



## Priming adaptation pathways through adaptive co-management: Design and evaluation for developing countries



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### ABSTRACT

Mainstreaming climate change and future uncertainty into rural development planning in developing countries is a pressing challenge. By taking a complex systems approach to decision-making, the adaptation pathways construct provides useful principles. However, there are no examples of how to operationalise adaptation pathways in developing countries, or how to evaluate the process. This paper describes a 4 year governance experiment in Nusa Tenggara Barat Province, Indonesia, which applied adaptive co-management (ACM) as a governance approach to 'prime' a transformation to adaptation pathways-based development planning. The project's Theory of Change (ToC) consisted of three causally-linked phases which mirrored the evolutionary stages of ACM: priming stakeholders, enabling policies and programs, and implementing adaptation. The first phase established a trans-disciplinary research team to act as facilitators and brokers, a multi-stakeholder planning process demonstrating adaptation pathways practice, and trialling of 'no regrets' adaptation strategies in case study sub-districts. A participatory evaluation method was designed to test the ToC's assumptions and measure ACM outcomes. Stakeholder interviews at the project's closure indicated that through ACM, stakeholders had been successfully primed: leaders emerged, trust, cross-scale social networks and knowledge integration grew, communities were empowered, and innovative adaptation strategies were developed and tested. However, there was limited evidence of institutional change to existing planning processes. This was attributed to the absence of policy windows due to ineffective and insufficient time for political engagement, and the fluid institutional environment caused by a national decentralisation policy. To enhance the priming of adaptation pathways into development planning under these conditions, three recommendations are made: (1) provide long term support for emergent leaders and brokers to become 'policy entrepreneurs' who can capitalise on policy windows when they appear, (2) establish and support local livelihood innovation niches as 'bridgeheads' for ACM, and (3) maintain participatory evaluation amongst primary stakeholders to re-kindle ACM.

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## Introduction

Mainstreaming climate change into decision-making to achieve ‘climate compatible development’ for vulnerable rural communities in the developing world is a pressing challenge (Mitchell and Maxwell, 2010). The process is complicated by the uncertainties in climate change projections and impacts (Ranger and Garbett-Shiels, 2012), and the multi-stakeholder and cross-sectoral nature of adaptation (Conway and Mustelin, 2014). Population growth, market volatility and modernisation driven by globalisation also interact with climate change to generate non-linear and unexpected outcomes and shocks for livelihoods (Scoones et al., 2007; Leach, 2008). Ramalingam (2013), p. 361 recently argued that as a consequence, development planning and evaluation requires a more “systemic, adaptive, networked, dynamic approach” based on complex systems thinking and governance.

By taking a complex systems approach, the construct of adaptation pathways provides a useful framework for integrating climate adaptation into decision-making under future uncertainty (Wise et al., 2014), and is potentially applicable to rural development planning in developing countries (Butler et al., 2014, 2016a). There are three central principles. First, climate change impacts and responses cannot be considered in isolation, but instead are components of dynamic, multi-scale social–ecological systems. Second, planning should design incremental adaptation strategies to address the proximate symptoms of communities’ vulnerability, plus transformative strategies to tackle the underlying systemic causes, which in developing countries are often institutional and political (Lemos et al., 2007; Pelling, 2011; Rodima-Taylor et al., 2012). Third, to avoid mal-adaptation (i.e. actions that impact adversely on or increase the vulnerability of other systems, sectors or social groups; Barnett and O’Neill, 2010), strategies should yield benefits under any future conditions of change, and therefore be ‘no regrets’ (Hallegatte, 2009).

The process of implementing these principles requires multi-stakeholder engagement and adaptive governance (Butler et al., 2014), whereby stakeholders voluntarily coordinate action through self-organisation (Folke et al., 2005). Adaptive co-management (ACM) is a novel manifestation of adaptive governance tailored to the stewardship of complex social–ecological systems, where multi-stakeholder collaboration is required to match the ecological scale and dynamics of a system (Armitage et al., 2009). By integrating the iterative learning, knowledge generation and problem solving of adaptive management with the power-sharing and negotiated decision-making of co-management (Olsson et al., 2004a; Armitage et al., 2007; Plummer et al., 2012; Fabricius and Currie, 2015), ACM fosters stakeholders’ adaptive capacity (Plummer, 2013), defined here as “the potential for actors within a system to respond to changes, and to create changes in that system” (Chapin et al., 2006, p. 16641).

