



Transdisciplinary partnerships for sustainability: an evaluation guide

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Abstract

Transdisciplinary research, in which academics and actors from outside the academy co-produce knowledge, is an important approach to address urgent sustainability challenges. Indeed, to meet these real-world challenges, governments, universities, development agencies, and civil society organizations have made substantial investments in transdisciplinary partnerships. Yet to date, our understanding of the performance, as well as impacts, of these partnerships for sustainability is limited. Here, we provide a guide to assess the performance and impacts of transdisciplinary partnerships for sustainability. We offer key steps to navigate and examine the partnership process for continuous improvement, and to understand how transdisciplinary partnership is contributing to sustainable futures.

Keywords Impact evaluation · Knowledge co-production · Performance assessment · Sustainability science · Transdisciplinary

Introduction

This paper aims to advance evaluation of transdisciplinary partnerships for sustainability. We argue that progress in this area is urgently needed and can be realized through an approach which is comprehensive and integrative, directing attention to both the means and ends of transdisciplinary partnerships for sustainability. Addressing contemporary sustainability challenges requires transdisciplinary research in which academics from different disciplines collaborate with non-academic actors to co-produce knowledge and pursue actionable solutions (Brandt et al. 2013; Holzer et al. 2018; Lang et al. 2012). This message has been made clear by funding organizations, international science consortiums,

and sustainability researchers (National Academies of Sciences, Engineering, and Medicine 2020; Norström et al. 2020).

The idea of partnership has received considerable attention and widespread use in both colloquial and scholarly lexicons. As with many popular ideas, the term is often imprecisely used and variously understood (Brinkerhoff 2002; Drahota et al. 2016; Luger et al. 2020; Plummer et al. 2021). Broadly, partnerships are a “...dynamic relationship among diverse actors, based on mutually agreed objectives, pursued through a shared understanding of the most rational division of labour based on the respective comparative advantages of each partner” (Brinkerhoff 2002, p. 21).

Our focus is on transdisciplinary partnerships for sustainability, which involve academics from different disciplines and non-academics engaging in problem-solving research and application, using multiple forms of knowledge, experience, and resources, to catalyze the transition towards sustainability (Bieluch et al. 2017; Kates et al. 2001; Lang et al. 2012; Wiek et al. 2012). These partnerships, which customarily involve higher education institutions (HEIs) and non-academic actors, afford a mechanism for operationalizing transdisciplinary solution-based inquiry at the science–action nexus (Bieluch et al. 2017; Spangenberg 2011; Yarime et al. 2012). Transdisciplinary partnerships for sustainability “bring together interdisciplinary groups of scientists with non-academic actors (e.g., government agencies,

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industries, and non-profit organizations) to participate in problem-based partnerships” (Bieluch et al. 2017, p. 88).

A central feature of these partnerships is the co-production of knowledge to address complexity and uncertainty. We define knowledge co-production here as a collaborative process that engages a plurality of knowledge sources and types (e.g., western science, local and Indigenous knowledges, knowledge held by policy specialists) to build an integrated or systems-oriented understanding of a problem, and to support actionable outcomes (Armitage et al. 2011; Norström et al. 2020). Knowledge co-production is linked to processes of social or collective learning within partnerships (Turnhout et al. 2020), and draws attention to the inevitable politics of knowledge that influences collective efforts to engage with sustainability challenges (Blythe et al. 2018; Fritz and Binder 2020). Understanding the performance and impacts of partnerships for sustainability must engage with the social relational dimensions of knowledge and knowledge production, as well as the implications for collective learning and action.

Despite substantial support for—and investments in—transdisciplinary partnerships, it remains difficult to gauge whether progress is being made towards sustainability through these initiatives. Determining if progress is being made requires evaluation, but there is limited consensus on how to go about it. Examples of transdisciplinary sustainability science evaluation are relatively few, and those that have been documented come with accompanying calls for more and widespread attention to this important issue (e.g., Backstrand 2006; Blackstock et al. 2007; Buizer et al. 2015; Holzer et al. 2018; Wiek et al. 2012; 2014). Most existing examples derive information from specific contexts or case studies (Agol et al. 2014; Marans and Callewaert 2017) and the transferability of these valuable insights to the broad range of sustainability challenges remains uncertain.

