# An integrative research framework for enabling transformative adaptation

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# An integrative research framework for enabling transformative adaptation

Matthew J. Colloff[1,2,*], Berta Martín-López[3], Sandra Lavorel[4], Bruno Locatelli[5,6], Russell Gorddard[2], Pierre-Yves Longaretti[7,8], Gretchen Walters[9,10], Lorrae van Kerkhoff[1], Carina Wyborn[11], Audrey Coreau[12,13], Russell M. Wise[2], Michael Dunlop[2], Patrick Degeorges[14], Hedley Grantham[15,16], Ian C. Overton[17], Rachel D. Williams[2], Michael D. Doherty[1,2], Tim Capon[2], Todd Sanderson[18] and Helen T. Murphy[19]

[1]Fenner School of Environment and Society, Australian National University, Canberra, Australian Capital Territory 2601, Australia

[2]Enabling Adaptation Pathways Project, CSIRO Land and Water, Canberra, Australian Capital Territory 2601, Australia

[3]Leuphana University of Lüneburg, Faculty of Sustainability, Institute of Ethics and Transdisciplinary Sustainability Research, Scharnhorststrasse 1, D-21335 Lüneburg, Germany

[4]Laboratoire d'Ecologie Alpine, CNRS – Université Grenoble Alpes, 38041 Grenoble Cedex 9, France

[5]Agricultural Research for Development (CIRAD), Avenue Agropolis, Montpellier 34398, France

[6]Center for International Forestry Research (CIFOR), Avenida La Molina, Lima 15024, Peru

[7]CNRS - Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), BP 53 38041 Grenoble Cedex 9, France

[8]INRIA–STEEP Team, 655 Avenue de l'Europe, 38334 Montbonnot Cedex, France

[9]International Union for Conservation of Nature (IUCN), Rue Mauverney 28, CH-1196 Gland, Switzerland

[10]Department of Anthropology, University College London, Gower Street, London WC1E 6BT, United Kingdom

[11]Luc Hoffman Institute, WWF International, Avenue du Mont-Blanc, CH-1196 Gland, Switzerland

[12]Centre Alexandre Koyré, 27 rue Damesme, 75013 Paris, France

[13]AgroParisTech, 16 rue Claude Bernard, 75005 Paris, France

[14]Ministère de l'Écologie, du Développement durable et de l'Énergie, 92055 Paris Cedex 15, France

[15]Conservation International, 2011 Crystal Drive, Suite 500, Arlington, VA 22202, USA

[16]Wildlife Conservation Society, 2300 Southern Boulevard Bronx, New York 10460, USA

[17]CSIRO Land and Water, Private Bag 2, Glen Osmond, South Australia 5604, Australia

[18]School of Economics, University of Sydney, New South Wales 2006, Australia

[19]Enabling Adaptation Pathways Project, CSIRO Land and Water, Atherton, Queensland 4883, Australia

*Corresponding author: Matthew.Colloff@anu.edu.au

ABSTRACT

Transformative adaptation will be increasingly important to effectively address the impacts of climate change and other global drivers on social-ecological systems. Enabling transformative adaptation requires new ways to evaluate and adaptively manage trade-offs between maintaining desirable aspects of current social-ecological systems and adapting to major biophysical changes to those systems. We outline such an approach, based on three elements developed by the Transformative Adaptation Research Alliance (TARA): (1) the benefits of *adaptation services*; that sub-set of ecosystem services that help people adapt to environmental change; (2) The *values-rules-knowledge perspective* (*vrk*) for identifying those aspects of societal decision-making contexts that enable or constrain adaptation and (3) the *adaptation pathways approach* for implementing adaptation, that builds on and integrates adaptation services and the *vrk* perspective. Together, these elements provide a future-oriented approach to evaluation and use of ecosystem services, a dynamic, grounded understanding of governance and decision-making and a logical, sequential approach that connects decisions over time. The TARA approach represents a means for achieving changes in institutions and governance needed to support transformative adaptation.

## 1. Introduction

The IPCC Fifth Synthesis Report stated it is *very likely* that surface temperature and sea levels will continue to rise and extreme weather events become more frequent (IPCC, 2014). By 2050 the global population is projected to increase from 7.2 to 9.6 billion, with mounting pressures on terrestrial, marine and freshwater resources. Global networks of commerce, technology and information have produced unstable systems that are vulnerable to uncontrollable failure, posing considerable threats to society (Helbing, 2013; Streek et al., 2016). Climate change combines with other drivers to synergise rates and extent of change to social-ecological systems. Dealing with synergistic effects of other global change drivers and climate change requires transformative approaches to adaptation.

Adaptation to global change presents a profound challenge because it requires the tackling of short- and long-term threats, changes and uncertainty that transcend sectors and scales. Over the past decade, efforts to understand the impacts of climate change on biodiversity have led to new concepts and approaches to support adaptation of biodiversity (Mawdsley, 2011; Cross et al., 2012; Reid, 2015). Conservation policy and practice have focussed on ecosystems, species and maintenance of biophysical integrity but tended to neglect institutional contexts: the people and organisations responsible for implementing adaptation (Armsworth et al., 2015). Smith (1997) emphasised the need for adaptation to be *anticipatory* rather than reactive, aimed at reducing social vulnerability to climate change and with policy criteria based on institutional attributes of flexibility, adaptability, resilience, and where benefits exceed costs. Almost 20 years later, anticipatory action has been limited. There remains a compelling need for researchers and practitioners to work together to identify how to put concepts of anticipatory transformative adaptation into practice.