ACM is potentially applicable to climate change adaptation because of the necessity to engage private and public actors across societal levels, to build their adaptive capacity, and to develop and implement policy and collective action through collaboration (Plummer, 2013). ACM’s characteristic focus on learning is especially relevant because both individual and social learning are pre-requisites for adaptation (Pelling, 2011). Within this, double-loop (re-visiting of assumptions about cause and effect) and triple-loop learning (re-assessing underlying values and beliefs, potentially resulting in changes to institutional norms; Pahl-Wostl, 2009; Reed et al., 2010) are particularly important because they can identify and challenge the systemic causes of communities’ vulnerability to climate change (Pelling, 2011; Rodima-Taylor et al., 2012). In addition, interventions which apply ACM principles to link actors across sectors and scales can ‘prime’ them to implement adaptation processes (Baird et al., 2014).

Hence ACM may facilitate the implementation of adaptation pathways, particularly for rural communities in developing countries which are dependent on ecosystems and often excluded from government planning processes (Butler et al., 2014). Nonetheless, this context also presents several challenges for successful ACM. Stakeholder capacity is low at all societal levels, constraining collaboration, and without long term resourcing and facilitation, self-organisation dissipates (Cundill and Fabricius, 2010). Participatory planning aiming to empower communities is often dominated by more powerful government and expert stakeholders’ agendas (Sherman and Ford, 2013), requiring approaches that can account for power asymmetries (Armitage, 2008). Also, rapid economic and cultural change continually re-shapes the political and institutional environment, undermining trust and cooperation between stakeholders (Wollenberg et al., 2007).

In this paper we present a governance experiment which applied ACM principles as a means to prime stakeholders in developing countries to integrate adaptation pathways principles into rural development planning. Using the example of a 4 year project in Nusa Tenggara Barat Province (NTB), Indonesia, we demonstrate the project’s design, and a participatory evaluation methodology which tracked project outcomes in terms of ACM. The results assess the applicability of ACM as a mechanism for establishing climate compatible development in developing countries. We also discuss the implications of our results for the design of future adaptation initiatives in similar social and political contexts.

## Attributes and evolution of ACM

The evolution and maintenance of ACM depends upon a combination of endogenous and exogenous system characteristics (Plummer, 2009; Plummer et al., 2012), summarised from the literature in Table 1. Endogenous factors are the combined attributes of individuals, organisations, social networks and governance processes which together yield ACM outcomes. However, power asymmetries often marginalise communities and individuals in negotiated decision-making and knowledge exchange with more powerful actors (Nadasdy, 2007; Armitage et al., 2008; Plummer et al., 2012), and in a development

**Table 1**  
Attributes and outcomes of successful ACM.

| Attributes                                 | Outcomes                                                                                                                                  | References                                                                        |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Stakeholders engaged throughout the system | Holistic and integrated systems understanding; multi-scale stakeholders engaged in co-management                                          | Armitage (2008), Armitage et al. (2009)                                           |
| Power dynamics addressed                   | Barriers to stakeholder representation understood and rectified                                                                           | Armitage (2008)                                                                   |
| Marginalised community members included    | Resource users empowered in co-management; traditional ecological knowledge engaged in management                                         | Armitage et al. (2009), Berkes (2009)                                             |
| Trust generated                            | Conflict resolution; bridging of stakeholders within and across scales                                                                    | Armitage (2008), Armitage et al. (2009)                                           |
| Cross-scale social networks established    | Social learning; double- and triple-loop learning; self-organisation; resources mobilised for problem-solving and innovation              | Plummer and Armitage (2007), Cundill and Fabricius (2010), Armitage et al. (2009) |
| Leadership generated                       | Leaders emerge as 'policy entrepreneurs', providing an alternative vision, acting as agents of change, and brokering amongst stakeholders | Olsson et al. (2004a, b), Armitage et al. (2009)                                  |
| Political engagement                       | 'Windows of opportunity' for policy change exploited by leaders                                                                           | Olsson et al. (2004a, b)                                                          |
| Monitoring and evaluation                  | Feedback enables reflexivity to complex system effects                                                                                    | Armitage et al. (2009), Cundill and Fabricius (2009)                              |

context this issue is a systemic cause of vulnerability (Lemos et al., 2007; Rodima-Taylor et al., 2012). Consequently, to be successful ACM must also address power dynamics and the inclusion of marginalised communities.