There are a few exceptions to case-based insights, which include more considered evaluation of transdisciplinary sustainability science partnerships. For example, Blackstock et al. (2007) draw on multiple bodies of literature (e.g., sustainability science, participatory research, and evaluation of partnership processes) to undertake a summative evaluation of participatory research in sustainability. Lang et al. (2012) identify evaluation in relation to their proposed ideal transdisciplinary research process, and highlight the need for evaluation to occur throughout the entire process as well as encompass scientific and societal impacts. While these works recognize the role and importance of considering process in evaluation, they do not offer a systematic approach for it. In contrast, Wiek et al. (2012) developed an analytical–evaluative framework to appraise five sustainability projects. The projects were found to be successful in terms of problem focus and transformational research methodology, but lacking in terms of stakeholder participation,

action-oriented results, and substantive impacts. This framework is also exclusively tailored to the particularities of sustainability science and employed by experts. Overall, there remains a need for a comprehensive and integrated approach to evaluation of transdisciplinary partnerships for sustainability, with attention given to both their means and impacts.

This paper starts by outlining the salient challenges related to evaluation in sustainability-oriented fields and transdisciplinary partnerships. We then, in turn, address key aspects of assessing performance (the actions and processes involved in carrying out or accomplishing objectives) and evaluating impacts (the causal outcomes for people and nature). In so doing, we develop a heuristic guide of considerations by those involved with evaluating transdisciplinary partnerships for sustainability. This two-pronged approach contributes to bolstering capacity to navigate sustainability challenges, ensuring knowledge generated is legitimate, salient and credible (*sensu* Cash et al. 2003), and ultimately, enabling transdisciplinary partnerships contribute to sustainable futures.

Challenges to evaluating transdisciplinary partnerships for sustainability

Evaluation is defined as “the systematic and objective assessment of an on-going or completed project, programme or policy, its design, implementation and results” (DAC 2002, p. 21). Among sustainability-oriented fields, evaluation is integral to effective conservation (Ferraro and Pressey 2015), environmental management and governance (Bennett 2016; Stem et al. 2005), sustainability science (Blackstock et al. 2007; Lang et al. 2012), translational ecology (Hallett et al. 2017; Lawson et al. 2017) and coupled social–ecological systems (Gurney et al. 2019; Holzer et al. 2018; Plummer et al. 2017a). Evaluation has implications for evidence-based decisions concerning the sustainable use of natural capital and ecosystem services (Guerry et al. 2015) and the promotion of societal well-being (Hicks et al. 2016). For example, accessible tools for evaluation can be used to develop a scientific evidence-based that links policies and decisions to impacts on natural capital and ecosystem services, as well as human well-being (Guerry et al. 2015). Further, evaluation is relevant to unfolding debates about allocation of funding to higher education institutions (HEIs; Jongbloed et al. 2018) and the justification of sustainability interventions in relation to public interests (Chelimsky 2014; Cooke et al. 2020). Specifically in relation to performance-based funding, attention has moved away from measuring research and education (Muse 2018), towards the need to demonstrate other contributions and benefits to society through outcomes and impacts, such as those produced by partnerships (e.g., environmental enhancement; Jongbloed et al. 2018).

Evaluating transdisciplinary partnerships for sustainability is a formidable undertaking. In this section, we identify and consider challenges to their evaluation. These matters of contention are inherent in transdisciplinary partnerships for sustainability as well as logistics to their evaluation (Belcher and Hughes 2020; Belcher et al. 2016; Gaziulusoy et al. 2016). Our discussion is guided by three main and interrelated considerations of what to evaluate, who should evaluate, and how to evaluate.

First, transdisciplinary partnerships for sustainability are experiencing considerable growth in peer-reviewed studies (Brandt et al. 2013). However, the character of precisely *what* is to be investigated in evaluating these partnerships is itself a very much open and often discussed subject. At the outset, it is imperative to recognize that “all approaches assessing research impact are underpinned by particular philosophical assumptions, and there is no ‘best procedure’” (Norström et al. 2020, p. 187). Evaluation reflects epistemological assumptions about what constitutes knowledge, how it is produced, and how it should be applied (Moon et al. 2021). In this paper, we follow recasting it in a complex adaptive systems worldview (see Innes and Booher 1999; Connick and Innes 2003; Plummer and Armitage 2007). Complex adaptive systems are defined by properties of “... (1) diversity and individuality of components, (2) localized interactions among those components, and (3) an autonomous process that uses the outcomes of those interactions to select a subset of those components for replication or enhancement” (Levin 2002, p. 4). Studying complex adaptive systems through interdisciplinary approaches in natural and social sciences is significant (Lansing 2003), a way to bridge the two (Ison et al. 1997), and inclusive of multiple theoretical perspectives (Blythe et al. 2017). With regard to the latter, our work is framed by social-ecological resilience thinking (*sensu* Folke 2016; Gunderson and Holling 2002; Berkes et al. 2003) and associated scholarship.

