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Adapting transformation and transforming adaptation to climate change using a pathways approach

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ABSTRACT

Human actions have driven earth systems close to irreversible and profound change. The need to shift towards intentional transformative adaptation (ITA) is clear. Using case studies from the Transformative Adaptation Research Alliance (TARA), we explore ITA as a way of thinking and acting that is transformative in concept and objectives, but achieved through a mix of incremental and transformative co-production processes that ultimately lead to the social-ecological system being transformed. Central to ITA are social and political issues of how individuals and collectives address environmental and social change and deal with power imbalances. ITA approaches are claimed to help overcome adaptation challenges, including: 1) re-framing human-nature relationships; 2) dealing with uncertainty; 3) engendering empowerment and agency and 4) addressing conflicting values and interests. However, it is unclear if these approaches work in practice. We examined six adaptation case studies in which participants used processes of: 1) co-producing visions of the future; 2) re-framing values, rules and knowledge to shift decision contexts for adaptation and 3) implementing actions using theories of change and adaptation pathways. We assessed the extent to which participants could use these processes to address their adaptation challenges. We found evidence of many positive achievements towards the implementation of ITA, but also examples where processes were not working, such as communities having difficulties in finding ways to work co-operatively. Different processes will be needed to address these issues, such as promoting pluralism, knowledge contestation, and deliberative re-politicisation of the adaptation agenda to shift power imbalances and enable change.

1. Introduction

On a centennial scale, transformation of social-ecological systems is inevitable. Our world is radically different from that of fifty years ago. Changes were driven by social, technological, political, economic and environmental shifts. Some changes were intentional, most were unplanned, some beneficial, others harmful and inequitable, some incremental, others radical, but the consequences were transformational. However, those transformations have driven the ecosystems that sustain

us precariously close to irreversible and profound change (Steffen et al., 2018).

The need for rapid, extensive intentional transformative adaptation (ITA) is clear. We define ITA as co-produced responses to observed or anticipated changes in environmental and social drivers that lead towards generally irreversible and fundamentally changed structures and functions of a social-ecological system, including norms, visions, values, rules and practices (Colloff et al., 2017; Díaz et al., 2019; Fedele et al., 2019). The term is basically synonymous with ‘sustainability transition’,

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as defined by the Sustainability Transitions Research Network (STRN; Köhler et al., 2019), i.e. radical shifts to new social-ecological systems, rather than marginal improvements and technological fixes to existing ones.

ITA has been claimed to help re-frame human-nature relationships (Colloff et al., 2020), deal with uncertainty (Wise et al., 2014; Bosomworth and Gaillard, 2019; Werners et al., 2021), engender empowerment and agency (Bentz and O'Brien, 2019; Barnes et al., 2020), and address conflicting values and interests over the 'how' and 'why' of adaptation (Abel et al., 2016). However, hard evidence for these claims is overshadowed by the complexity and messiness of 'adaptation on the ground', involving politics, social inequalities, contested objectives, differing knowledge, values and perspectives, and power imbalances among actors (Woroniccki et al., 2019). These issues overlap and connect. For example, agency is linked to power relations: what is regarded as adaptive by one group of people may be viewed as maladaptive by another and politics and power determine which view will prevail (Erikson et al., 2015). Power imbalances determine whose values, rules, and knowledge prevail in adaptation decision making (Colloff et al., 2019; Woroniccki et al., 2020).

Multiple perspectives on the complex societal dynamics of ITA can be seen (Werners et al., 2021). From a pathways perspective, for example, a synthesis of insights from past changes, foresight for future changes, and development of processes to influence outcomes can facilitate structural change and the development of agency for adaptation (Fazey et al., 2014). An important criterion for ITA is whether the processes and tools in use empower participants and give them agency. This calls for modes of co-production where participants can determine and define what is transformative or not and develop knowledge governance systems that work for them (van Kerkhoff and Pilbeam, 2017).

Feola (2015) observed that a plurality of frameworks have been used to make sense of transformation processes, including social-technical transitions, adaptation pathways, and leverage points for sustainability. This plurality helps build operational syntheses (Olsson et al., 2015), enabling participants to figure out what works and what does not for a range of contexts, depending on the adaptation task. For many participants, understanding of ITA concepts may be only partial and contingent on scope and scale. However, concepts with 'loose' meanings and strong conceptual metaphorical power are effective in stimulating research and action (Feola, 2015). An example is the plural perceptions of resilience (Olsson et al., 2015), which is often regarded by stakeholders in adaptation as a normative and desirable property; something to be managed for (Walker, 2020).

Previously, we presented a conceptual framework, developed by the Transformative Adaptation Research Alliance (Colloff et al., 2017), involving: 1) co-producing visions of the future; 2) re-framing of values, rules and knowledge (VRK) to change decision contexts for adaptation and 3) implementing actions using theories of change and adaptation pathways. Though these processes may enable participants to act differently to initiate ITA, it is uncertain whether this can be achieved in practice.

Herein we report on progress in operationalising and implementing this framework in six case studies. Responding to the need to better reflect on adaptation successes and failures, as proposed by Werners et al. (2021), our objective is to examine how ITA 'on the ground', involving different approaches and tools for the three processes listed above, led to particular outcomes: what worked and what did not. First, we consider roles of researchers, agency, power relations and empowerment, and ITA as both incremental and transformative actions. We then examine if the three processes (visioning, VRK and adaptation pathways) enabled or constrained adaptation actions in the case studies. In particular, we assess the extent to which participants were able to re-frame human-nature relationships, deal with uncertainty, engender empowerment and agency, and address conflicting values and interests over adaptation options. Finally, we present a synthesis on ITA co-production and participative learning, involving incremental shifts or

transitions that accumulate towards transformation (van Kerkhoff et al., 2019).

2. Implementing intentional transformative adaptation

How individuals and collectives address the complexity and uncertainty of environmental and social change is a central issue in ITA. Inherent to this issue, and to the success of ITA projects, is consideration of power imbalances and how they are addressed. Co-production dominated by a depoliticised discourse of scientific solutions ignores the power, politics, interests and positions of those engaged in the process and presumes a scientifically sanctioned rationality (Turnhout et al., 2020). We take a critical realist-constructionist perspective on adaptation, institutional reality, rules and power, whereby knowledge and meaning are contingent on social practices and contexts, co-constructed from interactions among people and between people and their world (Elder-Vass, 2012, pp. 55–62, Crotty, 1998, p. 42). The uncertainty and complexity of adaptation means that 'no single group has clear access to understanding the issue and its resolution' (Collins and Ison, 2009, p. 358), but knowledge about adaptation is given meaning by and for participants engaged in real-world co-production of ITA initiatives, particularly in developing visions for the future. Constructionism thus provides a counterpoint to adaptation as a problem to be solved by experts and governments.

