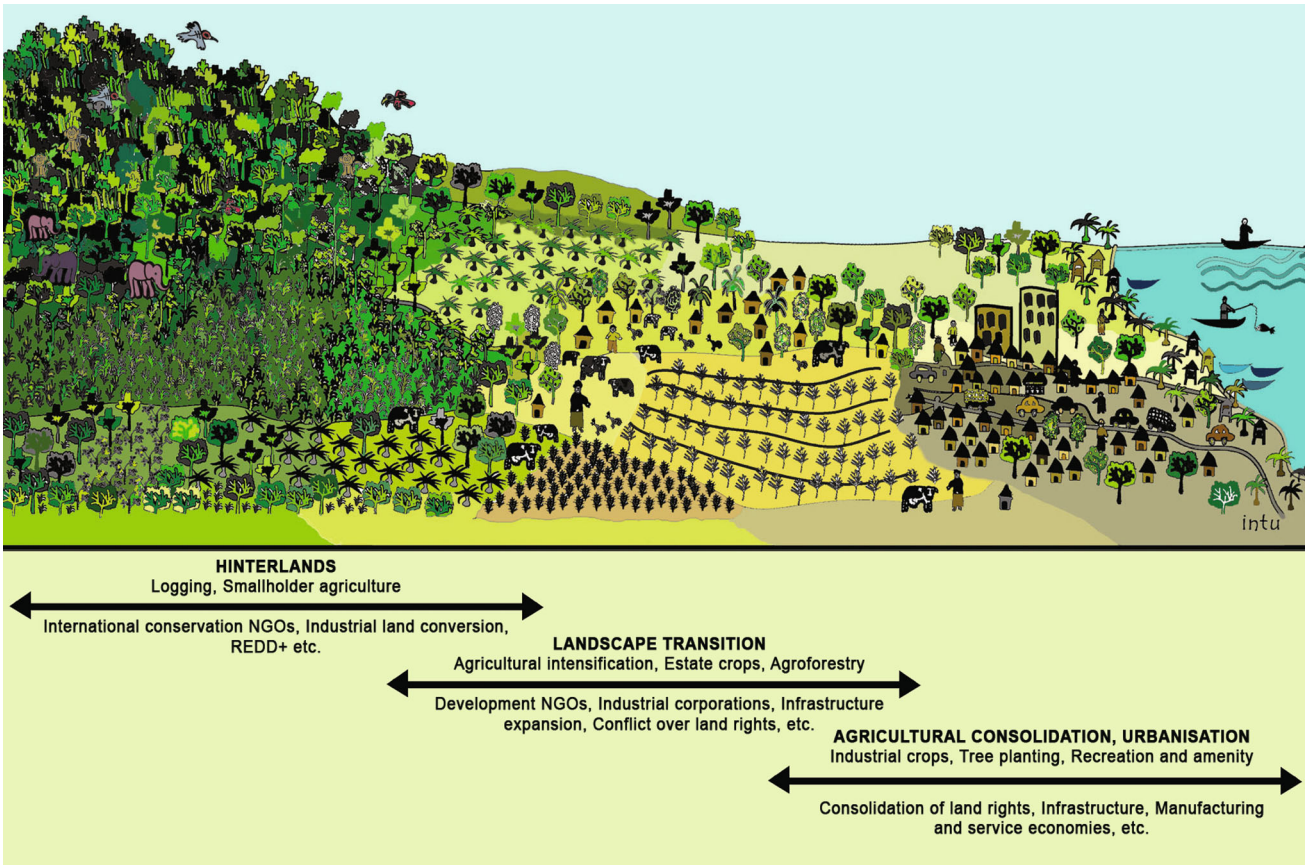

Fig. 1 Landscape transition curve. The *diagram* shows a spectrum of situations where landscape approaches are used. It shows generic changes in land cover and social processes as areas develop. Transitions occur when management intensity increases and infrastructure expands across development gradients from remote hinterlands to more developed regions. The key participants and the objectives that are pursued at different points on this trajectory are identified in the *lower part* of the figure