What to evaluate in transdisciplinary partnerships for sustainability is complicated and contested for multiple reasons. Fundamentally, the integration of knowledges, disciplines and experiences pose an inherent challenge to all transdisciplinary evaluation (Gaziulusoy et al. 2016; Hansson and Polk 2018). Transdisciplinary partnerships are not driven by a single goal (Klein 2008) and actors usually vary in their expectations of what such partnerships ought to achieve (Gaziulusoy et al. 2016; Klein 2006). As Steelman et al. (2021, p. 633) recently observe in the context of sustainability, “the challenges of transdisciplinary work lie in respecting, balancing, bridging, reconciling and/or sometimes integrating differing knowledge systems, values and processes among disciplines and with partner communities, which translate into potentially differing assumptions about what constitutes effective interaction and credible knowledge generation”.

Whereas evaluation has typically concentrated on the sustainable development triumvirate (ecological, social, economic; e.g., Agol et al. 2014; Wiek et al. 2014; see also Blackstock et al. 2007; Lang et al. 2012), the processes through which impacts are realized are increasingly being emphasized (e.g., Lang et al. 2012; Wiek et al. 2012). Specific measures ‘appropriate’ to gauge impacts as well as processes are now the subject of vibrant scholarly debate (e.g., Lang et al. 2012; Wiek et al. 2012; 2014).

Criteria and indicators are challenging to establish in practice because of the involvement of actors from various disciplines and practices (Belcher et al. 2016; Hansson and Polk 2018). In contrast to many disciplines with well-established criteria for evaluation, transdisciplinary research is more context-specific and problem-oriented (Hansson and Polk 2018). The integrative nature of transdisciplinary partnerships may also give rise to evaluation criteria which are contradictory or conflicting (Gaziulusoy et al. 2016; Klein 2006), variously understood (Gaziulusoy et al. 2016), and prioritized differently.

Who should conduct evaluation? Conventional evaluation is conducted by external actors (e.g., consultants, professional evaluators, academics, etc.). Conventional or external evaluation remains the prevailing approach (McDuff 2001), but has been the subject of scrutiny for decades. Commonly identified shortcomings include narrowly defined questions by external agents with little relevance, collection of information misaligned to the needs of participants, and results which are inapplicable or unused (e.g., McDuff 2001; Trimble and Plummer 2018; Zukoski and Luluquisen 2002). In contrast, participatory evaluation is carried out by the individuals involved. Participatory evaluation may be more appropriate for sustainability initiatives as it emphasizes active involvement of and responsiveness to the individuals involved, sensitivity to local context (knowledge, values, culture), capacity building, and an effort to engender two-way learning (e.g., Blackstock et al. 2007; Sterling et al. 2017; Trimble and Plummer 2018). While it matters who conducts evaluation, it is important to acknowledge that conventional and participatory evaluation are not discrete domains (Campilan 2000), and the two approaches emphasize different aspects and may even be combined (Trimble and Plummer 2018; Zukoski and Luluquisen 2002).

The inherent challenges of transdisciplinary evaluation and transdisciplinary partnerships for sustainability identified above necessitate careful consideration of multiple perspectives, knowledge systems, and types of evidence (Tengö et al. 2014). Layers of complexity in transdisciplinary partnerships are added as actors reconcile, integrate or open epistemologies (Cornell et al. 2013; Belcher et al. 2016; Blythe et al. 2017). Acknowledging that different epistemic communities hold credible and legitimate knowledge is a critical starting point for transdisciplinary partnerships

(Norström et al. 2020). Yet, transdisciplinary partnerships are often still broadly situated in contexts shaped by dominant culture institutions (i.e., universities modelled on western paradigms of knowledge and universal truths). Navigating these spaces (let alone accessing them) is neither straightforward nor easy, and the development of meaningful partnerships in these settings will require, at a minimum, fundamental changes to funding, capacity development and commitments to equity, diversity and inclusion (M's-it No'kmaq et al. 2021; Trisos et al. 2021).

Indeed, transdisciplinary partnerships for sustainability science also require attention to the issue of power imbalances (Norström et al. 2020; Moon et al. 2021). Meaningful collaboration, co-leadership, and knowledge co-creation which are characteristics of an ideal transdisciplinary research process (Lang et al. 2012; Fritz and Binder 2020) may insinuate balanced power relationships among the actors, but in practice none are neutral. Uneven dimensions of power are inherent in transdisciplinary partnerships and are not often addressed or considered (Blythe et al. 2018; Fritz and Binder 2020). As Fitz and Biner (2020, p. 2) observe, “desired sustainable futures and their associated pathways are hotly contested, and recognising participation as relational processes that are co-produced with the socio-political context demands the disclosure of the negotiations, conflicts, and power dynamics that shape these processes”.