Accordingly, we frame the role of researchers as participants in co-production rather than as the source of expertise to address the problem (Clark et al., 2016; West et al., 2019). This framing requires researchers to be reflexive (Preston et al., 2015), relinquish their status as 'experts' and find ways of working with actors engaged with initiatives 'on the ground', an unfamiliar role for many researchers (Butler et al., 2017; Wyborn et al., 2019). Operationalisation through co-production is a key step because adaptation initiatives are prone to failure if they move from concept to implementation without building a shared understanding about the issues, activities and expected outcomes and who participates (Matthews, 2013). Swart et al. (2014) and Preston et al. (2015) called for reflexive, practice-oriented research, or science for adaptation connected with fundamental inquiry, or science of adaptation. Bosomworth and Gaillard (2019) stressed the need for research details on *how* participatory adaptation pathways approaches have been done and not just *what* was done.

2.1. Transformative adaptation in action

Current social and institutional structures and power imbalances can limit the scope for agency in the co-production of ITA strategies and these strategies can themselves reproduce power imbalances (Eriksen et al., 2015). Socio-economic, political and institutional constraints upon agency involve multiple spheres of marginalization (e.g. of gender, ethnicity, class, age, income, education and geographical remoteness), but also issues such as who stands to gain or lose from adaptation outcomes. Structures refers to societal rules, norms and governance to which participants are subject in making decisions about adaptation initiatives. Agency refers to the ability of participants to achieve their objectives through mastering knowledge, resources, and social networks, either within current structures, or by working to change them (Wyborn et al., 2015). As Giddens observes (1984, p. 14): 'Action depends on the capability of the individual to "make a difference" to a pre-existing state of affairs or course of events. An agent ceases to be such if he or she loses the capability to "make a difference", that is, to exert some sort of power.' One way of exerting power is by co-creating shared systems of learning and doing, for example, by co-producing systems understandings that can be put into practice (Newell and Proust, 2017). Communicating the benefits of an adaptation plan can then enable knowledge exchange and co-production of adaptation strategies (Butler et al., 2018). Another approach is to create 'sites of resistance', whereby processes of empowerment are used to challenge

dominant structures, discourses or ways of operating. For example, a group of women farmers used their local knowledge to mobilise and support self-reliant seed saving practices through local exchange and collective credit, thereby shifting away from dependence on chemicals, corporate structures and government credit (Temper et al., 2018). In this example, power is a struggle against a globalised agro-industrial model of injustice rather than against a particular project or company.

Participants in adaptation projects face the task of ‘imagining the future’ and trying to develop and implement actions to overcome novel changes to their particular social-ecological system. These tasks can be daunting, even overwhelming. The demands of everyday life are a powerful inhibitor on people’s ability to think about the future and implement change. For example, in Colorado, participants considered climate change as incremental and that adjustments could be reactive (Wyborn et al., 2015). This view was framed partly by experiences of past change and an unwillingness to support proactive measures because of more pressing economic concerns. Adaptation is thus linked in a very real sense to the daily livelihoods, experience, and aspirations of individuals.

ITA involves overcoming novel challenges as new events are anticipated or occur and as new knowledge is co-produced about changes to social-ecological systems (Lavorel et al., 2019). But options for adaptation are limited by what is achievable within the bounds of biophysical change. Options are kept open and ‘no-regrets’, or ‘low regrets’ strategies implemented, whereby benefits are realised regardless of how change eventuates (Butler et al., 2016a). New options for livelihoods include the use of adaptation services, also known as nature’s contribution to adaptation (NCA): the ecological processes providing benefits to improve people’s ability to adapt to socio-economic and environmental change (Lavorel et al., 2015; Colloff et al., 2016, 2020). Options are created based on systems understandings, diverse perspectives and forms of knowledge, and by explicitly revisiting values, priorities and goals in the context of large-scale change (Múnera and van Kerkhoff, 2019).

2.2. Power and empowerment in transformative adaptation

ITA stands in tension with existing political structures and processes: it is inherently political because it is a societal activity requiring people to change the *status quo*, thus challenging existing power relations (Scoones, 2016; Temper et al., 2018). Power relations among ITA stakeholders affect how people and institutions can negotiate and act (Blythe et al., 2018). They are also determinants of the outcomes of an ITA process, which involves multiple competing values, goals and knowledge of stakeholders (Colloff et al., 2018) as well as the re-framing of organisational identities and capabilities. ITA is a socio-political process that has the potential to constitute and contest existing authority, subjectivity, and knowledge to open up or close down space for transformation (Eriksen et al., 2015; Eisenhauer, 2016). So the ‘work’ of these processes is to engage with and reframe collective agency in ways that engages the political and in doing so, mobilises their transformative potential.

Power imbalances as determinants of transformation can act as major barriers to successful implementation. For example, powerful actors may block adaptation approaches and actions or control them to maintain their preferred interests (Chaffin et al., 2016), especially if the approaches are aimed at rebalancing power and improving social justice (Chhetri et al., 2019). Shifts in power are likely to be an important leverage point or necessary condition for ITA, requiring new power relationships among actors and major changes in political and social structures (Feola, 2015; Pelling et al., 2015; Bentz and O’Brien, 2019). ITA is a participative approach that navigates conflict by deliberation and contestation of ideas and world views prior to making and implementing decisions. How power relationships are managed during ITA remains a challenge, as in any other participatory process (Gaventa and Cornwall, 2006; Turnhout et al., 2020).

Co-production processes that attend to power dynamics can be empowering, but those that do not will likely reproduce or exacerbate existing power imbalances (Turnhout et al., 2020). Using power in a positive way, as empowerment, involves participants in ITA engaging to mobilise collective agency. Power becomes a consequence, not a cause, of collective action (Latour, 1986, p. 269): it holds people together. This is empowerment derived from social relations, or deontic power: ‘The essential role of human institutions...is to create new sorts of power relationships. Human institutions are, above all, enabling, because they create power, but it is a special kind of power. It is the power that is marked by such terms as: rights, duties, obligations, authorizations, permissions, empowerments, requirements, and certifications’ (Searle, 1995, p. 10). In this sense, empowerment emerges and is distributed among individuals and collectives engaged in ITA by the creation of new options through changing the *status quo*. Being part of such a collective confers on individuals not only rights and responsibilities but also membership, identity, and belonging.

2.3. Adaptation as a mix of incremental and transformative actions

ITA is a long-term process of change to the *status quo* and necessarily involves a sequenced mix of incremental and radical adaptations which together result in transformed, adaptive social-ecological systems (Grin et al., 2010). ITA involving a mix of incremental and transformative actions is more likely to engage actors than approaches requiring recognisably radical change (Termeer et al., 2017). Participants still need to frame their goals as transformative but also engage with incremental processes such as forming groups to co-produce shared visions, exchange knowledge, re-frame decision contexts, navigate power imbalances and contestation and implement actions (Butler et al., 2016a).