necessary to generate the knowledge to allocate resources, learn, and adapt. Monitoring and evaluation should greatly influence both progress and outcomes (Kapos et al. 2009; Sunderland et al. 2012). However, there appear to be few examples of measures of the specific added value that the landscape approach provides (Reed et al. 2016). We failed to find examples of interventions being assessed in terms of their long-term impacts on the performance of the landscape in delivering a broad range of benefits to society (Agrawal and Chhatre 2006; Garnett et al. 2007). Metrics to assess livelihoods of local people have been developed (Aldrich 2007), but adequate investment in continuous monitoring and evaluation remains rare (Bauch et al. 2014). There is a considerable support for landscape approaches—evidence shows their rapid adoption by organizations with conservation, development, or production objectives (Shames et al. 2014). However, there is an unmet need for evidence that they perform better than sectoral approaches in delivering on long-term development and conservation goals. Lack of evidence of impact does not mean lack of impact, but we contend that inherent difficulties of measuring impact are limiting our ability to establish proof of concept.

Unlike traditional projects, landscape approaches are long-term evolving activities, so attempting to assess their impact at a single end point is problematic. Stakeholders will continuously alter their views on desirable outcomes—the goal posts will continually move (Kutter and Westby 2014). Effectiveness is difficult to assess when there is no agreement on desired impacts. Stakeholders may have fundamentally opposed views and agreement on goals may never be achieved. Landscapes are large diverse socio-ecological systems, epitomizing the difficulties of measurement inherent in all integrated social and biophysical research (Rounsevell et al. 2012).

The complexity, uncertainty, and uniqueness of each landscape are inimical to standardization and replication of outcome and impact measures. Standard experimental design incorporating ‘treatments’ and ‘controls’ may be applicable to components of landscapes, but situations where a single treatment will be applied across the entire landscape of interest will be rare. The opportunity to

have replicate landscapes with untreated controls seldom exists.

A major international initiative to use the landscape approach to resolve conservation and development trade-offs illustrates the difficulties of impact assessment. The Congo Basin Forest Partnership adopted 12 landscapes of outstanding biodiversity value where development and conservation organizations ran programs which aimed to achieve both conservation and development impacts (de Wasseige et al. 2010). Donors funded these landscape approaches on a short time cycle and favored measures of delivery and short-term outcomes over measures of longer term impact (Endamana et al. 2010, Sayer et al. 2016). Impacts on specific goals of the partnership, for instance elephant populations, were assessed (Stokes et al. 2010), but impacts on broader landscape values, such as changes in poverty or forest condition, were not evaluated. Such broader impacts were difficult to detect during the 1–3 year funding cycle of a typical project (Gollin and Probst 2015). This problem was exacerbated when the landscape initiatives were based upon many small projects funded separately for different durations and when conflicting donor interventions were cobbled together in attempts to achieve landscape-scale impacts.

The uncertainty in defining and measuring landscape success limits our ability to learn from successes and failures. The "lack" of evidence of effectiveness" of landscape approaches appears to result from both the inherent difficulties of measuring impacts in complex contexts and a lack of adequate investment in establishing and monitoring metrics over the long term.

One could argue that the landscape approach simply provides a framework within which specific goals may be pursued and that the "approach" does not need to be subject to impact assessment. However, we contend that the pervasiveness of landscape approaches requires that the framework itself must be subject to assessment.

We, therefore, propose that landscape approaches should be subject to a two-stage process of evaluation. They have to be assessed first according to how effective they are at identifying and periodically adjusting appropriate goals; and second against metrics which measure achievement of those goals. The entire process must be rooted in the development and use of a robust theory of change.

The use of "Theories of change" for integrated landscape management

Landscape approaches are bedeviled by the problem that their ultimate goals are often not easily defined. These goals will be long term and influenced by many forces that may be outside the control of those driving the landscape process. Deliverables, outputs, and outcomes can be measured but, the assumptions that link these to ultimate impact are often problematic. There is a long history of the use of theory-based techniques for evaluations in other spheres of activity (Weiss 1997), but we have found no evidence of such approaches being used to evaluate landscape initiatives. We, therefore, advocate the use of 'Theories of change' to make assumptions explicit and add credibility to pathways to impact. A theory of change traces the links between an intervention and an ultimate impact and makes the assumptions underpinning prediction of the end result explicit (Brooks et al. 2013; Prinsen and Nijhof 2015). We adopt a definition of assumptions from Vogel (2012) as the "interpretations of how change might happen relevant to the context, hypothetical cause-effect links, and explanations of the worldviews, beliefs, rationales, analytical perspectives, and evidence that inform this analysis."