A third, closely related question is *how* to evaluate transdisciplinary partnerships for sustainability? The specific means by which evaluation of sustainability and allied aims (e.g., conservation, stewardship, environmental management, etc.) may occur are diverse and determined by bounding, timing, purpose and focus (see Blackstock et al. 2007). However, the commonalities and complementarities among the approaches are not well articulated (see Mascia et al. 2014). Evaluation, for example, is often used interchangeably with assessment in the context of partnerships, although they are distinct and complementary (see Blackstock et al. 2007; Brinkerhoff 2002).

While many disciplines have customary and accepted processes for evaluation, transdisciplinary research is more context-specific and problem-oriented (Hansson and Polk 2018), which requires unique approaches (Gaziulusoy et al. 2016). Despite the risk of being redundant, it is important to recognize that the inherent challenges to all transdisciplinary evaluation (Gaziulusoy et al. 2016; Hansson and Polk 2018) described above also pertain to how it occurs. Consequently, replicability is difficult and quality criteria to guide evaluation are wanting (Belcher et al. 2016; Gaziulusoy et al. 2016).

Practical and logistical matters present dilemmas for how to evaluate transdisciplinary partnerships for sustainability. Communication can be difficult, especially when actors hold different disciplinary perspectives (Cheruvilil et al. 2014)

and means of linguistic expression (Jahn et al. 2012). Individuals may struggle to meet the expectations of the partnership and their own organization as performance criteria can be very different (Boon et al. 2014). A specific related issue is the expectation of researchers to produce knowledge that is practical or useful (Polk 2015), while non-academic project partners may have limited capacity or commitment to the project (Boon et al. 2014). Time pressure is a perennial issue (Polk 2015), but amplified in partnerships set out to solve societal issues evolving in real time (e.g., Gaziulusoy et al. 2016).

In the sections that follow, we detail how performance assessment and impact evaluation address these challenges, and in concert enhance the success of transdisciplinary partnerships for sustainability.

Assessing the performance of transdisciplinary partnerships for sustainability

Sustainability requires problem-solving research, which transcends disciplinary boundaries and bridges the science–society divide (Blythe et al. 2017; Brandt et al. 2013; Holzer et al. 2018; Lang et al. 2012; Wiek et al. 2012). Commonly, transdisciplinary partnerships for sustainability involve HEIs and as such, they ought to embody the established elements of HEI–community partnerships. In drawing upon recent HEI–community partnership literature, Plummer et al. (2021) summarized three main aspects of successful partnerships: dedicated inputs, meaningful processes, and resulting outcomes.

Inputs entail the contributions dedicated to the partnership by the two or more parties (e.g., financial and human resources, etc.). The process characterizes how the partnership operates (e.g., shared decision-making, effective communication, etc.). Finally, outcomes include what is produced as well as the impacts for those directly involved in the partnership (e.g., publications, satisfaction with the experience, learning). In extension, meaningful collaboration and knowledge co-creation, learning, and adaptation are specific hallmarks of transdisciplinary partnerships for sustainability (e.g., Armitage et al. 2008; Clark and Dickson 2003; Fang et al. 2018; Kates et al. 2001; Lang et al. 2012, 2017; Wiek et al. 2012). As Jackson and Kassam (1998, p. 2) observe, “it is precisely by sharing the different types of knowledge they bring to the evaluation process—and the new knowledge they create together—that citizens and professionals can generate analysis that will render interventions more capable of yielding significant and lasting results”.

Performance assessment determines status in relation to an archetype, with the intention of closing the gap between the present state ‘on the ground’ and the ideal (Gupta et al. 2007; Plummer et al. in progress). As such, performance



Performance assessment

Step 1. Clarify expectations: Partners must be clear on their roles and responsibilities, ensuring that each understands and agrees upon the expectations for them in the partnership as well as the results anticipated.

Step 2. Conduct baseline performance assessment: Assess performance early in the partnership (suggest end of year one) to capture the initial (baseline) state of performance and establish a benchmark.

Step 3. Reflect on baseline assessment: Data collected from performance assessment should be collaboratively examined and reflected upon in the spirit of learning. Indicators of success should be celebrated and those needing improvement carefully considered. This step initializes a shared learning process by which partners with different perspectives develop shared understanding of a problem explore solutions.

Step 4. Initiate relevant changes: Take action in partnership operations in order to address identified deficits and/or enhance areas.

Step 5. Continue to monitor performance: Repeat steps 1–4 on a regular basis. Incorporating performance assessment as part of routine monitoring enables tracking progress over time towards desired partnership performance.