ITA is thus a process of ‘enabling and accelerating small in depth changes’ that accumulate to transformation (Termeer et al., 2017, p. 571). Lindblom (1959, 1979) considered ‘muddling through’—mostly incrementality, with occasional opportunities for transformation—was appropriate for policy-making in democracies, embodying the messiness of social change. Radical changes may only be possible after a shift in political power. At other times, elites ensure reform is gradual (Cocks, 2003, p. 43). For example, Chilean coastal fisheries underwent collapse in abalone stocks due to a national policy to earn export dollars during the Pinochet dictatorship. Fisher collectives allied with scientists to generate new knowledge on target species and trial new pathways for stock recovery. The opportunity for transformative change came with the return to democracy in 1990: new legislation was introduced that transformed governance by allocating territorial rights and responsibilities to fisher collectives, leading to a sustainable fishery system (Gelcich et al., 2010).

3. Processes used for implementation of intentional transformative adaptation

In addressing the adaptation challenges outlined in the introduction (re-framing of human-nature relationships, dealing with uncertainty, engendering empowerment and agency and addressing conflicting values and interests), we consider three processes used in the case studies (co-producing visions of the future, re-framing of VRK to change decision contexts for adaptation and implementing actions using theories of change and adaptation pathways). Below, we present a rationale for each.

3.1. Co-producing visions for the future

Participatory visioning has been used in ITA initiatives and is gaining popularity (Butler et al., 2020a). This is partly because it involves imaginative deliberations that reveal to participants their preferences and dispositions, helping to build trust. Visioning differs from scenario planning in that visions are normative expressions of the aspirations and

beliefs of participants, whereas scenarios are more often assessments of possible changes to social ecological systems (Rosa et al., 2017). Co-production of visions depends on the different interests assigned by participants to particular outcomes, based on their experience, knowledge, values and dispositions. Unlike scenarios, visions usually do not involve forecasting the effects of drivers of change on ecosystems, though such impacts may be considered in ‘best case’ and ‘worst case’ scenarios (Butler et al., 2016b, 2018; Lavorel et al., 2019). A challenge in visioning is the difficulty for participants in engaging effectively with transformative change, leading them to propose changes that are predominantly incremental. This challenge underpins the importance of co-production as a process of iteration and continual engagement.

3.2. Re-framing the values, rules and knowledge of the decision context

Options for adaptation are determined by systems of values, rules and knowledge (VRK) that decision makers deem credible, legitimate and important (Fig. 1). ‘Values’ means held human values, expressed as preferences, and the ethical principles that inform them. High-level categories of values are conservatism, openness to change, self-transcendence and self-enhancement (Schwartz et al., 2012). Rules determine actions considered acceptable by observance of rules-in-form (laws, guidelines, regulations) and rules-in-use (social norms and behaviours) (Ostrom, 2011). Knowledge includes sense-making systems: science, beliefs, experiential and traditional knowledge, that is ‘useable knowledge’ for adaptation (Clark et al., 2016).

The decision context, defined by the interactions between VRK, is the set of political, social, economic and environmental circumstances relevant to the decision-making process. Interacting systems of VRK determine the powers and agency of decision makers and which values, rules and knowledge they preference. Such choices are influenced by the societal decision system: the network of distributed decision-making processes in civil society (Fig. 1; Gorddard et al., 2016; Colloff et al., 2018). Introducing new options for adaptation requires re-framing the

decision context and the systems of VRK that shape it. Decision contexts define the choices and possibilities for change and set boundaries on how societies address complex contested problems.

3.3. Theories of change and adaptation pathways

A shift to planning for doing things differently under conditions of uncertainty underpins what Haasnoot et al. (2013) call ‘dynamic adaptive policy pathways’, where visions of the future are created to explore and make decisions about possible actions, but allow for adaptation over time to meet changing conditions and new developments. Their example involves a transformative approach to river management in the Rhine Delta, using adaptation pathways and adaptive policy-making to prevent flood disasters caused by climate change. Adaptation pathways approaches thus involve not just doing things differently but transforming how decisions are made and actions implemented under deep uncertainty caused by complex, interacting drivers of change (Bosomworth and Gaillard, 2019). This perspective emphasises ‘pathways thinking’, i.e. how values, rules, knowledge, interests and institutions can constrain or enable societal responses to change, and forms a basis for adaptation pathways as the integrating framework for ITA (Wise et al., 2014; Wyborn et al., 2015).

Theories of change and adaptation pathways are complementary, enabling participants to implement adaptation options (Butler et al., 2016a). Adaptation pathways provide context for a theory of change and the desired change process. Participants can sequence actions iteratively based on how change occurs over time (Wise et al., 2014; Butler et al., 2016a,b). Each theory of change may involve several short-term strategies, shaped by the overarching adaptation pathway. A successful intervention will result in changes to the social-ecological system, requiring a new theory of change. Thus, a theory of change operates at ‘project scale’, addressing issues participants have agency over, such as for decision points or ‘windows of agency’ (Fig. 2; Lavorel et al., 2019). An adaptation pathway is more at system scale, with emphasis on