Adaptation has been framed as a continuum of resilience, transition and transformation (Pelling, 2011). At one end of the spectrum are incremental responses to proximate causes of vulnerability, while at the other is transformative adaptation to long-term, large-scale, non-linear, uncertain changes (Wise et al., 2014). Yet, most adaptation practice is reactive, local and short-term (Hodgkinson et al., 2014). Such actions are likely to be maladaptive (Barnett and O'Neill, 2010) because effects of long-term environmental change are marginalised and the interactions between decision lifetimes, uncertainties about the nature of biophysical change and possible adaptation options, tend to be downplayed (Stafford Smith et al., 2011). Proponents of short-term adaptation may not acknowledge that ecosystems are likely to transform (Park et al., 2012; Wise et al., 2014). But even when ecosystem transformation is acknowledged, societal transformation is considered beyond the capacity for adaptation because of a perceived lack of new options (Dow et al., 2013). The alternative view is that transformative adaptation of social-ecological systems is both necessary and possible, based on anticipatory approaches in which new options are co-created, explored and experimented with (Rickards and Howden, 2012; Rickards, 2013).

We define a social-ecological system as a coupled biogeophysical entity (e.g. an ecosystem, landscape or bioregion) with social actors and institutions that has properties of complexity, adaptiveness and multiple cross-scale feedbacks (Fischer et al., 2015). Transformation of a social-ecological system may be initiated by changes in ecosystem drivers (e.g. temperature regime, water availability, nutrient balance), followed by ecosystem changes (e.g. in extent and composition of vegetation communities and their and associated biota), leading to adaptation by social actors including altered use of ecosystem services, livelihoods and governance arrangements for natural resources (Box 1). Changes in ecosystem drivers may be due to climate change or other anthropogenic pressures including transformations in social systems such as establishment of an irrigation system. Such changes have occurred at Lake Faguibine, Mali (Djoudi et al., 2013) and the Murray-Darling Basin, Australia (Colloff et al., 2016a) where complex, non-linear transformative ecological and social changes have followed declining inflows to rivers caused by climatic drought and high water diversions for irrigation.

Climate change may limit societal choices over which ecosystem services can be supplied by changing ecosystems. But new knowledge gained from experimenting with adaptation may provide some influence on the direction of ecosystem change, if participants in adaptation decisions and actions are willing and able to use this knowledge in participatory and deliberative ways to alter interests, values and rules that constrain implementation (Chapman, 2011). Co-evolving systems of societal values, rules and knowledge define the decision contexts of individuals, groups, organisations and societies which can be purposefully shifted (e.g. Voss et al., 2007) to enable anticipatory transformative adaptation based on co-creation of options and learning by doing. Such an approach can help overcome limited problem awareness leading to low public support for adaptation that has impeded agents from learning about climate change impacts and the range of actions they can take (Eisenack et al., 2014).

The willingness of people to engage in transformative adaptation is not enough. Powerful stakeholders who perceive threats to their interests will attempt to prevent others from such action (Klein, 2014). Global and national institutions will be vital for facilitating and supporting transformative adaptation, which "…will require fundamental transitions in the systems of production and consumption that are the root cause of environmental and climate pressures. Such transitions will, by their character, entail profound changes in dominant institutions, practices, technologies, policies, lifestyles and thinking" (EEA, 2015). Providing evidence of successful transformative responses is critical to overcoming barriers to adaptation (Peterson et al., 2003), which include uncertainty regarding risks, benefits and perceived costs, as well as institutional behaviours that serve to maintain the *status quo* (Kates et al., 2012), such as forced and predatory economic growth (Bhaduri, 2008).

In this paper, we outline a framework for enabling transformative adaptation, developed by the Transformative Adaptation Research Alliance (TARA https://research.csiro.au/tara/), an international network of researchers and practitioners who study and promote transformative adaptation. The TARA approach provides clear and structured ways of diagnosing and framing complex problems, co-generating innovative solutions and overcoming decision inertia to engender agency for adaptation. The TARA approach is based on a novel, cohesive, operational framework that integrates three powerful existing concepts: (1) the *values-rules-knowledge* perspective on adaptation decision-making, that focuses on reframing current decision-making contexts to enable future adaptation decisions and actions; (2) the *adaptation pathways* approach, for planning and implementing adaptation to transform social-ecological systems to become adapted to the effects of global change, and (3) the *adaptation services* concept, that redefines the relationship between people and ecosystem services based on likely future ecosystem states and changes in the supply of services.

## 2. Three elements to enable transformative adaptation

We propose that operationalising the three elements listed above provides a basis for adaptation planning and action that moves beyond incremental approaches targeted at proximate causes of vulnerability to those capable of addressing transformative adaptation and strategically tackling long-term, systemic problems.

### *2.1 The values*, *rules* and *knowledge perspective* (*vrk)*

For anticipatory, transformative adaptation to be realised, a new perspective on decision-making is required that reveals the need for transformative adaptation. Decision contexts are informed and defined by interactions between systems of societal values and rules and the forms of knowledge considered salient and legitimate by the decision makers (Gorddard et al., 2016). The *vrk* perspective on decision contexts helps identify how decision making can be constrained by the preferences of decision makers, their institutional context and their understanding of how the world works (Gorddard et al., 2016).

'Values' in the *vrk* perspective refers to the set of individual and collective motivations that guide goals and actions, priorities and moral framings (Schwartz, 2012). However, these motivations are expressed in adaptation decision making via the other use of the term 'value', to mean 'importance, worth or usefulness'. In this sense, we recognize the importance of values pluralism –the multiple ways of understanding nature by diverse social actors– under the categories of intrinsic, relational and instrumental values (Diaz et al., 2015). Inclusion of values pluralism in deliberation and decision-making allows for different and novel adaptation approaches (Martín-López and Montes 2015). Such approaches go beyond just instrumental values, where nature is regarded as a source of material benefit and wellbeing, and incorporate intrinsic values (i.e. inherent values, independent of usefulness) and relational values (i.e. desirable, and desired, relationships between people and nature (Chan et al., 2016).‘Rules’ in the *vrk* perspective refer to both ‘rules-in-use’ (norms, practices, taboos, habits, heuristics and behaviours) and ‘rules in form’ (regulations, laws, treaties, ordinances, directives), which ‘knowledge’ includes evidence-based (scientific and technical) knowledge and experiential and meanings-based knowledge (Gorddard et al., 2016).