Textbox 1 How-to guide for incorporating performance assessment in transdisciplinary partnerships for sustainability

assessment of transdisciplinary partnerships for sustainability intends to capture the present state of an initiative in relation to the aforementioned features. The process of assessment involves a number of activities, including defining and comparing the gap between current and desired performance, examining the problem or problems that have created this gap, understanding the factors contributing to the current conditions, determining how specific aspects can be changed to produce the desired conditions, as well as developing an evidence base for decision-making and strategies (Estrella and Gaventa 1998; Gupta et al. 2007; Marzano et al. 1993). Assessment is accomplished through the systematic collection of data on specified indicators, to provide insight into the current performance of the partnership itself (Caplan et al. 2007; Estrella and Gaventa 1998; Onyango 2018; Stem et al. 2005). In the spirit of learning and continuous improvement, assessment takes place continuously throughout the life of a partnership. This iterative process allows for reflection and learning, which can ultimately help determine any areas or aspects within the partnership that need further improvement (Estrella and Gaventa 1998), and in turn, produce better outcomes or impacts.

Drawing upon recent theoretical advances and applied experiences with HEI-community partnerships, we identify

five essential steps to effectively assess transdisciplinary partnership performance for sustainability (see Textbox 1). The first step to performance assessment coincides with the partnership initiation, in which the prospective partners communicate their interests, motivations, and resources (Plummer et al. in progress). This may stem from or build upon the goals outlined in a written document used to establish the partnership. Clarification at this stage includes the individual roles and responsibilities, as well as transparent and open communication about expectations. It is important to have mutual understanding and agreement on these aspects at the outset of a partnership, while also acknowledging the inherent dynamics and potential need to revisit certain aspects (McNall et al. 2009).

Next, an assessment should be undertaken early in the partnership to capture the initial state of performance. This establishes a baseline from which subsequent assessments can be benchmarked (Estrella and Gaventa 1998). While there is not a singular prescribed time for assessment, doing so annually permits sufficient time for steps which follow. Data should be collected using indicators which provide insight into the aspects of the partnership as well as activities. Methods for data collection may vary, but should include both qualitative and quantitative indicators.

A specific example stemming from HEI literature with transferability to sustainability is the HEI–Community Partnership Performance Index (HCPPI). This tool sets out 47 accurate and validated indicators for measuring/tracking inputs, processes, and outcomes for successful partnerships (Plummer et al. 2021). For example, input indicators can include adequate financial resources as well as in-kind human resources, the compatibility of the partners, etc. Process indicators can include an appropriate amount of communication between partners, confidence in a partner’s actions, etc. Examples of outcome indicators include the number of products produced in line with expectations, partners are performing well, etc. (see Plummer et al. 2021 for full list of indicators).

The third step involves reflecting on the data collected from the performance assessment. Collaborative reflection allows entities to highlight and celebrate successful aspects of the partnership, as well as recognize areas that need improvement. The role of reflection in sustainability is seen as beneficial for increased accountability, effective management of actions, knowledge building and learning (Blackstock et al. 2007; Spagenberg 2011; Trimble and Plummer 2019). Importantly, including all entities in the data collection and reflection process is critical to accurately gauge performance as well as learn from feedback to make improvements (Srinivas et al. 2015; Trimble and Plummer 2019). This also provides an opportunity to manage and negotiate expectations, and ensure there is mutual understanding of partnership activities and goals.

A key characteristic of sustainability as a discipline is “linking knowledge to action” (Fang et al. 2018, p. 6). In acknowledging recent critiques of differing ideas on how knowledge and action should be linked (West et al. 2019; Caniglia et al. 2021), we note that knowledge exploration and practical application may not be linear and can occur in dynamic ways using a broad range of relevant knowledge or approaches (West et al. 2019). Therefore, the fourth step requires taking action to address inadequacies or deficiencies in the partnership—closing the gap between the present state and the ideal. Learning from experience ultimately creates the conditions conducive to action and change (Estrella and Gaventa 1998). With the necessary information needed to adjust aspects of the partnership in hand, the entities need to come to a collective decision about appropriate revisions.

The final step involves iteratively repeating the steps and monitoring results. Incorporating performance assessment as part of routine monitoring enables tracking progress over time towards desired partnership performance (Estrella and Gaventa 1998). As this process is repeated, opportunities will emerge for learning which will benefit the current partnership, as well as future collaborations.

Evaluating the impacts of transdisciplinary partnerships for sustainability

Impact evaluation is concerned with the causal effects of an intervention, and involves measuring the difference made by considering what happened with the intervention to what would have happened without it (i.e., the counterfactual; Ferraro and Hanauer 2014). It figures prominently in many fields related to human well-being (e.g., education, health, development). Notwithstanding a few recent exceptions (Lavery et al. 2021; Norström et al. 2020), impact evaluation in environment-related research and practice (e.g., conservation, sustainability, resource management) lags significantly behind (Ferraro and Patanayak 2006; Guerry et al. 2015; Plummer et al. 2017a).