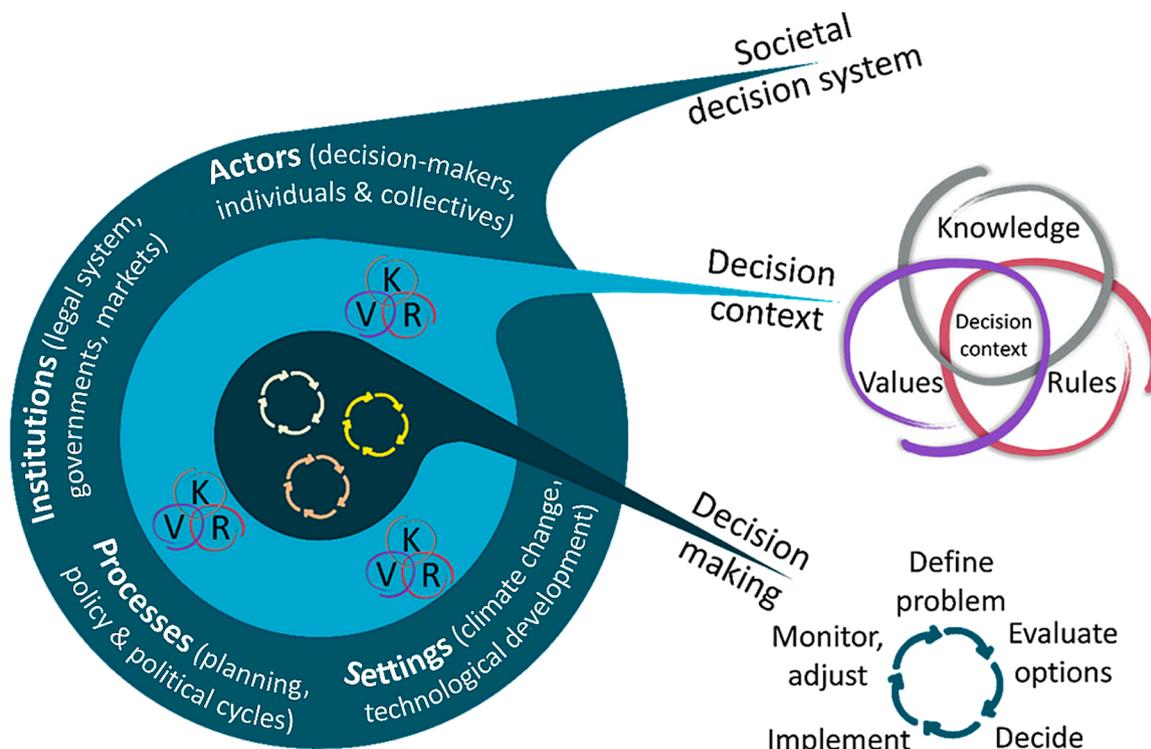


Fig. 1. Three scales of a perspective on decision systems and decision making in society. The decision context, determined by the interaction of systems of values, rules and knowledge (VRK), forms the link between how a decision-making process is affected by its relationship with the broader societal decision system. In democracies, decision-making is devolved to institutions and actors in civil society, including markets, planners, courts, government agencies and parliaments.

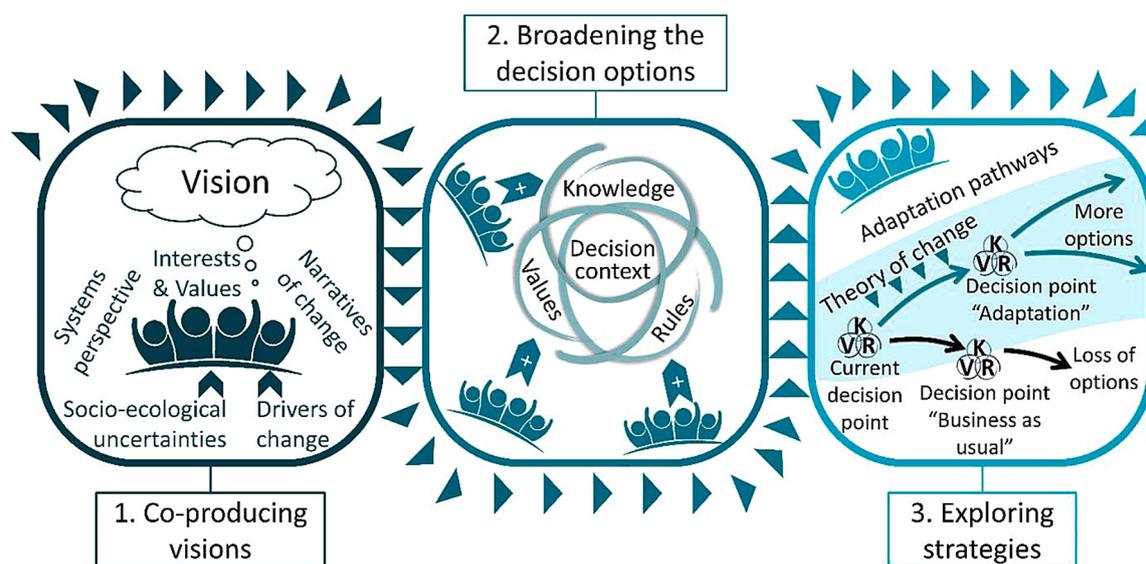


Fig. 2. Three processes for operationalisation and implementation of intentional transformative adaptation: (1) co-producing visions under uncertain futures, developing a systems perspective and narratives of change by participants holding diverse values, interests and dispositions; (2) broadening options for adaptation by changing the values, rules and knowledge that shape the decision context; (3) exploring strategies with theories of change and adaptation pathways to implement options for adaptation. The pathway, showing decision contexts (values, rules and knowledge) at each decision point, or ‘window of agency’, is influenced by objectives and activities in the theory of change.

changes increasingly beyond participants’ control.

A theory of change is ideally co-produced by participants, enabling them to learn from doing, extend a shared understanding of the system, and develop narratives of their world views, visions, logic and assumptions about causal system linkages and dynamics (Vogel, 2012; Butler et al., 2016a). Theories of change and adaptation pathways require a systems perspective that is simple enough to confer agency but of sufficient complexity to provide a systems understanding without being too abstract (Newell and Proust, 2017). This systems view is linked to stages of the adaptation initiative in an iterative sequence, as part of a theory of change within an adaptation pathway, for example: 1) identifying drivers of change and impacts on livelihoods; 2) visioning of futures; 3) building community adaptive capacity and 4) implementing low regrets strategies to achieve the collective vision.

4. Application of adaptation processes in case studies

We report here on how the three processes described above were applied in the six ITA case studies and the extent to which participants could use them to address the four adaptation challenges (re-framing human-nature relationships, dealing with uncertainty, engendering empowerment and agency and addressing conflicting values and interests). Features in common were: 1) ecosystem changes were occurring at a scale that led to 2) transformative changes to livelihoods and management; 3) adaptation involved some systems understanding of drivers of change and 4) adaptation actions were ecosystem-based (cf. Table 1 and references therein). Case studies were from the northern and southern hemispheres, temperate and tropical zones, coastal, inland and mountain regions. Five were focussed primarily on livelihood adaptation and one, Colombia, on transforming knowledge governance for protected area management. One or more of the authors worked on each case study except the Australian case, which was analysed retrospectively based on knowledge of the project by the lead author, supplemented by published reports.

4.1. Co-producing visions for the future

Participatory visioning was used explicitly in four case studies (Table 2). In the French Alps, participants converged on a preferred

vision (*Seeds of Hope*): adaptation of traditional pastoralism, ecotourism, nature conservation and diversified agricultural production, but also considered three plausible but undesirable alternatives. The process revealed the difficulty participants had in imagining the future and uncertainties such as the impacts of climate change. But it also made explicit the problems and opportunities participants have tried to address in their desired vision, as well as opposing values and world views about the development of the region. Engagement in visioning was driven, in part, by community recognition they could not rely on government, precipitated by the 20-month closure by landslide of the main access road, a vital link for work, school, goods and services (Lavorel et al., 2019). The four visions were then incorporated into an adaptation pathway, with critical ‘windows of agency’ or decision points. This pathway approach differs from other case studies by explicitly identifying drivers of change and tipping points between desirable and undesirable states of the social-ecological system and where and when such shifts can be avoided.

In Solomon Islands, participants identified the most important drivers of change affecting their livelihoods (e.g. population growth, climate change and sea level rise, economic pressures, social change) and produced a vision based on ‘how would you like your grandchildren to be living?’ They then constructed a scenario matrix, from moderate to major change for each of two drivers and thus four possible scenarios, including ‘business as usual’, which were then used to inform a modified vision (Butler et al., 2018). Participants could discuss conflicting views and interests by engaging their strong customary capacity for resolving issues by dialogue and debate.