Exogenous factors are also necessary to trigger ACM. These can be a resource crisis or shock, a change in the political context (Plummer, 2009; Butler et al., 2015a), or an intervention intentionally engineered to induce ACM through collaborative activities (e.g. Cundill and Fabricius, 2010; Smedstad and Gosnell, 2013). Following an exogenous influence, ACM evolves through stages, enabled by the endogenous characteristics of actors and processes (Olsson et al., 2004a; Berkes et al., 2007; Plummer, 2009). Olsson et al. (2004b) identified three. First, in 'preparing the system for change', leadership emerges amongst local resource stewards. These 'policy entrepreneurs' build knowledge of the problem, develop social networks within and across scales, and provide a vision and goal for an alternative approach. Second, in 'the window of opportunity', policy entrepreneurs exploit or precipitate policy windows at higher political levels to enact the alternative approach agreed in the first stage. Third, in 'building resilience of the desired state', a 'policy community' is formed. This consists of expanding cross-scale social networks and partnerships between stakeholders with common objectives that arise during the window of opportunity, who act to build resilience of the social–ecological system's desired state.

## Project design

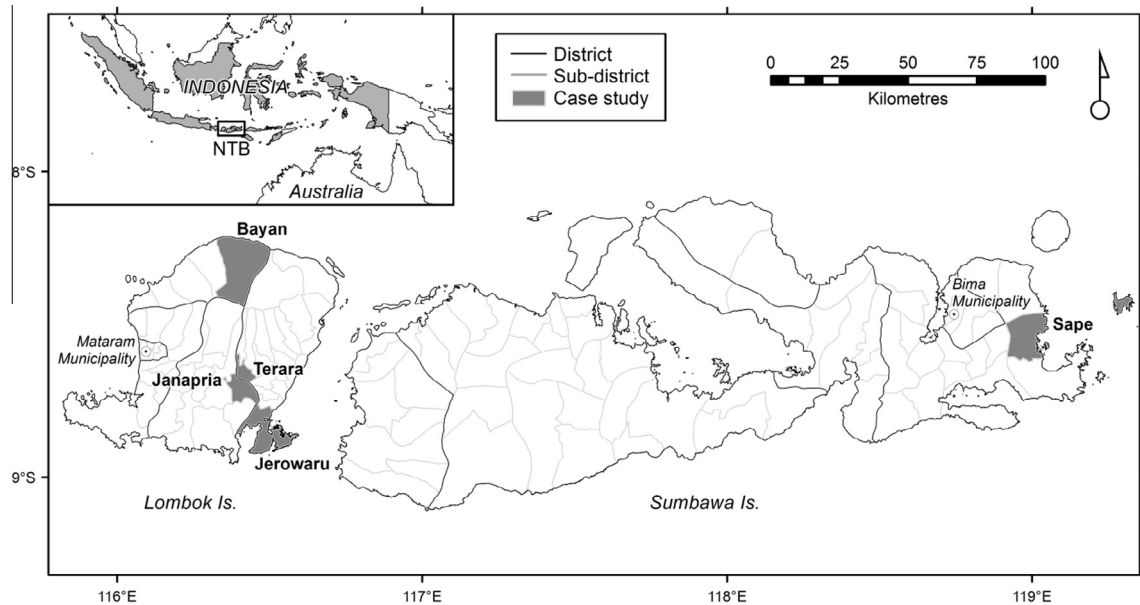
### Study area

Nusa Tenggara Barat (Fig. 1) is one of the poorest provinces in Indonesia, and most poverty occurs in rural areas. Systemic causes of poverty and community vulnerability are population growth, corruption, weak leadership and inadequate community participation in development planning. These underpin proximate causes including a lack of health and education services, and declines in land, food and water availability and mutual assistance practices (Butler et al., 2014, 2016b). In 2010 the NTB provincial government established a Climate Change Task Force (CCTF) to integrate adaptation and development within the province, the first of its kind in Indonesia (Ministry of Environment, 2010). However, due to poor coordination between government, donor and non-government organisations (NGOs), exacerbated by stakeholders' lack of awareness of future impacts of climate change and other drivers, the potential for mal-adaptive decision-making remains high (Butler et al., 2014).

As part of a national decentralisation policy, in 2004 the Indonesian government introduced an annual cycle of integrated top-down and bottom-up development planning ('musrenbang'). Through multi-stakeholder consultations at the village, sub-district and district government levels, the process formulates community development plans which are linked to provincial and national public expenditure planning. While communities are represented at all consultation stages, the process is often captured by political elites and government officials, resulting in communities' needs not being met. Information on which to base decisions is often unavailable to communities, women and poorer households are marginalised by the lack of procedural justice, and non-government stakeholders are seldom included (Purba, 2011; Aswad et al., 2012). There is also considerable confusion amongst participants about their roles (Aswad et al., 2012), exacerbated by the regular subdivision of districts and sub-districts to create new administrative units and bureaucracies (Hunter, 2004).