Evaluating the impacts of sustainability initiatives is notoriously difficult. Information required is usually missing, inadequate or expensive to obtain; comparative conditions are often required at landscape scales; confounding factors, time lags and complex feedbacks complicate policy impacts; and, complex and not entirely understood causal links make discerning attribution difficult (Agrawal 2014; Guerry et al. 2015). A further key challenge to gauging impacts is the need to consider self-organization properties and cross-scale effects of complex adaptive systems (Connick and Innes 2003; Plummer et al. 2017a).

Over the past decade, a number of studies have provided guidance on undertaking evaluations of the social and ecological impacts of environment-related interventions (e.g., Adams et al. 2019; Ferraro and Hanauer 2014; Gurney et al. 2019; Pressey et al. 2017; Woodhouse et al. 2015). Several key steps to impact evaluation are laid out in these studies and synthesized here (see Textbox 2).

First, identifying the evaluation question of interest, including elucidating anticipated changes to the social–ecological system arising from the intervention being evaluated (Adams et al. 2019; Ferraro and Hanauer 2014). Second, developing a conceptual model of the system of interest that articulates the hypothesized causal mechanisms linking the intervention with the anticipated social–ecological changes. Often undertaken using a theory of change approach, this conceptual modelling also entails identifying the key assumptions underpinning the hypothesized mechanisms and the other events and/or processes concurrent to the intervention that may affect anticipated social–ecological outcomes. For example, Gurney et al. (2019) undertook these first two key steps in developing their social–ecological systems monitoring framework for coral reef fisheries management. To meet reef managers’ need to demonstrate social and ecological impacts to donors, and to learn within and across country programs as to what management actions work where and



Impact evaluation

Step 1. Identify key questions: Identify the key evaluation question of interest, including what changes to the social-ecological system are anticipated as a result of the transdisciplinary co-production process.

Step 2. Develop conceptual model: Elucidate the hypothesized causal mechanisms linking the transdisciplinary process with social-ecological system changes. Determine the assumptions underpin these causal mechanisms, including effects of other events and/or processes concurrent to the transdisciplinary co-production process.

Step 3. Consider heterogeneity: Assess the possibility of heterogeneous impacts according to: a) the outcome examined; b) the time at which the evaluation is undertaken; c) the degree of aggregation (e.g. for social impacts, individual, household, community etc); and d) demographic characteristics.

Step 4. Select evaluation design: Determine whether the indicators and evaluation method are appropriate given available resources and the saliency, legitimacy and credibility of the evidence produced by alternative methods for the various actors involved.

Step 5. Implement evaluation and manage partnership adaptively: Ideally, impact evaluation should commence as early as possible during the partnership in order to establish a baseline assessment. As the evaluation proceeds and information about impacts becomes available, sustainability activities undertaken by the partnership should be adjusted through an adaptive management process.

Textbox 2 How to guide for undertaking impact evaluation in transdisciplinary partnerships for sustainability

why, two evaluation questions were developed to articulate clear objectives for the monitoring framework, a critical but often neglected step in conservation monitoring (Posingham et al. 2012). These were, “how do management interventions affect the social and ecological state of coral reef systems?”, and “what are the contextual and institutional conditions associated with changes in the social and ecological state of coral reef systems?” Next, theories of change were developed for different management actions, which involved mapping causal links between key management actions (e.g., promote local compliance monitoring), outcomes (e.g., fairness of management impacts, fish biomass), intermediate outcomes (e.g., level of compliance) and the conditions or assumptions underpinning each link (e.g., rights to sanction rule breakers held by local community).

The third key step to undertaking impact evaluation is considering sources of heterogeneity in impacts (Ferraro and Hanauer 2014; Woodhouse et al. 2015). Impacts can vary depending on, for example, the time elapsed since the intervention was implemented (e.g., Beauchamp et al. 2018), which social or ecological dimension is considered (e.g., Gurney et al. 2014), and how units in the social–ecological

system are aggregated. In regard to the latter, for social systems for example, impacts can differ by key social subgroup (e.g., gender, ethnicity; Gurney et al. 2015), as well as which scale of social organization the unit of analysis corresponds to (e.g., individual, household, community).

The fourth key step to impact evaluation is selecting the appropriate evaluation design. There are a range of quantitative and qualitative approaches to causal inference, which identify the difference made by an intervention through consideration of the counterfactual in different ways (Woodhouse et al. 2015). Recently, experimental or quasi-experimental approaches have been at the center of many conservation scientists and decision-makers’ calls for impact evaluation of environmental interventions due to their promise in delivering precise estimates of impact (Pynegar et al. 2019). These quantitative methods have arisen from economics and employ a counterfactual approach via consideration of controls units identified through randomization (experimental) and quantitative or qualitative matching (quasi-experimental). For example, Ferraro and Hanauer (2014) use remote sensing data in a quasi-experimental impact evaluation design to examine the mechanisms through which protected areas affect poverty in Costa Rica.