In Colombia, visioning was used in the co-design of the project, particularly for scoping activities and exploring the challenge of shifting from traditional approaches to conservation to transforming the knowledge governance system to a future-oriented approach. Participants identified options for adaptation with an emphasis on benefits to society, not just on biophysical attributes (van Kerkhoff et al., 2019). Framing conservation to include social values and benefits allowed participants to appreciate that local communities have different visions for their land which need to be recognised to engage with their knowledge and values (Múnera and van Kerkhoff, 2019).

In Nusa Tenggara Barat, Indonesia, desired intergenerational visions were integrated within the statutory, government-driven community

Table 1

Characteristics of the case studies undertaken by members of the Transformative Adaptation Research Alliance (TARA). Case studies 1 and 3 are ongoing, case studies 2, 4, 5 and 6 are completed. Case study 6 involved a retrospective analysis.

Case study	Ecosystems and land use	Changes in environmental & other drivers	Ecosystem transformation	Adaptation objectives	Participants	Adaptation approach: bottom-up or top-down	Knowledge co-production	References
1 French Alps (Pays de la Meije)	Temperate montane grasslands, summer pastures, conifer forest, high alpine vegetation; alpine grazing, agriculture & tourism; national park	Shorter snow season, increased temperature & variability of precipitation, melting glaciers, increased rockfall & landslide threat	Increased dominance of drought-resistant grassland species, colonisation by forest	Locally sustainable, nature-based tourism & agriculture	Community members, farmers, tourist sector personnel, national parks staff, students, business owners, researchers, artisans, local government staff	Bottom-up adaptation to achieve vision for future livelihoods based on adaptation pathways & services	Researchers & communities develop shared vision & adaptation pathways. Local groups linked with regional institutions, national parks authority, farmer and tourism collectives & extension services	Lavorel et al. (2019, 2020) ; Bruley et al., 2021
2 Indonesia (Kalimantan & Central Java)	Tropical forests & rubber plantations (Kalimantan), crops & agroforestry (Java); rubber, gold mining (Kalimantan), cattle (Java), subsistence crops (both sites)	Increased temperature & rainfall variability leading to soil water deficits during rice growing season; rice disease outbreaks (Java), floods & erosion (Kalimantan)	Expansion of rubber plantations & protection of forests along rivers & on hilltops (Kalimantan), reforestation (Java)	Food production & incomes from forests (Java); reduction of flood & erosion risks (Kalimantan)	Community members, representatives from local associations, researchers	Planned bottom-up livelihood diversification achieved via changes in land use & local governance arrangements for forestry	Learning by doing: strong systems focus & local ownership. Decision making on land use change made at village scale & by local associations	Fedele et al. (2017, 2018)
3 Solomon Islands (Western Province, Guadalcanal, Ontong Java)	Tropical forest (Western Province), coastal floodplain agroecosystems (Guadalcanal), coral atoll & lagoon (Ontong Java)	Sea level rise, tropical storms, increased temperature, human population growth	Coral bleaching, flooding, damage due to storm surges & sea level rise	Food production & incomes from land & sea; reduction of flood risks	Village leaders, young people & women, researchers, NGO staff (Plan International, WWF, Solomon Islands Development Trust), government staff	Adaptation to achieve food & water security & livelihoods: bottom-up, some top-down	Engagement in visioning, adaptation pathways planning, identifying drivers of change, community capacity for adaptation and low regrets strategies	Butler et al. (2018) , Colloff et al. (2020)
4 Colombia (Churumbelos & Alto Fragua National Parks & Otún Quimbaya Flora & Fauna Sanctuary)	Sub-Andean rainforest in national parks in the Amazon Piedmont & Andean forest and wetlands in the Coffee Triangle	Increased temperature & variability of precipitation, combined with 50 years of civil war	Landscape degradation & altered water balance; glacier melt; lower streamflow, shifts in biotic communities; drought impacts on ecosystem structure & function;	The role ecosystem benefits play in enabling people to adapt & mobilise resources for conservation in protected areas	National Parks staff, researchers, NGO staff (WWF, Luc Hoffman Institute), consultant, community members (people living in or near the parks)	Transformative adaptation of knowledge governance for conservation: bottom-up, some top-down	Multi-stakeholder learning process to address impacts of climate change on conservation governance & management: knowledge governance framework addressing social-cultural aspects of adaptation decision making.	van Kerkhoff et al. (2019) ; Múnera and van Kerkhoff (2019) ; Nordstrom et al. (2020)
5 Indonesia (Nusa Tenggara Barat)	Smallholder farming, fishing, forestry and mining	Changing rainy seasons, intensifying weather events, sea level rise, population pressure and	Destruction of coastal reefs and ecosystems, deforestation, soil infertility, salinization of groundwater	Food security, livelihoods and poverty alleviation that are culturally appropriate	Farmers', fishers', faith & women's groups, local & provincial officials, politicians, business people,	Transformation of integrated bottom-up and top-down <i>Musrenbang</i> community development planning	Multiple decision-makers developing desired future visions, potential future scenarios, low	Butler et al. (2016 a,b,c) , Wise et al. (2016) .

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Table 1 (continued)

Case study	Ecosystems and land use	Changes in environmental & other drivers	Ecosystem transformation	Adaptation objectives	Participants	Adaptation approach: bottom-up or top-down	Knowledge co-production	References	
		shifting cultural norms		and climate-resilient	NGOs, researchers		regrets strategies & adaptation pathways		
6	Australia (Southern Riverina, New South Wales)	Semi-arid inland floodplain chenopod shrubland; grazing systems	Land clearing caused dryland salinity, combined with rainfall variability & drought	Replacement of floodplain woodland with chenopod shrubland: land was abandoned or barely used	Sustainable, drought resistant grazing systems for lamb & wool production	Graziers, government agency staff (Land & Water Australia), researchers, extension officers	Transformed production system via research & knowledge transfer: bottom-up & top-down	Learning by doing via field trials run by graziers; knowledge exchange via grazer networks supported by national-scale R & D co-ordination	Colloff et al. (2016, 2020)

development planning process, *Musrenbang* (Butler et al., 2016c), to enable long-term goal setting, and decisions needed to achieve the visions under rapidly-changing social-ecological-conditions (Butler et al., 2014, 2020b). To manage the acute power imbalances among *Musrenbang* decision-makers and their distinct knowledge culture (Bohensky et al., 2016), a process was designed to engage provincial decision-makers, officials and politicians separately from local community groups, so that the constraints of the *Musrenbang* system could be discussed freely. Following this, the participants, their visions and priority development strategies from each group were combined (Butler et al., 2015, 2016b). This approach aimed to balance and reconcile mismatches between the dominance of government's economic development agenda with the visions of local communities and their demands to determine their own futures (Wise et al., 2016).