Where values, rules and knowledge are considered explicitly in adaptation decision-making, they are often treated as independent, disaggregated entities (Fig. 1a), rather than interdependent components. Treating these components as disconnected obscures how certain forms of values, rules and knowledge and their interactions are excluded from decision making; for example, moral and ethical values relating to distribution of power, consideration of the rules of natural justice, local ecological knowledge and Indigenous knowledge and belief systems. In such situations, adaptation is framed without considering the complex, interactive behaviours of human agents and their social and institutional settings. The result tends to be promotion of short-term technological solutions that do not address dynamic, complex human interactions in circumstances of social-ecological change. In this regard, the diagnostic value of the *vrk* perspective echoes the outlook of Abson et al. (2016) that “biophysical, social, economic and political facets of sustainability are addressed in isolation from each other…A common feature of such framings is that they often imply that sustainability problems can be resolved without consideration of the structures, values and goals that underpin complex problems at deeper levels.” Abson et al. (2016) draw upon the deep leverage points model of Meadows (1999): the places in a complex system where small shifts may lead to large system changes. The *vrk* perspective represents a means of intervening at the deepest leverage points; of system *design*, which include rules, incentives, constraints and capacity for change, and *intent*, which include goals, paradigms and the power to transcend them.

Shifts in paradigms, norms, world views, interests and values by decision makers and practitioners are needed to foster changes in societal rules relating to adaptation and the emergence of innovative governance systems for transformative adaptation (Chaffin et al., 2016). And by changing rules, so we may change values. New forms of knowledge and new ways of learning are required to facilitate adaptation decisions and actions, particularly those aimed at systemic causes of problems (Cornell et al., 2013). Triple loop learning involves reflexive enquiry into changes in forms of knowing and learning, including questioning the systems of values, rules, and knowledge inherent to a paradigm or an organisation such as a policy decision-making body (Tosey et al., 2012). Agency for change can then arise from collective learning and decision making. The *vrk* perspective augments triple loop learning by emphasising that agency and scope for change are constrained. For example, the *vrk* perspective reveals that new scientific knowledge does not, on its own, translate to changes in adaptation decisions (Gorddard et al, 2016; Fernandez, 2016). Researchers have limited agency to achieve change without also considering values and rules in relation to new knowledge. Instead, the *vrk* perspective allows policy decision makers to deliberate of each adaptation decision: "do we know the outcome?" [knowledge] and, if so, having considered knowledge interactions with values and rules, ask "do we want the outcome?" [values] and, if so, having considered knowledge and rules, ask "are we allowed the outcome?" [rules], considering knowledge and values. If the answer is "no" at any stage, then the next step is to identify what needs to change in values, rules and knowledge in order to get to "yes", or to consider other adaptation options. If the answer is uncertain, this signals that more deliberation is required on the sources of uncertainty and what needs to change to get to "yes" or "no".

The legitimacy of adaptation objectives depends on how people perceive the impacts of change on their interests and values (O'Brien and Wolf, 2010). However, limits to adaptation imposed by such perceptions are not immutable (Adger et al., 2009). Interests can be shifted by new knowledge of the options available, such as the prospects for adaptation of livelihoods based on new adaptation services. Adaptation can be facilitated by changes in rules to help realise those options and through planning, learning and implementation as part of an adaptation pathways approach. For example, threatened species are a key driver of conservation, policy and practice in many countries, in response to legislative mandates and considerable societal values placed on certain species. But shifting from a threatened species focus to 'climate-ready' conservation practices will require major shifts in knowledge, values and rules of how we plan and implement conservation under climate change (Wyborn et al., 2016). Barriers to be addressed for adaptation in conservation include lack of resources and political support, poor cross-sector coordination, uncertainty over governance responsibilities (rules); conflicting priorities and interests (values); and shortcomings of expertise or feasible, acceptable solutions (knowledge) (Wyborn et al., 2015).

Recently, some authors have considered binary interactions between values, rules and knowledge, such as how rules influence values and norms (Kinzig et al., 2013; Rico García-

Amado et al., 2014); how power is used by decision makers to exclude some forms of knowledge (Cash et al., 2003; Termeer et al., 2011), how economic drivers prioritise technical knowledge at the expense of local ecological knowledge that has co-evolved with the environment (Iniesta-Arandia et al. 2014), and how societal interests and values can be shifted by new knowledge (Cornell et al., 2013; Leith et al., 2014). Sequential approaches to *vrk* interactions have begun to be applied to adaptation decision making (Hobday et al., 2015).

We consider the interactions of values, rules and knowledge are inseparable and multi-directional. Interactions are co-evolutionary and unique to each context: change in one of the domains of knowledge, vision, process and context of adaptive governance precipitates change in other domains (Wyborn, 2015). We suggest that these interactions can catalyse transformative change in other domains. Part of the TARA research agenda is to develop greater understanding of how interacting systems of values, rules and knowledge can both constrain and enable the decision context for transformative adaptation.

### *2.2 The adaptation pathways approach*

Metaphors structure our sense-making of complex issues such as climate change. Meaning is created for concepts through their relationship with the metaphorical frame (Lakoff, 2014). The adaptation pathways metaphor evokes a narrative journey into an uncertain future (Fig. 1b), complementing another climate change metaphor of “never going home again” (Chapman, 2011). On such a path, problems emerge and choices have uncertain, far-reaching consequences. People may strive to be forward-looking, learn and be changed by the journey; though the prospect of change is a source of resistance for many. Options for responding to future uncertainties are enabled or constrained by choices made along the journey, changing the path in ways that may be irreversible. Moral and ethical dilemmas are explored en route; conflicts, resolution and co-operation play central roles. Interactions of decisions, social dynamics and environmental change determine the outcomes. These elements are a rich basis to envision how social-ecological systems may traverse the future: adaptation pathways can play an important role in broadening our thinking and actions for transformative adaptation.