Figure 2 shows a generic theory of change for landscape approaches. The theory of change demonstrates the causal pathway and feedback loops driving progress towards improved landscape performance. We contend that metrics are needed at multiple stages throughout the process to inform progress and decision-making (discussed in "Methods"). A theory of change can provide a framework for developing metrics and opportunities for the use of technology and citizen science. Competing claims for resources establish the need for ongoing review and continuous adaptation. The management coalition is responsible for establishing and regularly reviewing and revising the resource inventory and driving the process. Simulation tools, such as Vensim or STELLA, and analytical methods, such as multi-criteria analysis are used to make assumptions and trade-offs explicit. Understanding of trade-offs feeds into the design of interventions and allows updating of the resource inventory. The development of a theory of change for a landscape approach requires an open and transparent dialogue between the full ranges of stakeholders to create a shared vision of the desirable future condition of the landscape. The theory of change should include the identification of intermediate outputs and outcomes that might plausibly lead to the desired goals. A robust theory of change would, therefore, enable assumptions in a landscape project to be subject to verification. A significant amount of investment in understanding the local context is required to ensure that interventions and outcomes are relevant and achievable.

Effective metrics

The axiom 'what gets measured, gets managed' applies (Stiglitz et al. 2010). Outcome metrics must relate to the underlying goals explicitly identified by the theory of

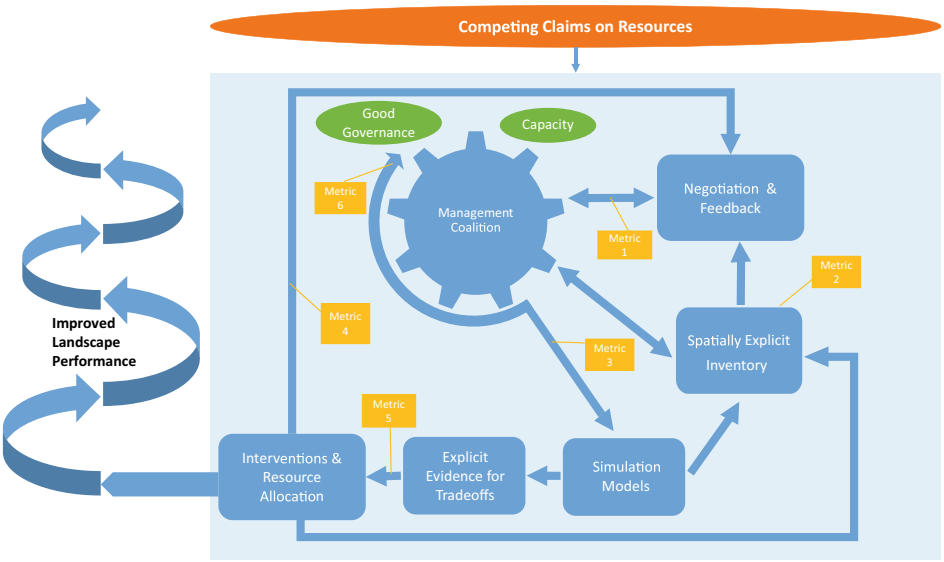

Fig. 2 Generic theory of change for landscape approaches. The management coalition drives progress towards ultimate goals—the *arrow* shows the direction of movement of this system. Good governance and capacity are positive feedback variables. Competing claims provide the justification for the process. The long-term goal is external to the process and results from landscape interventions. Suggested points of measurement are indicated. Each metric corresponds to the critical processes which are *1* negotiation and communication of clear goals, *2* a clear and agreed theory of change, *3* a rigorous and equitable process for continuing stakeholder engagement, *4* connection to policy processes and key actors, *5* effectiveness of governance, and *6* transparency

change. If excessively large and cumbersome sets of metrics are established, or metrics do not derive from the processes outlined above, they are unlikely to influence processes of change, may be too costly to measure, or local capacity for measurement may be lacking. Ambitious and comprehensive sets of metrics are only likely to be monitored if funding agencies are willing and able to provide resources. Metric sets developed in the design stage of a landscape approach often prove irrelevant for project implementers and are abandoned (Castella et al. 2014). Skeptical practitioners may not actually measure all metrics but simply provide their best estimates, thus jeopardizing learning and adaptation (Endamana et al. 2010; Lawrence et al. 2006; Constantino et al. 2012).