In these four case studies, visioning served to prime the co-production process by identifying common interests and divergent viewpoints. It formed a basis for dialogue on changing decision contexts for adaptation and the development of theories of change and adaptation pathways, based on the question, 'what do we need to do to get from where we are to where we want to be?' Visioning helped participants address uncertainty and overcome constraints of societal structures by empowering themselves through changing the way they thought about adaptation.

4.2. Re-framing the values, rules and knowledge of the decision context

In all case studies, re-framing of systems of VRK led to major changes in decision contexts regardless of explicit or tacit use of the VRK perspective (Table 2). In the French Alps, the VRK perspective was used as a diagnostic tool to analyse participants' discourses to identify how the decision context for each window of opportunity in the adaptation pathway might be enabled or constrained by interactions between combinations of V, R and K. In addition, participants engaged in a game that simulated changes to their social-ecological system and possible interventions they could make (Salliou et al., 2021). During debriefings, they identified important changes in VRK required to achieve the vision. In an example of VRK interactions as constraints, participants who identified with traditional land management were more resistant to change; an interaction between their experiential knowledge and held values. Recognizing the adaptive value of revitalised traditional practices could help reframe this constraint as an enabling factor (Lavorel et al., 2020). Co-producing knowledge on livelihood options from adaptation services began to shift entrenched preferences, addressing uncertainty and gaining support for changes to rules and governance (Bruley et al., 2021). Changes in knowledge and values for appreciation of local produce resulted in considering options including novel crops,

horticulture and the reprisal of traditional farm produce (Lavorel et al., 2019). This case study has mostly been driven by changes in knowledge that revealed VRK interactions and the reconsideration of values to broaden the set of credible options. The shifts in K and V provide a basis for shifts in R to create an enabling environment for these options to be implemented, supported by government policy and funding. Values have not really shifted, but agency has been brought to bear through shifts in knowledge co-production.

In Kalimantan, Indonesia, values-rules interactions resulted in a ban on the practice of shifting cultivation in certain forests to promote long-term access to resources and sustainable logging. Knowledge that deforestation increases vulnerability to floods incentivised communities to agree on common rules for conservation and management. Farmers in Central Java formed a community forestry association with sustainable natural resource management labelling and certification. Conflicting interests over resource uses were overcome, in part, by tacit use of VRK to reframe decision contexts for the co-production of new rules and practices for land use and management (Fedele et al., 2017, 2018). It was difficult for communities to agree on shared longer term visions because daily lives are focused on immediate needs. However ideas for ITA were mostly inspired by small-scale trials by individuals, or government-supported programs, emphasising the importance of learning by doing and by demonstration as a means of shifting the knowledge base to enable adaptation.

In Solomon Islands, tacit use of VRK enabled communities to apply systems thinking and long-term planning to collective action for adaptation (Butler et al., 2018). For example, people have revised their plans for the location of new houses based on sea level rise projections. Community members identified numerous options for livelihood adaptation including community forestry, sustainable fisheries, applying and receiving grants to improve water security and donating profits from sale of cash crops to social funds of local Savings Clubs for use in community projects.

In Colombia, the VRK perspective was used explicitly by participants to deliberately reflect on current decision contexts and decision-making and start to re-frame them towards the goal of 'future-oriented conservation'. It enabled them to explore new governance arrangements, prepare for ecosystem change while remaining focused on shared values underpinning protected areas (van Kerckhoff et al., 2019). Issues of power and politics were evident throughout the co-production process, highlighting mismatches in expectations and understandings of the role and usefulness of certain activities and the different world views and expectations of participants. For example, the project was about climate change but land use change was often considered more important by some NGO staff, thus shifting the focus on power relations to other actors. These different interpretations were made more difficult to

Table 2

Details of the case studies, involving three processes: (1) co-production of shared visions; (2) use of values, rules and knowledge (VRK) perspective to reframe decision contexts and broaden options; (3) use of theories of change (ToC) and adaptation pathways (AP) and how these were used to re-frame human-nature relationships, deal with uncertainty, develop empowerment and agency and address conflicting values and interests over adaptation options. Explicit use: where processes were used in co-production workshops. Tacit use: where processes were used informally, as inferred from case study outcomes.

Case study & status	Processes			Issues addressed by processes			
	Co-production of visions for the future	Broadening options & decision contexts using VRK	Use of theories of change & adaptation pathways	Addressing uncertainty	Re-framing power, structure & agency issues	Re-framing human-nature relationships	Addressing conflicting world views & interests
1 French Alps: ongoing	Explicit use: co-production of shared vision for the region in 2040, using workshops & a game that simulated changes to social-ecological system	Tacit use as a diagnostic tool, e. g. changes in VRK for appreciation of local produce resulted in scoping renewed forms of management: novel crops & traditional farm products	ToC: not used; AP: explicit use as courses of action to reach vision and identify 'windows of agency' for change, enhanced by use of a game to engage community & explore adaptation options	Use of adaptation services: grazing of drought-resilient grasslands, diversified agricultural production & tourism. Some change in views of how people can act collectively for adaptation	Community realised the need to organise & act collectively to achieve change & not rely on government	Relatively slight so far, except recognition that <i>Patzkea paniculata</i> grassland, considered of poor quality, is highly drought resilient & supplies adequate fodder	Conflicting traditional v. novel perspectives addressed by consensus on vision & recognised benefits from diverse livelihoods. Tensions between conservatism and 'sustainable non-development'
2 Indonesia (Kalimantan & Central Java): completed	Tacit use: problem of rainfall variability, erosion & deforestation recognised; shared community vision on what to do about it	Tacit use: in Kalimantan, new community rules developed & enforced to protect forests to ensure multiple benefits from adaptation services	Tacit use: focus group discussions on livelihood adaptation strategies & responses to increased rainfall variability	Reducing risks to livelihoods by transforming land use & practices	Formation of community forest association & new common rules to conserve forests & reduce erosion	Recognition of socially-accepted & inclusive benefits from supply of adaptation services incentivised further adaptation	Decision-making operates via strong local community associations, with consultation, discussion & consensus
3 Solomon Islands: ongoing	Explicit use: co-production of shared visions for the future in community workshops	Tacit use: changes in VRK enabled communities to start applying systems thinking & long-term planning to collective action for adaptation	Explicit use: to identify 'no regrets' strategies, prioritise actions & develop proposals for funding	Major changes in view of what people can do to achieve adaptation, focussed on practical measures for livelihood & income diversification	Visioning & AP gave communities a systems approach to adaptation planning, empowering them	People thinking & acting more systematically about managing natural resources in a climate change context	Addressed via decision-making involving strong customary practices of dialogue & debate
4 Colombia: completed	Explicit use: in co-design of the project, scoping & exploring the challenge	Explicit use: applied throughout the project to ensure dialogue included social & political values; institutional settings, conventions & rules, technical and non-technical knowledge	ToC: explicit use to ensure dialogue & reflection; AP: tacit use as a series of linked transitions from traditional to future-oriented conservation	Synthesis of local ecological impacts of climate change highlighted what was known & limits on current state of knowledge	Climate adaptation re-framed from a scientific issue based on problem solving to a governance issue & ongoing learning	Shift from conservation plans & practices focussed on biodiversity & resisting ecological change to ones that anticipate change & include social values & benefits	Conflict between traditional view of conservation to future-orientated view addressed by structured series of workshops, processes & tools
5 Indonesia (Nusa Tenggara Barat): completed	Explicit use: in investigating potential futures during multi-stakeholder workshops	Explicit use: applied to identify knowledge cultures & their influence on the decision context	Explicit use: to identify low regrets strategies, objectives & actions for their implementation	Exploration of alternative futures caused by rapidly changing drivers & deriving low regrets strategies	Community visions & priorities empowered by tackling embedded discrimination in <i>Musrenbang</i>	Recognition of over-exploitation of natural resources & need for improved, innovative management measures	Recognising politics of <i>Musrenbang</i> and managing power imbalances through participatory processes
6 Australia (Southern Riverina): completed	Tacit use: as part of conventional project planning and objective setting	Tacit use: from top-down approach of scientists & extension officers giving graziers options for change to bottom-up: graziers learning by doing	AP: not used. ToC: tacit use via project planning; where are we now, where do we want to be in the future & how do we get there?	Development of profitable markets for saltbush lamb led to reduced economic risk	Rebalancing power relationships of who has control over knowledge co-production	Recognition that saline chenopod shrubland, previously deemed unproductive, can support a sustainable grazing system	Addressed via field days & demonstration sites: other graziers convinced by seeing results for themselves