As well as metaphor, the adaptation pathways approach can be formalised as an adaptive decision process for ‘exploring and sequencing a set of possible actions based on alternative, uncertain developments over time’ in ways that seek to avoid maladaptation (Wise et al., 2014) (Fig. 1c). This conceptualisation explicitly aims to examine trade-offs between the benefits of maintaining the flexibility to respond to future uncertainties against the costs of attempting to maintain the status quo. Adaptation pathways can aid implementation by revealing elements required for transformative adaptation (Wyborn et al., 2015) by focussing on both social and ecological dynamics (Haasnoot et al., 2013; Wise et al., 2014).

The adaptation pathways approach conceptualised by Wise et al. (2015), unlike many futures scenario approaches, enables examination and changes in the decision context at each sequenced decision point (Fig. 3), based on the following attributes: *The diagnosis of the adaptation challenge* at a particular time, and over time, relies on the knowledge regarding the magnitude, rate and extent of biophysical change and impacts on ecosystems, livelihoods, economic development or other focal contexts. *The setting of agreed and desirable objectives* for adaptation interventions takes into account the diverse values, rules and knowledge framings of multiple stakeholders, including the use of adaptation services under different scenarios of environmental change. *The sequencing of decisions and actions* for paving the pathway towards new adaptation actions depends on the sequence of decisions and actions according to lead times, the duration that such decisions remain valid (Stafford Smith et al., 2011) and the role of each action in paving the pathway. *The development of governance systems* that allow adaptation is based on monitoring, evaluation and learning of the management actions up to that point and allows changes in decision processes to realise objectives. A mechanism – the *vrk* perspective – is critical for examining and changing the decision context at each decision point in an adaptation pathway in order to avoid incremental, short-term, maladaptive and path-dependent (historically determinant) sequencing of adaptation actions. Changes to the decision context are the prerequisite for adaptation actions that are implemented between the decision points that pave the way for ensuring a wider set of options is available at the next decision point.

The adaptation pathways approach provides the basis for actors to learn and co-create solutions from doing, experimenting and innovating because as its starting point it requires decision makers to address questions such as: are decisions and actions robust to future scenarios and can they be halted or reversed if conditions change? Will actions prevent the crossing of a biophysical threshold? Framing adaptation pathways in this way (as opposed to a route map or simple plan) is both necessary and more likely to be effective in situations where goals are ambiguous, decisions are contested, social-ecological systems are highly dynamic and trajectories of change are unpredictable (Butler et al., 2014). An example of *vrk* – adaptation pathways interactions is where decision makers in New York transformed their decision context by including increased future risks of climate change into plans for rebuilding after destruction caused by Hurricane Sandy (Rosenweig and Solecki, 2014).

*2.3 The adaptation services concept*

Adaptation services are a sub-set of ecosystem services that provide benefits to people from increasing their capacity to adapt to environmental change (Lavorel et al., 2015; Colloff et al., 2016a, 2016b). Adaptation services are supplied via the properties of ecosystems to moderate and adapt to change and provide future options and insurance for adaptation (Fig. 1c). Benefits accrue from (1) novel provisioning and regulating services that become newly-available due to ecosystem transformation, such as timber, charcoal and forage from a forest that grew on a dry lake bed in Mali (Djoudi et al., 2013); (2) latent services, i.e. ones that were available but not recognised as services or used as such, but which provide options for adaptation. An historical example is feral goats, a pest species in Australia, but now the basis of a profitable rangeland meat export industry by former wool producers (Jones, 2012); (3) the management of supporting and regulating services to underpin provisioning and cultural services and (4) the adaptive capacity of ecosystems to remain more-or-less in the same state and continue to provide existing services, or transform to a new state and provide new ones. Adaptation services alone are not a panacea, but together with ecological restoration and preventing ecosystem degradation, they are critical to the management of changing ecosystems (Colloff *et al*. 2016a, 2016b; Doherty et al., 2016).

The adaptation services concept is required for transformative adaptation because of the limits of the ecosystem services concept as it relates to global change, particularly where the predominant resource allocation mechanism is market-based, which inevitably favours provisioning services (and some regulating services) that can be commodified, exchanged and priced, over most supporting and regulating services that cannot (Rausdepp-Hearne et al., 2010). Such a market economics-based approach generally constrains adaptation because the delayed and uncertain effects of climate change on the future production and supply of ecosystem services cannot be accounted for (Norgaard, 2010). Instead, adaptation services are focussed on future options, but there is an explicit requirement for a trade-off framework as part of their management to ensure future options are not compromised.

## 3. Integrating *vrk*, adaptation pathways and adaptation services

Integration of the values, rules knowledge perspective and adaptation services within an adaptation pathways approach enables exploration of the interactive dynamics of ecosystems and social systems in their adaptation journey Fig. 2). In this framing, the adaptation services concept is a new way to evaluate scientific knowledge on changes to ecosystems and evolving societal perspectives on their use and management as part of *vrk*. Adaptation services and their underpinning ecological mechanisms provide new options for adaptation as well as enabling supply of some current ecosystem services to be maintained (Lavorel *et al*., 2015). By focussing on future options, the adaptation services concept can help individuals and collectives explore how to use adaptation services, together with public institutions (e.g. transport systems, economic freedom, democratic processes, health and education systems, land rights) to engage in transformative adaptation. Administrations can support these capabilities by co-producing acceptable, legitimate transformative policies. Such policies, and the decision contexts related to them, would extend the adaptation services concept beyond its instrumental value in providing future options, and including intrinsic and relational values.