### Governance experiment

The establishment of the CCTF and the institutional flux caused by decentralisation presented an opportunity to establish an alternative approach to development planning in NTB. Consequently, in 2010–2014 the Australian government's aid



**Fig. 1.** Nusa Tenggara Barat Province (NTB), Indonesia, showing the five rural sub-district case studies.

donor, AusAID, funded a project with the goal to ‘integrate adaptation pathways practice into development planning to build stakeholders’ adaptive capacity, and reduce the vulnerability of rural communities to adverse future change’. This would be achieved by running a planning process mimicking musrenbang in five rural sub-district case studies (Fig. 1). Through engagement and learning, stakeholders would be primed to transform musrenbang to include adaptation pathways practice and diverse stakeholders’ knowledge in an iterative, self-organising and equitable decision-making process reflecting ACM.

The project was designed as a governance experiment, whereby actors in a system are engaged to purposefully induce change in that system (Loorbach, 2010). Creating a ‘learning architecture’ is fundamental (Burns, 2014), and is achieved by linking stakeholders and their knowledge through planning, learning-by-doing and reflection (Brown, 2008; Loorbach, 2010). Studies from socio-technical transition (e.g. Bos and Brown, 2012; Bos et al., 2013) and action research (e.g. Ballard, 2005; Brown, 2008; Burns, 2014) have recommended design principles for governance experiments that create opportunities for individual, social, double- and triple-loop learning, and thus systemic change. Bos et al. (2013) collated these into three themes: pre-conditions, project governance and process design. When combined with similar principles from action research, plus Burns (2014) suggestion that running parallel processes can mitigate power asymmetries amongst stakeholders, 10 design dimensions are apparent across the themes (Table 2).

The intent of these dimensions to generate multi-stakeholder engagement, empowerment and learning clearly mirror the attributes and outcomes of ACM (Table 1). Hence, by applying these principles in the design of our governance experiment, we expected to prime an ACM process. This was to be achieved by linking multiple actors across geographical scales and jurisdictional levels through four activities, facilitated by a research team (the ‘Tim Kolaboratif’) and a Steering Committee (Fig. 2). The facets of the design are described below and summarised in Table 2.

#### *Tim Kolaboratif*

The project was initiated as a formal partnership between researchers from the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), the University of Mataram (UNRAM), and Indonesia’s National Agricultural Technology Assessment Agency and the Bureau of Meteorology and Geosciences (BMKG). The first year was spent establishing the Tim Kolaboratif, consisting of 15 biophysical and social scientists (five CSIRO and 10 Indonesian). An experienced bi-lingual Indonesian facilitator was also employed to join the Tim Kolaboratif, who through the project activities coached team members in facilitation techniques. The Tim Kolaboratif was the project’s fulcrum, brokering amongst stakeholders, and organising and facilitating all activities (Fig. 2).

#### *Steering Committee*

To provide the partnership with strategic direction, a Steering Committee was established. This consisted of the directors of the two provincial government departments responsible for the CCTF, plus a representative of the project donor, AusAID. The World Food Program (WFP), which was running extensive climate change and food security projects in NTB, was also represented by its provincial director. The Tim Kolaboratif was represented by the senior CSIRO and UNRAM researchers. Meetings were held approximately quarterly, enabling an agile response to changes in the policy environment. The Steering

**Table 2**

Design themes, dimensions and definitions for governance experiments based on Ballard (2005), Brown (2008), Bos and Brown (2012), Bos et al. (2013) and Burns (2014), and equivalent features of the project in NTB.