However, the application of experimental or quasi-experimental evaluation approaches to environmental interventions can be challenging due to, for example, the significant technical and financial resources often required, bias towards dimensions of the social system that are easily quantified, and the trade-off often involved between achieving the sample size required and capturing the multi-dimensionality of social–ecological systems (Agrawal 2014; Gurney et al. 2015). Thus, the full range of approaches to causal inference should be considered in selecting an evaluation design; these include theory-based, statistical, case-based, and participatory designs (see Woodhouse et al. 2015). Participatory designs, whereby those involved in an intervention systematically assess changes themselves, are particularly pertinent for evaluating transdisciplinary partnerships. Such approaches are advocated for their comprehensiveness (Gouveia et al. 2004), value in difficult situations, and ability to overcome barriers of cost and time (Bennett 2016; Lund et al. 2010). On the other hand, participatory approaches are contested for lacking objectivity, reliability, and validity (Ferraro and Pattanayak 2006; Lund et al. 2010; Scott 2015), introducing confounding variables (Biddle and Koontz, 2014), and susceptibility to contextual factors (Bennett 2016; Huijts et al. 2012).

Ultimately, the appropriate evaluation design(s) depends on considerations such as the evaluation question at hand, resources available, characteristics of the intervention, the type of evidence required and by whom. Often it will be appropriate to draw on multiple approaches in single evaluation design. This strategy was employed for the Wildlife Conservation Society’s coral reef program social–ecological systems monitoring program (the Marine and Coastal Monitoring (MACMON) framework; Gurney et al. 2019). This framework, which was developed through a transdisciplinary co-production process, was designed to enable triangulation across theory-based (e.g., theories of change), case-based and statistical approaches.

By drawing on these four steps, it becomes possible to undertake the fifth, and final, step: implementation of the impact evaluation. Ideally, impact evaluation should commence as early as possible during the partnership in order to establish a baseline assessment. To evaluate the scientific and societal impact, Lang et al. (2012, p. 30) suggest questions including “are the goals [of the partnership] being achieved?” and “what additional (unanticipated) positive effects are being accomplished?” We suggest it is also critical to examine unanticipated negative effects. As the evaluation proceeds and information about impacts becomes available, sustainability activities undertaken by the partnership should be adjusted through an adaptive management process (e.g., see Armitage et al. 2009; 2011).

Reflections on enhancing progress of transdisciplinary partnerships for sustainability

Transdisciplinary partnerships for sustainability are imperative for tackling complex social–ecological challenges. Increasing importance is being placed on these partnerships, in which academic and non-academic actors with various perspectives meaningfully collaborate to co-produce knowledge and generate actionable solutions (Brandt et al. 2013; Hansson and Polk 2018; Holzer et al. 2018; Lang et al. 2012; Norström et al. 2020). Evaluation is required to determine if progress towards sustainability is being made through these partnerships (e.g., Blackstock et al. 2007; Buizer et al. 2015; Holzer et al. 2018; Wiek et al. 2012; 2014) and comprehensively appraise both aspects of process and impact (Hansson and Polk 2018).

A myriad of challenges are apparent and our discussion of them was guided by questions of what to evaluate, who should evaluate, and how to evaluate. Deliberation upon these questions surfaces their highly interdependent nature. It also reveals the extent to which matters of contention are inherent in transdisciplinary partnerships for sustainability (Belcher and Hughes 2020; Belcher et al. 2016; Gaziulusoy et al. 2016). In response, we develop and detail a guide of heuristic considerations for those involved with evaluating transdisciplinary partnerships for sustainability (Fig. 1).

The five steps outlined in Textbox 1 explicate how performance assessment can systematically be incorporated into these partnerships. Textbox 2 highlights ways in which to capture the impacts of transdisciplinary partnerships on people and the planet. Taken together, they provide a ten-step guide to evaluate the performance and impacts of transdisciplinary partnerships for sustainability (Fig. 1).

The guide responds to the need for more, systematic (consideration beyond case-based experiences), and/or comprehensive (not just outcomes) evaluation of transdisciplinary partnerships for sustainability (e.g., Blackstock et al. 2007; Lang et al. 2012; Wiek et al. 2012). Unlike a framework, which “... usually denotes a structure, overview, outline, system or plan consisting of various descriptive categories, e.g., concepts, constructs or variables, and the relations between them that are presumed to account for a phenomenon” (Nilsen 2015, p. 2), the guide follows the approach of principle or guide-based evaluation (sensu Patton 2017). It does not prescribe concepts and constructs operationalized as measures nor context-specific variables, as indicative of frameworks and disciplinary efforts (Nilsen 2015).