navigate in part because power and politics were not explicitly addressed.

In Nusa Tenggara Barat, the community development planning process began with the recognition of acute power imbalances among cross-level decision-makers and their knowledge cultures, and the co-production process had to be managed to mitigate these. Thus, the K component was applied as an entry point to influence the decision context. Subsequently, the V and R were revealed and addressed by visioning, adaptive capacity assessments and identifying strategies (Butler et al., 2015, 2016b).

In Australia, interactions between held values of graziers associated with openness to change, combined with the need for new knowledge for livelihood options, led to transformational changes in rules about how research is undertaken. These changes enabled control and ownership by graziers over the research agenda, knowledge transfer and governance for co-production of novel sustainable grazing systems on saline land (Colloff et al., 2020).

In all case studies, the VRK perspective resulted in examples of major changes in ways that participants thought about and acted on adaptation options. These included design and implementation of new options for livelihoods, creation of community groups and sets of rules for management of natural resources, major changes in rules and social norms for knowledge governance and significant shifts in roles, responsibilities and behaviours. One of the most important applications of the VRK perspective was its use to inform changes to decision contexts, as required at each decision point, or window of agency, in an adaptation pathway (Lavorel et al., 2019).

4.3. Using theories of change and adaptation pathways

Theories of change and adaptation pathways were used explicitly in three case studies (Table 2). In the French Alps, the adaptation pathway, developed through the game-playing process and incorporating the preferred *Seeds of Hope* vision, represents a course of action, but also a working conceptual model of the dynamics of the social-ecological system, its drivers of change and the alternative, undesirable states. The process of building adaptation pathways allowed participants to identify levers and barriers to adaptation to reach the preferred vision, helped by the VRK perspective analysis (Bruley et al., 2021).

In Solomon Islands, visioning formed the basis for adaptation planning. Prior to developing their adaptation pathways, participants identified the adaptive capacity of their communities, strengths and weaknesses, and low regrets strategies to achieve their vision, compatible with the possible future scenarios. These strategies were prioritised and aligned with community capacity to achieve them. Participants then identified pathways of decisions and actions needed to implement the strategies. The adaptation pathways incorporated a theory of change by identifying specific sequenced actions, who undertakes them and how (Butler et al., 2018). This final stage was particularly important for communities because it enabled them to submit funding applications for implementing adaptation initiatives in the next phase of the project.

In Colombia, a theory of change was used to ensure dialogue and reflection among participants. Tacit use of adaptation pathways was via a series of linked transitions and actions to help participants move from traditional to future-oriented conservation (van Kerkhoff et al., 2019; Fig. 1 therein).

5. Discussion

We have detailed how three processes (visioning, the VRK perspective and adaptation pathways) were applied in six ITA case studies. We found examples where these processes clearly helped participants engage with and address the challenges of ITA: re-framing human-nature relationships, dealing with uncertainty, engendering empowerment and agency, and addressing conflicting values and interests (Table 2). However, we also detailed examples of where processes were not

working, such as communities having difficulties in finding ways to work co-operatively to achieve their objectives.

Co-production of shared visions for the future enabled a sense of engagement and ownership by participants. In the process of co-production, we found clear examples of participants learning about systems perspectives that gave them agency to alter the decision context for adaptation by re-framing systems of VRK. This allowed development and implementation of options for adaptation using theories of change and adaptation pathways. These findings accord with those of Barnes et al. (2020), who recognised three domains of adaptive capacity common to adaptive and transformative actions: organization, learning, and agency. These authors found social networks were a source of support and adaptive capacity, influencing transformative actions and agency, and supporting learning. However, different social networks can lead to different governance outcomes. For example, emergence of novel ideas and approaches can be constrained by social networks that contribute to the reinforcement of current norms and perceptions (Bodin, 2017). Dowd et al. (2014) found that Australian farmers with strong social networks tended to be incremental adaptors, whereas more transformational adaptors had sparse social networks but extensive knowledge networks. This finding is consistent with our argument herein – that building social cohesion and implementing incremental adaptations may be necessary precursors to transformation of the system as a whole.

Some case studies are ongoing (Table 2), but participative learning and co-production of visions has given participants agency to apply the VRK perspective to windows of agency in an adaptation pathway, particularly in Nusa Tenggara Barat and the French Alps (Fig. 2; Butler et al., 2016a, 2016b; Lavorel et al., 2019). In the latter case, some of the processes have helped participants scope new options for livelihoods, start to re-frame local adaptation decision making and begin engaging with governments, NGOs and other partners (Lavorel et al., 2019). However, scope for collaborative action and working together appears limited by path-dependencies in the current top-down governance system (Butler et al., 2016c).

We also found that each of the six case studies was underpinned by strong pre-existing social connections and networks. These connections entail attributes of co-operation, trust, engagement, inclusion, and shared identity from which co-production can be mobilised. These attributes helped participants address challenges and trade-offs inherent to ITA (Lavorel et al., 2020). Without such connections, co-production of knowledge and change is likely to be harder to undertake.