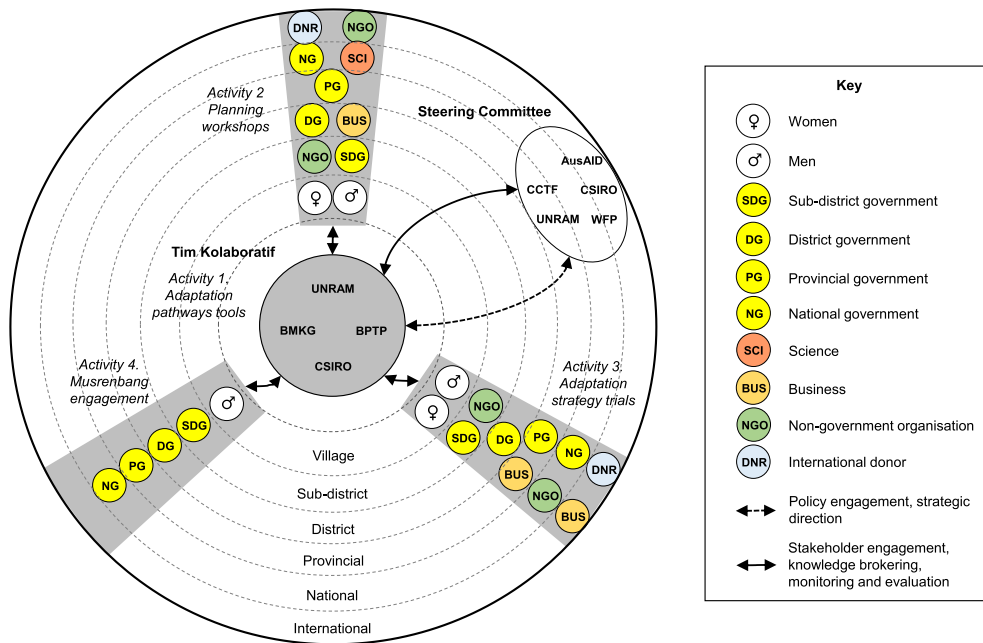
| Theme              | Dimension                               | Definition                                                                                                             | Project equivalent                                                                                                                                                                                                                       |
|--------------------|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (a) Pre-conditions | – Legitimacy                            | Political support to endorse alternative and experimental process                                                      | Political support secured through CCTF membership of Steering Committee, enabling the Tim Kolaboratif to engage with musrenbang in Activity 4                                                                                            |
|                    | – Resources                             | Dedicated resources to develop and implement innovative policy and tools                                               | AusAID committed 4 years of funding                                                                                                                                                                                                      |
|                    | – Time                                  | Time to develop and adapt learning processes and trust amongst actors                                                  | 1 year to establish Tim Kolaboratif through Activity 1; 2 years for Activity 2; 18 months for Activity 3                                                                                                                                 |
| (b) Governance     | – Multi-stakeholder representation      | Actors engaged within and across levels of the system                                                                  | Steering Committee represented international, national and provincial levels; Activity 2 and 3 engaged stakeholders from village to international levels                                                                                 |
|                    | – Reflexive, adaptive                   | Monitoring and evaluation designed to respond to shifting political context and learning process                       | Monitoring and evaluation sub-team established in Tim Kolaboratif; embedded in activities and quarterly Steering Committee meetings to encourage learning and capacity building within the project                                       |
| (c) Process design | – Shared learning agenda with resonance | Issues of mutual concern to be explored                                                                                | Project focussed on community adaptation and poverty alleviation                                                                                                                                                                         |
|                    | – Focus projects and learning-by-doing  | Multiple inquiries connected within and across levels to analyse systems as a complex problem, and to test innovations | Activity 2 workshops analysed climate change as a component of social–ecological systems, and linked stakeholders' perspectives and solutions across levels; Activity 3 tested adaptation strategies as innovations                      |
|                    | – Multi-organisational peer groups      | Form groups to promote knowledge exchange, social networks, double and triple-loop learning, leadership and trust      | Stakeholder groups formed by Activity 2 workshops, which also promoted social learning and double- and triple-loop learning; Activity 3 created farmer groups and collaborations with Tim Kolaboratif and other multi-level stakeholders |
|                    | – Parallel processes to manage power    | Separate stakeholders to manage power, knowledge and competing goals                                                   | Activity 2's stage 1 and 2 workshops segregated higher from local level stakeholders prior to integration in Stage 3                                                                                                                     |
|                    | – Distributed facilitation              | Diverse roles and responsibilities to broker knowledge and bridge scales                                               | Tim Kolaboratif coached as facilitators and acted as brokers to link stakeholders; skilled facilitator employed; Steering Committee provided political leadership                                                                        |

Committee was intended to gain political legitimacy for the project by including the CCTF's directors and their linkages to international, national and provincial policy processes (Table 2, Fig. 2).