Stakeholder inequality

Attempts at impact assessment may favor the interests of the sponsors or leaders of programs at the cost of less powerful stakeholders (Browder 2002). The spatially explicit inventory of capital assets in the landscape used in the theory of change makes these inequalities transparent and available for consideration by the management coalition. Marginalized stakeholders should be included in development of theories of change, and they should feel ownership of the agreed theory. The concept of innovation systems should be applied (Buck and Scherr 2009), such that stakeholders learn together and feel ownership of the process of solving complex problems.

Failure to align local needs and objectives with regional or national commitments will likely result in unsatisfactory outcomes. For example, the Congo Basin Forest Partnership has attracted criticism for maintaining metrics on populations of elephants and gorillas but not on the nutrition, health, or education of children living in the landscape (Endamana et al. 2010; Sayer et al. 2016). Commitments to collecting data in places where landscape approaches are applied must be long term and must allow for generating a plausible counterfactual scenario. There must be a way of assessing what would have happened if the interventions based on the landscape approach had not been made. Powerful stakeholders may not welcome evidence that the objectives sought by weaker stakeholders are not being achieved. Interventions in large complex landscapes may have small incremental impacts on numerous variables which may be dwarfed by major development trends (Roe et al. 2014). Finding statistically significant evidence for these small effects is likely to be harder than finding evidence of the transformational change brought about by sectoral interventions, such as introduction of a new crop or construction of roads etc. (Minang et al. 2014).

Emerging opportunities

While these challenges may be daunting, opportunities are currently emerging, to help address them. The systems science that supports landscape approaches is becoming widespread. This science crosses the divide between

positivist and constructivist epistemologies (Sayer et al. 2013; Young et al. 2006; Ostrom 2009; DeFries et al. 2012). Positivism describes more formal planning approaches to landscapes implying a high degree of predictability. Constructivism entails progressively adapting, learning, and building an understanding of the landscape and recognizes uncertainty as to the longer term outcomes sought. Constructivism requires combining the soft skills of facilitation and communication (Boedhihartono 2012) and the harder skills of rigorous impact evaluation (Fisher et al. 2014; Baylis et al. 2016) Both qualitative knowledge and quantitative knowledge are required to build theories of change. It is necessary to tease out the causes of change in a landscape and make explicit the assumptions that underpin any management interventions that seek to mediate that change. We use the term 'drivers of change' to describe agents, including formal and informal institutions, and individuals that may influence the whole landscape system.

Technical feasibility and social capacity for collecting and representing data are rapidly improving

Methods and tools for conducting spatially explicit monitoring and analysis of interactions between social and ecological phenomena are becoming widely accessible and cost effective (Sandker et al. 2010; Campbell et al. 2003). Many practitioners now argue that landscapes are so complex that formal simulation models must be the preferred tools for understanding changes (Nelson et al. 2009; Wu and Hobbs 2002). Models provide a framework that enables stakeholders to contribute knowledge and insights on the costs and benefits of landscape approaches (Boedhihartono 2012). Models can exploit the improved resolution of remotely sensed data and applications for integrating multiple sources of information are expanding the capacities of scientists to track performance across multiple dimensions (Sandker et al. 2009; Hansen et al. 2013; Atzberger 2013; Rounsevell et al. 2012). Furthermore, tools that enable multi-criteria analysis of trade-offs between conservation and development in landscapes are now available (Margules et al. 2007; Sarkar et al. 2016).

Metrics for evaluating effectiveness

Clear and simple metrics that can measure performance are required to establish good practice in implementing landscape approaches. We distinguish between deliverables, such as equipment provided or studies completed; outputs which are reports or data sets resulting from interventions; outcomes which are short to mid-term changes in the condition of affected people or their environment as effected by outputs; and the ultimate impacts which measure long-term achievement of the goals that have been set for the landscape (OECD-DAC 2002). Due to the dynamism of landscapes and the stakeholders operating within them, there is a fundamental requirement for metrics along this entire continuum of effects. Output and outcome metrics must derive directly from the interventions. Impact metrics must then be derived from the theory of change and must measure the extent to which the agreed long-term goals are being achieved. We acknowledge that there will be challenges attributing outcomes to interventions. We recognize that a range of evaluation methods might be used to test the efficacy of interventions, but investment in landscape-level evaluation science will be necessary to improve our ability to assess effectiveness and learn (Stern et al. 2012).