Realising the options of adaptation services will often require changing aspects of the decision context, using the *vrk* perspective to diagnose barriers and identify the sequencing of interventions, and purposefully attempt to change the prevailing interactions of *vrk* that constrain response options. Such an approach represents adaptation pathways as possible sequences of strategic interventions aimed at overcoming institutional, cultural or knowledge constraints so that adaptation services can be legitimately considered by future decision makers in conservation or natural-resource management (Fig. 3).

The adaptation pathways approach represents a set of sequenced shifts in the decision context, and hence in systems of *vrk* in response to the use of adaptation services and changes to social-ecological systems (Fig. 3). The systems of *vrk* evolve along these pathways as adaptation decisions are implemented over time. But the links are not only one way because *vrk* influences which adaptation services might be used, and hence the particular route along the pathway. Adaptation thus involves influencing the evolution of societal responses to biophysical change so that future decision makers can understand the opportunities and constraints and select options in the adaptive space.

By identifying adaptation services and the *vrk* context of a focal social-ecological system, management and decision making to support adaptation services (e.g. habitat protection, connectivity and restoration; Lavorel et al., 2015) is integrated into planning and implementation. Implementing an adaptation pathways approach then requires institutional and community co-learning, including engagement in adaptive monitoring and research, co-producing and trialling new management practices and novel approaches to livelihoods, decision making and governance (Wyborn, 2015; van Kerkhoff and Lebel, 2015). By connecting management actions with policy, planning and learning, the TARA approach provides a basis to identify barriers that extend beyond the scale and context of individual management activities, and helps creating new decision contexts supported by co-diagnosis of constraints on decision making; co-development of a common systems framing and co-creation of futures scenarios supporting the planning and implementation of adaptation pathways in a way that stimulates deliberation, choice and empowerment.

## 4. How the TARA approach compares and links with other adaptation frameworks

There is an increasing number of adaptation approaches, some with properties in common with the TARA approach. Examples include Ecosystem-based Adaptation (EbA; Vignola et al., 2009; Munang et al., 2013; Doswald et al., 2014); Eco-disaster Risk Reduction (Eco-DRR; Renaud et al., 2013); resilience (Walker et al., 2004) and Community-based Adaptation (CBA; Ayers and Forsyth, 2009; Dodman and Mitlin, 2013). These approaches aim to support sustainable adaptation under global change and focus on ecosystems (except CBA); the prospect of ecosystem transformation (TARA and resilience) and transformative adaptation of social-ecological systems, either as the primary focus (TARA) or as an observed phenomenon (other approaches). Initially, resilience (Tanner et al., 2015), EbA and the precursor to Eco DRR (hazard mitigation) were not primarily focused on governance but rather on technical aspects, such as ecological engineering and biodiversity conservation.

The focus on implementation, especially of transformative adaptation, has tended to be stronger in adaptation (e.g. EbA and Eco-DRR) than in resilience (Miller *et al*., 2010), which emphasises adaptation as the mobilising of adaptive capacity for absorption of stress and maintenance of function in response to environmental and social change (Berkes and Jolly, 2001; Pelling, 2011). While resilience addresses social dimensions, it has involved a generalisable, top-down approach that does not address decision contexts (Stone-Jovicic, 2015). Resilience is concerned with human agency and the power to act under changing social-ecological conditions, but has been criticised because it does not explicitly address power relations or political realities (reviewed by Boonstra, 2016). In contrast, the TARA approach is bottom-up, with a primary focus on interactions of *vrk* systems and future-oriented reframing of decision contexts. Furthermore, the reframing of decision contexts is a process that deliberatively addresses the redistribution of power and agency.

Transformation of societal interests and values are inherent to the implementation of the TARA approach: neither EbA or Eco-DRR contain an explicit process for transforming decision contexts and societal values as part of implementation though they (and also resilience and CBA) contain the implicit objective of achieving such transformations. Applying the TARA approach to a reframing of policy and governance can start to shift from a focus on climate impacts in isolation of people and institutions towards holistic approaches to adaptation. Co-learning is embedded at each stage: (1) in the diagnosis of constraints on decision making and the need to change decision contexts, as revealed by the *vrk* perspective; (2) in the co-development of a common systems framing based on environmental change, as enabled by the adaptation services concept; (3) in the co-construction of future scenarios, drawing on the adaptation pathways approach and (4) in planning and implementation of adaptation pathways. CBA and resilience thinking also include co-learning in principle.

As these various approaches are modified though cycles of implementation and re-design, they have begun to resolve earlier shortcomings, resulting in a convergence of approaches. While there are areas of overlap between them, the choice of which approach is likely to be useful (or which elements) depends on the adaptation task; the stakeholders involved; the prevailing social-political context and the degree of acceptance of the need for transformative change. Human agents may choose a particular approach or draw on practical, complementary elements from a variety of approaches (such as between EBA and TARA, cf. Box 2). The TARA approach takes the latter option and represents a means to assess advantages and disadvantages of each approach. The example of ecological restoration practice (Box 2) shows how the context of existing approaches can be broadened to include complementary approaches (e.g. EBA and TARA). Such broadening of context highlights how restoration might contribute to other aspects of transformation; for example, how EBA could shift from a focus on adaptation services to a focus on decision context. Such a shift would enable practitioners to work with existing structures and processes, but start to build an understanding of the required changes to governance that can enable transformative adaptation.

The linking of adaptation services, *vrk* and adaptation pathways in the TARA approach enables an integrated framework for transformative adaptation that can broaden the framing of adaptation problems. For example, in conservation practice by extending the decision context beyond the assessment of ecosystem changes and short-term maintenance of biophysical integrity, the TARA approach can help conservation policy and governance adapt and change by focussing on biophysical change to re-interpret and reframe the problem and value definition (e.g. by using the questions in Section 2.1: “Do we know the outcome? Do we want it? Are we allowed it?”). This shift then allows examination of the implications of the reframing for conservation policy, management and then governance.