### Activities

*Activity 1 Adaptation pathways tools:* In this activity the Tim Kolaboratif prepared the methods, data and tools required to implement adaptation pathways practice in musrenbang. Undertaken in the first year, it fostered the trans-disciplinarity necessary to analyse social–ecological systems by invoking four principles: the joint development of an analytical framework that integrated and equally recognised social and biophysical components (Strang, 2007), allowing time for idea generation (Pennington, 2008), and encouraging self-reflection and learning (Angelstam et al., 2013) mediated by an independent facilitator (Harris and Lyon, 2013). Tools, data and their application have been presented in other papers in this special issue, and in summary include:

- Downscaled climate change projections (McGregor et al., 2016) and potential impacts for the agriculture and water sectors (Kirono et al., 2016).
- Population projections (Fachry et al., 2011).
- A typology of sub-districts based on ecosystem services (Rochester et al., 2016).
- A participatory model for evaluating future scenarios' impacts on ecosystem services and human well-being (Skewes et al., 2016).
- A scenario planning framework which analysed rural communities as components of social–ecological systems, capturing multiple drivers of change for livelihoods including climate change. Planning workshops formed consecutive, structured learning cycles (Butler et al., 2015b), and steps were designed to trigger double- and triple-loop learning and identify transformative strategies to tackle systemic issues. Back-casting from future scenarios screened strategies to ensure that they were no regrets under all potential development trajectories (Butler et al., 2016b).
- Multi-criteria analysis which prioritised adaptation strategies according to their 'climate compatibility' (Wise et al., 2016).



**Fig. 2.** The project's design and four activities, relative to stakeholder groups and their jurisdictional levels. Acronyms are CSIRO (Commonwealth Scientific and Industrial Research Organisation), UNRAM (University of Mataram), BPTP (Agricultural Technology Assessment Agency), BMKG (Bureau of Meteorology and Geosciences), NTB Climate Change Task Force (CTF) and the World Food Program (WFP).

**Activity 2 Planning workshops:** Planning workshops aimed to engage stakeholders from the village to international levels (Fig. 2) in the five case studies. The process covered the project's second 2 years, and involved three stages: Stage 1 provincial scenario planning, Stage 2 sub-district scenario planning, and Stage 3 sub-district integration (see Appendix A). The Stage 1 and 2 workshops analysed future livelihoods from the perspectives of stakeholders from higher and local levels, respectively, which were shown to differ (Bohensky et al., 2016). This parallel process aimed to mitigate potential power asymmetries amongst stakeholders prior to their integration in Stage 3 (Butler et al., 2015b).

The workshops applied the Activity 1 tools to formulate priority no regrets strategies and a development plan for each case study (Fig. 3a). Prior to each workshop a stakeholder analysis was carried out to identify and prioritise 30–40 individuals with responsibility for and knowledge of community development and natural resource management at the levels concerned, and included musrenbang participants. To ensure representation of women, female stakeholders were prioritised.

**Activity 3 Adaptation strategy trials:** Twelve prioritised adaptation strategies were tested by the Tim Kolaboratif over 18 months through participatory action research with farmers and fishermen in the case studies. Examples included an innovative seaweed growing technique that minimised storm damage (Fig. 3b), and food diversification and processing by women's groups to reduce dependence on drought-prone rice (Fig. 3c; Liu et al., 2016). Trials aimed to integrate knowledge, empower communities and women, and generate cross-scale social networks and partnerships between local communities and other stakeholders (Fig. 2).

**Activity 4 Musrenbang engagement:** Following completion of the planning workshops and strategy trials, the Tim Kolaboratif engaged with the 2013–2014 musrenbang cycle of meetings in the case studies. Team members presented the development plans, trialled adaptation strategies, adaptation pathways tools, and the Activity 2 planning process to musrenbang participants, consisting largely of male village representatives, sub-district and district government officials (Fig. 2). It was expected that this engagement would be expedited by the Steering Committee's political influence.

### Monitoring and evaluation

Monitoring and evaluation was embedded within the project by a sub-team of the Tim Kolaboratif. The sub-team carried out evaluation surveys amongst workshop participants (Butler et al., 2015b; Bohensky et al., 2016), and 'wash-up' sessions with the Tim Kolaboratif after events to review lessons learned and consider improvements to the process, which also fostered trans-disciplinarity (see in Section "Activities"). The adaptation strategy trials were reviewed every 6 months. Feedback on activities' progress was reported to the Steering Committee (Fig. 2). Together, these methods intended to promote reflexive project management and learning amongst the Tim Kolaboratif and Steering Committee (Table 2), exemplifying ACM within the project's governance. This was augmented by the ex-post evaluation presented in the following section.



**Fig. 3.** (a) Workshop participants applying scenario planning, and adaptation strategy trials for (b) seaweed production and (c) food processing by a women's group.