The guide provides a heuristic to assist all involved with navigating the myriad of challenges when evaluating

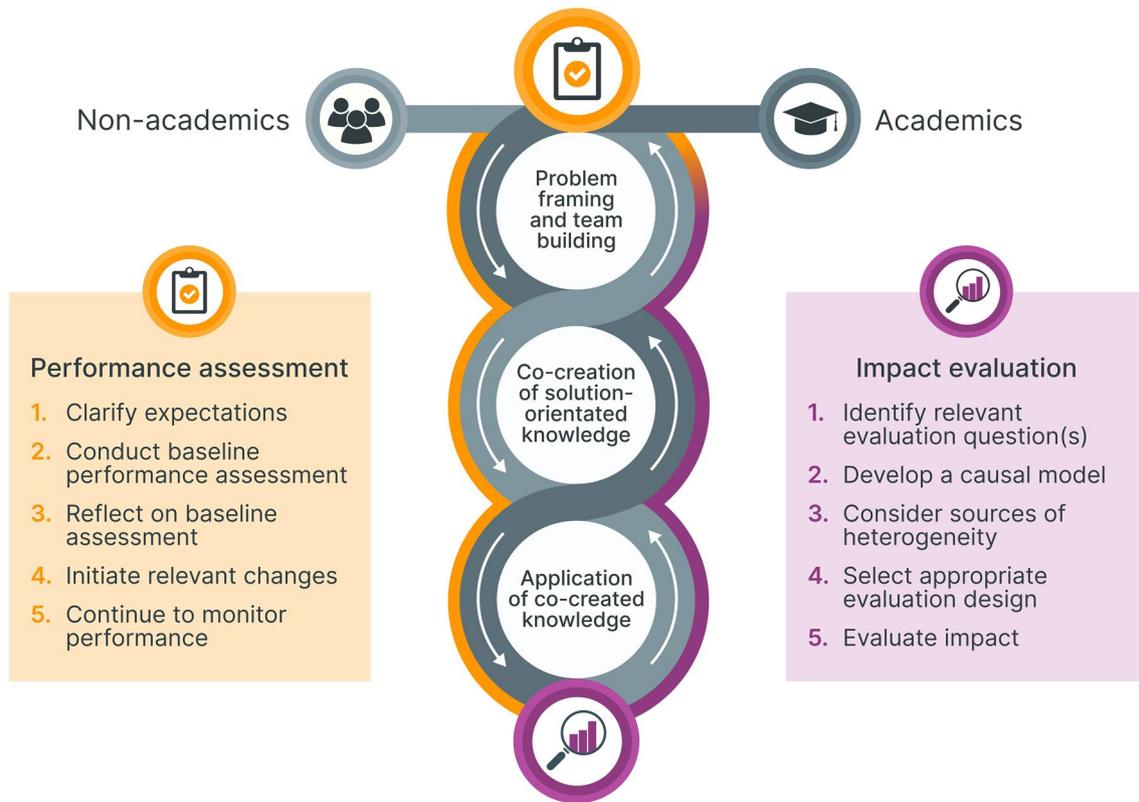


Fig. 1 Guide for the evaluation of transdisciplinary partnership for sustainability

transdisciplinary partnerships for sustainability. Engaging with these ten steps as part of a transdisciplinary co-production process will advance sustainability. Doing so from the outset is critical to ensuring information generated is legitimate, salient and credible (sensu Cash et al. 2003). This is critical to the success of knowledge co-production processes. Performance assessment and impact evaluation afford complementary feedback mechanisms upon which those engaged in transdisciplinary partnerships for sustainability can reflect, and if required, alter course. It is this very process of social learning that is necessary for sustainability (Blackstock et al. 2007; Kates et al. 2001; König 2018; Miller et al. 2014). As such, all those involved with the transdisciplinary partnership should benefit, and the sustainability initiative itself will be strengthened.

Systematically incorporating performance assessment and impact evaluation into transdisciplinary partnerships for sustainability affords insights into what works, when, and why. In particular, it provides a basis for examining causal relationships or pathways between partnerships and impacts, which are imperative for fostering sustainability, but lack empirical evidence and understanding (Guerry et al. 2015; Plummer et al. 2017b). Incorporating performance assessment and impact evaluation requires forethought, effort, and time; however, it is far from insurmountable and offers

considerable opportunities to enhance transdisciplinary partnerships for sustainability.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

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