## 5. Conclusions

Enabling transformative adaptation requires new ways to evaluate and adaptively manage trade-offs between maintaining desirable aspects of current social-ecological systems and adapting to major biophysical changes to those systems. We have attempted to position the TARA framework within the context of linked social-ecological systems and emphasise that we add an adaptation lens to a social-ecological systems approach (Figure 2). Binder et al. (2013) reviewed the different approaches to analysing social-ecological systems and did not mention adaptation or transformation. Fischer et al. (2015) linked the concept of social-ecological systems to the understanding of the dynamics of environmental and societal change and set priorities for research and policy, including inter-regional linkages and governance, long-term drivers, power relations and a stronger science-society interface. In this paper, we attempt to add an enabling transformative adaptation framework to the “lens of analysis that sharply puts in focus humanity’s dependence on nature, our burgeoning influence on it, as well as our ethical obligations towards it” (Fisher et al, 2015).

In the TARA approach, the reframing of decision contexts is a process that deliberatively addresses the redistribution of power and agency. We consider this redistribution as fundamental to overcoming a major barrier to transformative adaptation. A central premise of the TARA approach is that human agents involved in implementing adaptation to global change can achieve more power and agency, not just if the institutions and decision making systems were organized differently, but from the processes of being actively engaged in questioning, learning, changing, revising and reforming the institutional framework in which adaptation occurs.

The challenges of implementing transformative adaptation are formidable and future uncertainty is a key theme (Eisenack et al., 2014). The TARA approach helps address uncertainty in adaptation decision making by taking an integrated, holistic perspective to values, rules and knowledge, but it cannot always ensure knowledge will be adequate to help define the decision context under high uncertainty. Integrated approaches may help mitigate uncertainty, but still require improved understanding of the emergent properties of social-ecological systems (e.g. Liu et al., 2015). We acknowledge that dealing with complexity needs to be circumscribed appropriately, and each situation for transformative adaptation will be different. There will always be the prospect of including certain forms of knowledge in the decision context at the expense of others, or ignoring the emotional attachment that stems from values of identity and culture. Shifts in knowledge will not overcome such values, so we need to find ways that new knowledge can used to shift individual and collective interests without alienating or discounting societal values of identity. Reframing of adaptation decisions to ones that can be considered as transformative therefore requires transformation of governance arrangements (Type 3 transformations in Box 1).

Revealing the need for changes to aspects of human organisation that have been taken for granted hitherto is therefore an important adaptation task, as is supporting what people are already trying to do in order to transform. We consider the TARA approach is a means to integrate between the transformation of ecosystems under global change, shifts in decision contexts that acknowledge the need for societal change and the development of adaptive, transformative governance to enable transformative adaptation.

Bennett et al. (2016) considered that current global futures scenarios are often based on simplified world views that can be improved by incorporating “seeds of a good Anthropocene”, which are “diverse examples of good practice, innovations, and experiments…that can help us to understand the different components of a better future that people want, and to recognize the processes that lead to the emergence and growth of initiatives that fundamentally change human–environmental relationships.” Imbued in the concept of “seeds of a good Anthropocene” is the positive feedback relationship between *hope*, in the sense of a pragmatic, positive, forward-looking perspective, and *agency*, entraining empowerment, options for the future and collective motivation. We consider that the TARA approach represents one such contribution to a good Anthropocene.

## Author contributions

All authors contributed to developing, interpreting and refining concepts and the research framework during the first and second TARA workshops. M.J.C. led the writing, with major contributions from B.M.-L., S.L., B.L., R.G., P.-Y.L, L.V.K. and C.W. B.L., B.M.-L. and MJC designed and produced the figures; R.G. and G.W. wrote the text boxes. All authors contributed to the writing and editing of the paper.

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**Box 1. Definitions of concepts of the three types of transformation used in the TARA approach.**

There are multiple uses of the term *transformation* in relation to adaptation to global environmental change (Feola, 2015). We do not consider transformation as a process separate from adaptation that occurs after limits of adaptation are reached (Dow et al., 2013). Three types are defined: transformation as a process of change in a social-ecological system without deliberate intervention is described by Types 1 and 2 below. Transformation as a deliberate process is described by Type 3.

(1) *Transformation of ecosystems*: is defined by a permanent shift to an alternative stable state, as in resilience thinking (Walker *et al*., 2004). But such 'Type 1 transformation' also involves a change in the way a focal ecosystem is viewed from the relevant decision context. This change requires a reframing of how the ecosystem is considered in relation to its core driver and response variables, its attributes that are valued by society, and how people relate to and act within the system, including options for managing and using the ecosystem that are normalised and permitted.

(2) *Transformation of decision contexts*: focusses on the recognition that because ecosystems and their drivers are transforming, so transformation to decision contexts supported by evolving governance arrangements Is required (Gorddard *et al*., 2016). Thus, 'Type 2 transformation' represents a major shift in the social arrangements that define the decision context, including: (1) the networks that are formed in the process of decision making; (2) the knowledge and belief systems ("knowledge"), societal values and motivations ("values") and formal and informal rules and governance arrangements ("rules") that define how powers are defined, allocated and used, and (3) how resource allocations flow to empower the decision process and are affected by the focal decision-making group.

(3) *Transformation as developing the capacity for adaptive, transformative governance*: the capacity to develop adaptive, transformative governance is relative to the type of change that is intended and the position of the people within the system who are seeking the change. Transformative change in governance (e.g. Chaffin et al., 2016) will be needed to support transformative change in the decision context for adaptation. Like specific resilience, with its requirement to specify resilience *of* what, *for* what (Carpenter et al., 2001), it is necessary to frame 'Type 3 transformation' as developing the capacity for adaptive, transformative governance for *whom*, to enable *what* kinds of changes in governance systems, for *what* purpose.