5.1. Two contrasting approaches to intentional transformative adaptation

Participants in ITA initiatives may aim to achieve deliberate, continuous anticipatory objectives as their primary focus; an approach that accords with the belief that transformative adaptation should be in-depth, broad-scope, and rapidly implemented, despite major trade-offs between these attributes (Termeer et al., 2017). An alternative perspective, based on our experiences from the case studies, involves incremental actions as anticipatory priming for change, to take advantage when opportunities for transformation arise. Incremental adjustments shift the system towards structural change (Termeer et al., 2017) and ‘cumulative incremental changes may coalesce into what appears in retrospect as a transformational adaptation’ (Kates et al., 2012, p. 7156). Participants learn, re-frame, and explore futures, connecting old and new ways of doing things that are acceptable and create demand for transformation. In Nusa Tenggara Barat, pockets of transformational knowledge and partnerships were established at the village level by trialling innovative low regrets livelihood strategies which formed ‘bridgeheads’ for wider transformation should political windows of opportunity arise (Butler et al., 2016a, 2016c).

In the Colombian case study, van Kerkhoff et al. (2019) considered four propositions for change, and developed tools to support them, in shifting from traditional conservation towards a future-oriented transformative approach for management of protected areas. Individually,

these propositions represent incremental transitions, but cumulatively they support transformative change in social organisation and knowledge governance systems, in which change is considered the norm and managers can think beyond calendars and maps and engage with Indigenous knowledge and perspectives (Múnera-Roldán et al., 2020).

Here, we take a similar perspective, with five propositions (Fig. 3): moving from resisting to anticipating change, dealing with uncertainty as the norm, strengthening bottom-up agency and synergising it with top-down approaches, shifting adaptation from a science issue to one of governance, and from problem-solving to learning and co-production (Clark et al., 2016; West et al., 2019). We consider these transitions, and the processes and heuristics that support them, will lead to transformative adaptation. Each transition is illustrated with examples from the case studies. Two are of particular note. In the French Alps, the use of a carefully designed game (Salliou et al., 2021), accompanied by debriefing interviews provided the structure that enabled agency to scope a broad range of strategic adaptation options by a diverse group of participants who had little or no experience of co-production processes. In Solomon Islands, participants in a training workshop openly and enthusiastically embraced systems thinking and long-term planning, again with little or no prior experience, and passed on what they had learned to their local communities. This knowledge transfer and engagement led to the submission of grant applications and the awarding of funding to implement their plans.

5.2. A plurality of concepts, processes and heuristics

As well as the approach we detail here, other frameworks can be used for ITA, including: (1) leverage points for sustainability (Abson et al., 2017), whereby changes to social structures, values and goals can lead to large system changes, (2) systems thinking in practice capability (Ison, 2018) that builds systems competency to address change and (3) the Sustainability Transitions Research Network approach (Wittmayer et al., 2017; Köhler et al., 2019). These frameworks are complementary, but each has its limits. For example, deep leverage points for system transformation may be inaccessible to participants if they cannot change the decision context for adaptation at deeper levels. Perhaps what matters most is not the specifics of the approach of choice but whether it involves processes for participative learning for co-production of adaptation in ways that link theory with practice and engender empowerment and agency (Newell and Proust, 2017; van Kerkhoff et al., 2019). Swart et al. (2014) argue that a strong emphasis on practice-oriented adaptation research needs to be connected with fundamental inquiry and

concept development using knowledge from a range of disciplines and issues beyond climate change adaptation.

5.3. Muddling through the paradoxes of intentional transformative adaptation

There are inherent paradoxes in the frameworks listed above that must be lived with when trying to act purposefully to implement ITA. For example, the three processes we outlined allowed some participants to view the system from a position of agency, but the question arises of how to choose actions when the future is so uncertain. Participants could identify strategies required to change decision contexts, but may lack sufficient knowledge of contexts and VRK interactions to achieve meaningful change (Olsson et al., 2015). These contradictions cannot be solved, because they arise repeatedly, according to circumstances and contexts. Hence, they can only be dealt with by ‘re-solving’, i.e. by being addressed again and again (Rittel and Weber, 1973) through the application in each context of the range of complimentary tools and heuristics applicable to these frameworks. ITA as a continual, iterative process of re-solving raises the issue of governance for adaptation initiatives. Ultimately, adaption governance takes the form of whatever social conventions people bring to address these issues, such as the strong traditional community practices for resolving issues by inclusive dialogue and debate in the Java and Kalimantan and Solomon Islands case studies. Adaptation governance arrangements will therefore tend to be context-dependent, *ad hoc*, co-produced, and based on existing structures and processes, but will include features to enable participative, multi-level learning and a future orientation in planning.

Implementing a theory of change or an adaptation pathway requires an inclusive systems approach. However, participants may be biased towards their own interests and unrepresentative of the broader community, requiring a re-framing of perspectives as implementation progresses. Central to this re-framing are issues of ethics and inclusiveness. Again, the framework of choice is perhaps a secondary issue and what matters is whether it helps build deliberate *systemic practice*: empowered purposeful action, reflexivity and responsiveness to change (Ison, 2018). Such an approach highlights the need to move from selfish actions to collective ones. Most transformative actions require novel and meaningful collaboration, rather than individuals acting alone. This is one of the main contributions that co-production of governance can make to pathways practice (Wyborn et al., 2019).

Focussing on governance enables changes to how things are done, rather than just what is done (Termeer et al., 2017; Wyborn et al., 2015).



Fig. 3. Five transitions from conventional approaches to adaptation to transformative approaches, with examples of actions, processes and outcomes from the case studies. Based on van Kerkhoff et al. (2019; Fig. 1 therein).

Part of systemic practice involves transforming governance to systems of co-production of planning, experimenting and learning (Ison, 2018). But governance systems also have the potential to exacerbate inequalities (Huitema et al., 2016). As adaptation measures are implemented, so new conflicts and power issues will emerge. Co-production and adaptive governance may help, but only if the adaptation agenda is re-politicised using legitimate and robust processes to promote debate over different ideas and values. Turnhout et al. (2020, p. 18) stated: ‘it is important to understand co-production as both a knowledge-making and a political practice which is inevitably imbued with unequal power relations that need to be acknowledged but cannot be managed away. Instead, it will be vital to allow for pluralism, create scope to highlight differences and, enable the contestation of interests, views, and knowledge claims.’ Opening up adaptation as a contested political space may risk reducing collaboration, but recognising and navigating this tension is ultimately necessary to scale-up by engaging and empowering large sections of society to adapt to climate change.

Author statement

MJC led the drafting of the manuscript, co-ordinated and drafted the revisions. BL produced the figures and MJC, BL, CW, JRAB, SL, LvK, CM-R, EB, GF, RMW and MD were engaged in, and contributed information from, the six case studies. All co-authors contributed to editing and revising the text.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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