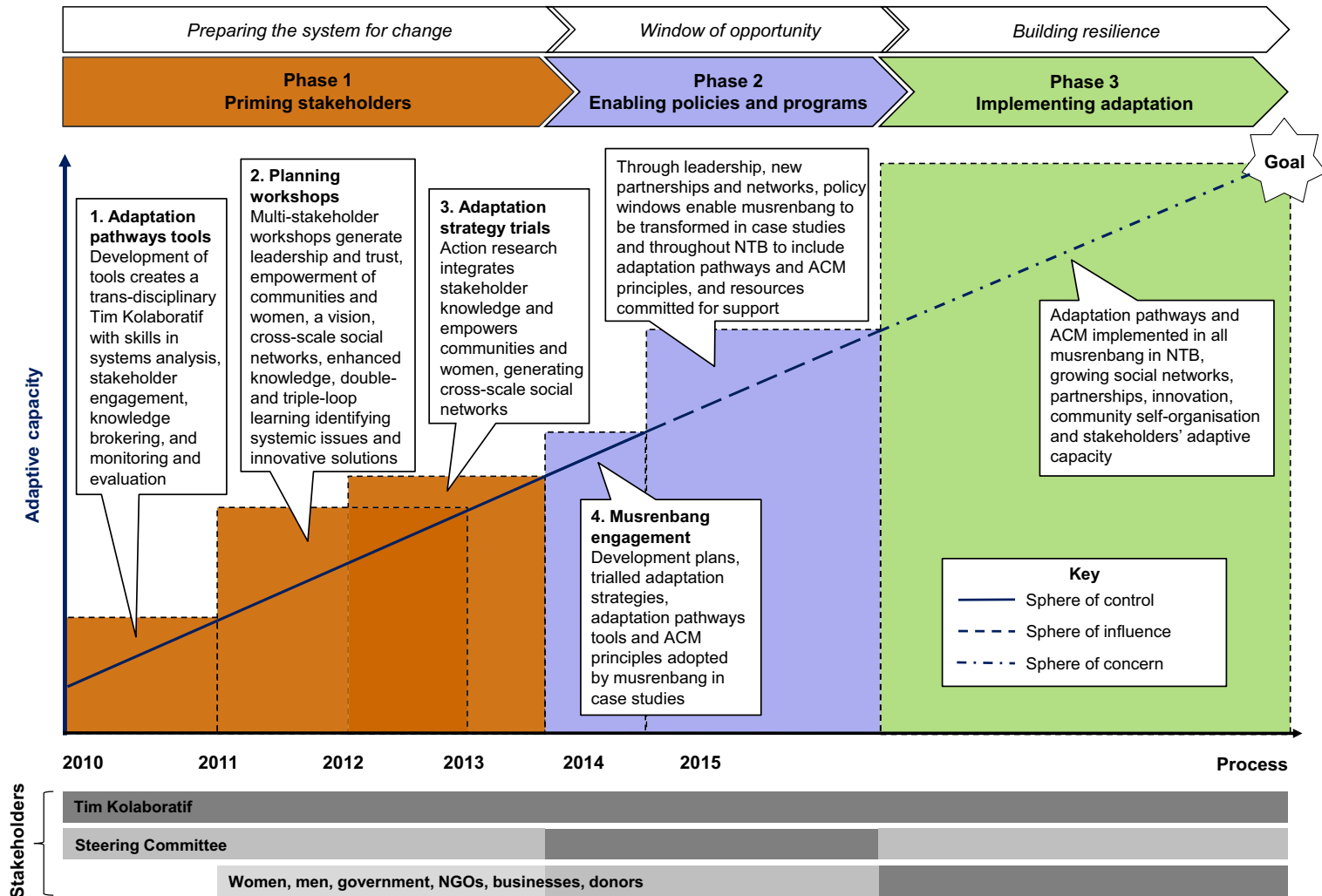
## ACM evaluation

### *Theory of Change*

To frame the anticipated evolution of ACM, a project Theory of Change (ToC) was developed by the Tim Kolaboratif. A ToC articulates a vision of social change, and describes the assumptions about the sequential relationships between interventions and change (Vogel, 2012; Bours et al., 2014). The ToC assumed that ACM would be triggered by the project design, priming stakeholders to implement adaptation pathways practice in the case studies. As a consequence, policy windows would be precipitated, enabling the transformation of musrenbang in the case studies and throughout NTB, ultimately achieving the goal of building stakeholders' adaptive capacity and reducing the vulnerability of rural communities to adverse future change.