Practitioners who implement landscape approaches must give careful consideration to selecting metrics which assure the integrity of the process of engagement and negotiation amongst stakeholders. The process metrics outlined below echo the ten principles of a landscape approach (Sayer et al. 2013), and their application would ensure quality process management. The proper observation of the processes will lead to the correct identification of outcome and impact metrics as defined by the theory of change.

Monitoring process management

Process is the main driver of learning and adaptation in the early years of any landscape-scale initiative. The process of a landscape approach needs to be transparent and stakeholders need to understand the legitimacy and justification for a course of action (Sayer et al. 2013). Revisions of strategies, learning, and adaptation should arise from multiple sources of feedback throughout the process. Process metrics are fundamental for providing feedback to guide adaptive management. Good process management is essential for overcoming the institutional and human resource challenges in facilitating landscape change. Process management should be monitored using the six features shown in Fig. 2.

1. *Negotiation and communication of clear goals* The definition of clear goals should be a stakeholder-driven process and will require skilled facilitation. The independence of the facilitation process is often a challenge. The lead institutions or those controlling resources may select facilitators and unwittingly influence the process to favor the outcomes that they prefer. Genuinely independent facilitation is rarely achieved. Different stakeholders have different interests and often conflicting goals, making the definition of universally accepted goals difficult (Balint et al.

2011). The negotiation of goals is necessary to identify impact metrics. Annual reflection should allow for changes in goals to be negotiated and agreed amongst stakeholders. Metrics are needed for each stage of the process of setting and adapting goals.

2. *A clear and agreed theory of change* The complexity and inherent unpredictability of change in the multiple dimensions of a landscape pose special problems for theory of change methods. However, we believe that rigorous application of such methods is fundamental. A valid theory of change is built upon analysis of past trends, the exploration of scenarios, and understanding of drivers of change. It must be produced and agreed upon through a multi-stakeholder process that brings together all sources of knowledge about the landscape. Theories of change must come from a sound understanding of the social and policy context needed to stimulate positive change. Historical change analysis, scenario visualization, simulation analysis, and other tools can be used in the production of a theory of change (Boedhihartono 2012). In developing a theory of change, key milestones and processes to achieve the goals must be identified—these should provide the basis on which process and outcome metrics are identified.
3. *A rigorous and equitable process for continuing stakeholder engagement* The landscape approach requires a high level of rigor in equitable engagement of all stakeholders in data collection and decision-making processes. Engagement is essential for feedback to inform learning and as the main vehicle for building the capacity of stakeholders to understand landscape processes. Regular stakeholder meetings, the most common form of engagement, may not achieve equitability, because one or a small number of the more vociferous interests can dominate these meetings (German et al. 2007; Balint et al. 2011). The use of panels of local people who are consulted periodically to assess their perceptions of changes in their livelihoods and their environment is an under-utilized approach. Participatory monitoring may also be effective (Chambers 1994; Manetti 2011; Endamana et al. 2010), but is costly and difficult to implement. Metrics must be agreed to capture each stage of the process of stakeholder engagement.
4. *Connection to policy processes and key actors* Explicit connections to policy processes at local, national, and global levels are essential in landscape approaches. Progress in achieving these connections should be tracked. Quantifying the number of public–private actors that use new incentive mechanisms or market models that explicitly promote improved landscape outcomes are possible metrics. This would measure the extent to which the landscape approach is reaching key actors.
5. *Effectiveness of governance* Governance failures remain the fundamental challenge that most landscape approaches are facing and rigorous public discussion of governance metrics will be essential (Dale et al. 2013; Mansourian 2016). Governance metrics can measure the effectiveness of institutions, their connectivity, and the extent to which they reflect the views of, and are trusted by, the full range of actors in the landscape.
6. *Transparency* Transparency is necessary for achieving landscape-level outcomes and is required for building trust in the management process and leadership (Gupta 2010). Comprehensive and rigorous spatial information systems will be needed to underpin landscape approaches. Measurement should focus on progress in ensuring that maps, data, publications, and processes are of adequate quality, are in the public domain, and are pro-actively communicated to all concerned people (Rosa et al. 2014). The existence of open access principles applicable to data collection and storage is a fundamental condition.