Change in decision contexts relating to Type 1 and Type 2 transformations cannot be separated in practice because Type 2 transformations are a consequence of Type 1 and both require no deliberate human intervention in order to occur. Reframing decisions that can be considered as transformative therefore requires transformation of governance arrangements (type 3).

**Box 2. Adaptation and ecological restoration under climate change and the contribution of the TARA approach**

Restoration is now considered one solution to climate change adaptation and mitigation, and an important part of approaches to implementing the United Nations conventions on climate change, desertification and biological diversity (UNFCC, UNCCD and UNCBD; Aronson and Alexander, 2013).

Restoration, including ecological restoration (ER), forest landscape restoration (FLR) and ecological engineering (EE), focuses on restoring elements of ecological conditions and function, and ecosystem services, often for societal benefit (Stanturf et al., 2014). Although ER has focused on restoring ecosystems to past conditions and functions, this approach may no longer be relevant (Choi, 2004). Practitioners of ER now consider how to restore ecosystems under a changing environment (Hobbs et al., 2011; Locatelli et al., 2015). EE focuses largely on addressing future societal issues, such as developing novel ecosystems (Mitsch, 1996) in the context of creating wetlands to mitigate climate-related flooding (Temmerman et al., 2013).

These restoration concepts largely focus on ecosystems rather than on the governance context, although it is now recognised that governance is key to making restoration successful (Guariguata and Brancalion, 2014, Mansourian 2016). For example, in Ghana, restoration work conducted by members of a Community Resource Management Area was reduced in effectiveness by issues related to accountability and transparency (Baruah et al. in press).

Already, FLR focuses on addressing current societal needs (Dudley *et al*., 2005) and recently began developing national and sub-national multi-stakeholder restoration discussion processes (Maginnis, 2014) which can be tailored to discussions on adaptation. Consideration of how restoration interventions and other nature-based solutions can be improved by forward thinking and decision making process is being proposed (Stanturf et al., 2015, Cohen-Shacham et al. 2016). One concept, Ecosystem-based Adaptation (EBA) uses restoration as part of its toolkit to help societies adapt to climate change (UNEP, 2010). Although restoration approaches are progressing towards helping societies use ecosystems to adapt to climate change, they could benefit from the TARA approach, specifically by identifying adaptation services and shifting management approaches towards enabling their delivery, using the *vrk* and pathways framing.

Of particular value would be ensuring that restoration decisions include minorities, that multiple values of ecosystems and their uses are included in decision making and that knowledge required for decisions is as inclusive as possible. Some of these outcomes can be achieved by engaging more social scientists in restoration processes (Eden and Tunstall, 2006).

Figure 1. The three elements of the TARA approach: (a) values, rules and knowledge (i) in standard decision making, where values, rules and knowledge are regarded as independent inputs; (ii) in the *vrk* perspective, where allowable decisions are the product of the *decision context* which results from interactions between the processes in society forming or revealing values, rules and knowledge. This allows us to ask of each adaptation decision: “do we know the outcome?” (*k*) and, if so, “do we want the outcome?” (*v*) and, if so, “are we allowed the outcome (and the means of achieving it)?” (*r*); (b) an *adaptation pathway* for planning and sequencing decisions and actions for transformative adaptation. Opting for ‘business as usual’ at the first decision point may constrain future options and require further decisions to avoid maladaptation; (c) *adaptation services*, whereby options for adaptation are created according to whether ecosystems will persist or transform to alternative states. Where ecosystems persist, some currently-valued services will continue to be supplied and used. Under ecosystem transformation, novel services will be supplied and latent services (those not previously recognised or used), will provide options for adaptation.