Outcome metrics

Outcome metrics are inevitably much more diverse and context specific. Once defined, outcome indicators can be assessed using standard and widely used methods. The extent to which the outcomes have impact on the ultimate goals of the intervention will only become clear over time. Impact metrics should be re-examined during the periodic reflections and learning events that must accompany all landscape approaches. Most of the existing outcome and impact metrics employed by conservation and development organizations are not designed for assessments at a landscape-scale. They are ill-equipped to deal with trade-offs between conservation and development, and struggle with combining effectiveness of individual interventions with status measures of the whole landscape. In an attempt to fill this gap, Eco-Agriculture Partners and Cornell University developed the Landscape Measures framework, which distinguishes between four broad goals of landscape approaches. These goals can be used for the selection of outcome metrics (Buck et al. 2006):

1. *Conservation*: The landscape conserves, maintains, and restores biodiversity and ecosystem services. This requires the maintenance of the diversity of species and habitats that comprise the landscape. This diversity will be important in enabling the landscape to adapt to changing conditions, for instance to climate change.

2. *Production*: The landscape provides for the sustainable production of crops, livestock, fish, forest, and wild edible resources. The value chains that enable these resources to be exploited for human benefit must be maintained or enhanced.
3. *Livelihoods:* The landscape sustains or enhances the livelihoods and well-being of all social groups who reside there. Social capital and the interests of minorities and marginal groups living in the landscape must be maintained or enhanced.
4. *Institutions*: The landscape-scale institutions support the integration of conservation, production, and livelihood functions. The capacity of institutions to do this effectively can be assessed by a range of metrics, including the existence of clear and secure property rights—a goal of many landscape approaches—and the functioning of intermediary or boundary institutions (Clark et al. 2011).

Outcome and impact metrics might also include cross-cutting criteria related to socio-ecological resilience, adaptation to climate change, and the mitigation of greenhouse gas emissions. The final selection of outcome and impact metrics will depend on the theory of change, which will, in turn, depend on negotiations about goals among different stakeholders in the landscape.

Conclusions

The world is confronting major challenges in improving human well-being while simultaneously maintaining the natural resource base upon which future societies will depend. Significant funding is being deployed to meet these challenges in local jurisdictions, watersheds, and other sub-national "landscapes". Landscape approaches are the most recent in a long series of attempts to achieve multiple outcomes through spatially defined interventions, many of which have fallen out of favor, because their effectiveness could not be demonstrated (Sayer and Campbell 2004). Past attempts to establish systems of metrics have failed because of a lack of clarity of goals, short time horizons of donors, and the lack of real incentives for practitioners. Funding and expertise are often not available to sustain monitoring efforts for long enough to detect impacts, facilitate learning, and improve frameworks and processes. Yet, the need remains to build evidence to demonstrate the effectiveness of landscape approaches. Given the urgency and scale of the problems they tackle, the lack of evidence of effectiveness is a cause for concern. Agencies that embark upon landscape approaches should recognize that as the objectives of landscape management become more complex and multi-stakeholder coalitions assume control, it will be necessary to measure new variables in new ways. Measuring effectiveness will be costly and time consuming. Citizen science may provide some low cost measurement opportunities and institutions may have to bear the cost of initiating and nurturing citizen science. Local knowledge, learning, and engagement are fundamental to success and citizen science has a key role in driving this (Sayer et al. 2015). If agencies are unable to provide the required investments to measure their effectiveness, they should recognize that what they are doing cannot be accurately described as a landscape approach. A fully considered landscape approach must be underpinned by the rigorous development of a theory of change supported by metrics to measure progress along impact pathways. Theories of change should enable the identification of simple metrics that can provide practitioners with evidence to verify that effective process is underpinning landscape-scale interventions. If we are to realize the full potential of landscape approaches to address major social and environmental challenges, we must apply rigorous theory of change methodologies, ensure effective processes, define clear goals, ensure continuity of funding, and deploy appropriate multi-disciplinary skills to measure metrics at all stages along the impact pathway.

Acknowledgements This paper resulted from a meeting held in North Queensland, Australia. Funding for the meeting was provided by the Center for International Forestry Research, Bogor, Indonesia, and the Center for Tropical Environmental and Sustainability Science of James Cook University, Cairns, Australia. We thank workshop participants and three anonymous reviewers.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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