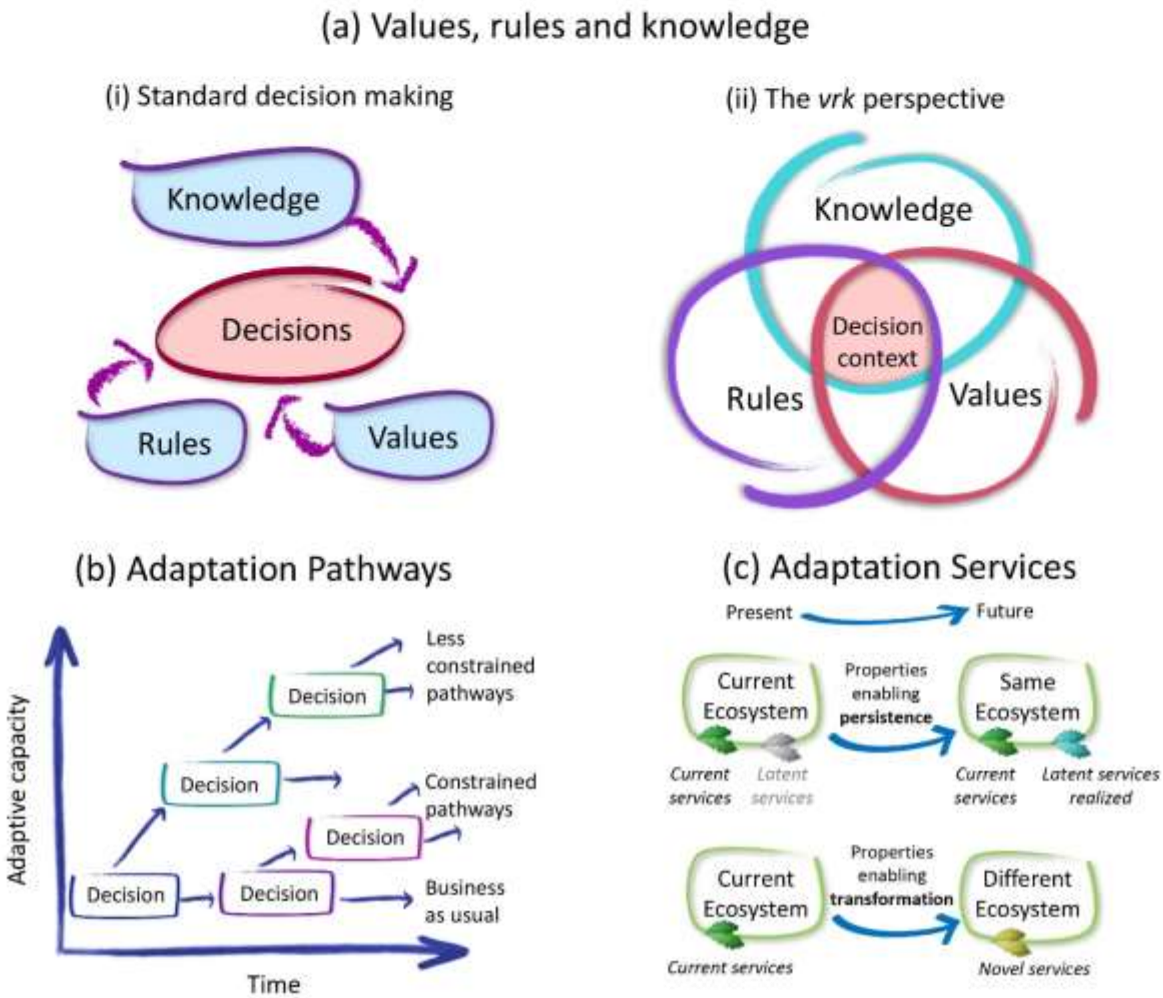

Figure 2. Linkages and interactions between adaptation pathways, adaptation services and the values, rules and knowledge (*vrk*) perspective in the context of transformative adaptation to global change. The *vrk* interactions define the decision contexts in an adaptation pathway. The adaptation pathway represents a system of adaptive governance for anticipating and planning decisions to enable future adaptability, based on changes to ecosystems and the supply of ecosystem services for livelihoods and wellbeing. Adaptation services–the sub-set of ecosystem services that provide options for adaptation–form a basis for decisions, integrated within an adaptation pathway, for the management and use of ecosystems in the future, considering changes in supply of ecosystem services due to ecosystem change. Type 1, Type 2 and Type 3 refer to types of transformations (of ecosystems, decision contexts and capacity for adaptive governance, respectively) detailed in Box 1.

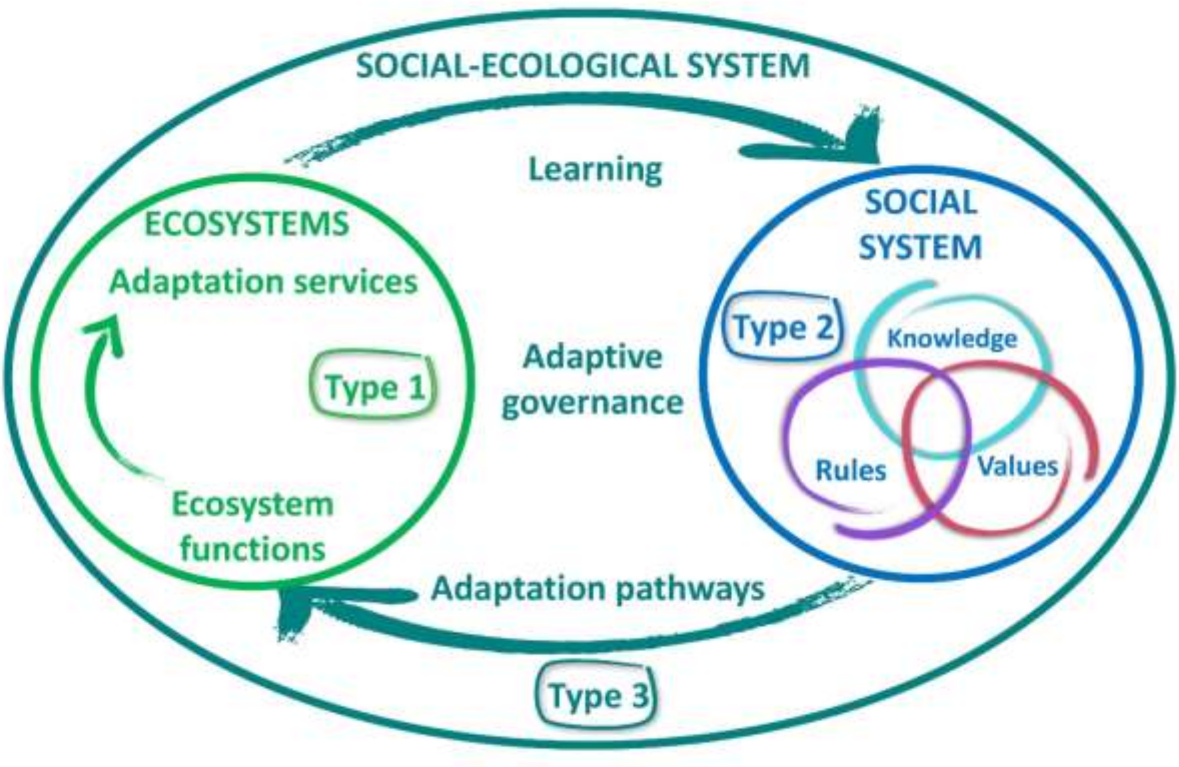

Figure 3. An adaptation pathway that incorporates shifts in the decision context for adaptation options enabled by interactions between values, knowledge and rules (*vrk*) at each decision point. The *vrk* system evolves along each pathway enabling or constraining decisions at each point. Adaptation services increasingly provide options for adaptation, represented as 'bundles' of ecosystem services. At each decision point, the bundle available will be different from those at previous points. Path dependencies arise where a decision limits future adaptation options, or management for adaptation services enables future options. The boundary to what is considered maladaptive space (where available ecosystem services no longer meet societal needs and there are limited or no options to transform to a desirable state) also changes over time.