The ToC followed three causally-linked phases, which we equated with Olsson et al. (2004b) stages of ACM evolution (Fig. 4). Phase 1 priming stakeholders reflected 'preparing the system for change'; Phase 2 enabling policies and programs reflected the 'window of opportunity', and Phase 3 implementing adaptation reflected 'building resilience of the desired state'. Through each stage it was assumed that the numbers of stakeholders engaged would grow, cumulatively building adaptive capacity at all levels in NTB.

As the primary brokers and facilitators, it was planned and expected that Tim Kolaboratif members would become leaders and policy entrepreneurs in all phases (Fig. 4). The Steering Committee's role peaked in Phase 2 when they would provide



**Fig. 4.** The project Theory of Change, time frame, phases, activities and assumed outcomes. Darker shading of stakeholders indicates a stronger role. [Olsson et al. \(2004b\)](#) equivalent stages of ACM are also shown (top). The project goal was to 'integrate adaptation pathways practice into development planning to build stakeholders' adaptive capacity, and 'reduce the vulnerability of rural communities to adverse future change'.



political influence to transform musrenbang, and linkages to broader policy processes. This would recede in Phase 3 once policy windows had been generated. Other multi-level stakeholders were engaged cumulatively starting in Activity 2, and their roles were assumed to strengthen in Phases 2 and 3 as leadership, new partnerships and networks emerged and expanded, involving more communities. The project's sphere of control covered the four activities. This was assumed to recede after project closure in June 2014, but the leadership and partnerships developed amongst the stakeholders were expected to continue through Phases 2 and 3.

### Participatory evaluation

#### ACM indicators

There is no standardised approach to evaluating ACM due to the plasticity and context-specific nature of the process (Plummer, 2009). Hence we adapted three complementary perspectives. Plummer and Armitage (2007) proposed a generic framework to evaluate ACM interventions based on 20 tangible and intangible outcome parameters. Plummer (2009) synthesised key characteristics necessary for the emergence of ACM, and Armitage et al. (2009) suggested 10 preconditions for the evolution and maintenance of effective ACM. These perspectives highlight the dual objectives necessary for evaluating collaborative processes: measuring the attainment of intended outcomes, plus assessing whether the outcomes have created preconditions for the process to continue (Innes and Booher, 1999).

We selected indicators from these approaches to match the ToC's assumptions (Fig. 4). Nine outcome indicators were used to evaluate Phase 1, five of which were preconditions for ACM to continue (Table 3). Six outcome indicators were relevant to Phases 2 (Table 4) and 3 (Table 5), of which four were also preconditions for ACM to continue. Two outcome indicators in Phase 3 reflected the project's goal. Community empowerment was included as a precondition and outcome indicator for Phase 1 due to its importance for ACM in developing country contexts. As recommended by Plummer and Armitage (2007), indicators within each phase were intended to overlap to provide triangulation.

#### Stakeholder interviews

At the project's closure in June 2014, the monitoring and evaluation sub-team carried out structured interviews with project participants. Interviewees were selected following a three stage filtering process. First, to focus on participants who had the broadest and most contextualised perspectives of the process, only individuals that had attended at least two planning workshops were selected, including Indonesian members of the Tim Kolaboratif. Second, their availability was determined, and third, if available their willingness and consent to be interviewed was elicited.

Indicators were transposed into questions (Appendix B) and translated into Bahasa Indonesia. Interviews were carried out individually and took 1 to 1 ½ h. To counter 'memory distortion' (Wiek et al., 2014), the project's ToC was revisited at the start of each interview. Responses to questions were discussed for up to 5 min. Each question was then presented as a proposition, and the interviewee was asked to give a score on a 5-point Likert scale from 'strongly agree' (score = 2), 'agree' (1), 'maybe' (0), 'disagree' (−1) and 'strongly disagree' (−2). Interviewees' responses were digitally recorded and later translated into English for analysis. The scores given for each indicator were averaged to standardise responses (van Vaerenbergh and Thomas, 2013). All scores in each phase were also averaged, providing a more robust composite measure of outcomes (de Vaus, 2002). 'Don't know' responses were recorded but omitted from the calculation of means.

**Table 3**

Indicators for ACM preconditions and outcomes to evaluate the Theory of Change assumptions in Phase 1 priming stakeholders (see Fig. 4).

| Indicator                                                                                                        | Precondition (P) or outcome (O) | Theory of Change assumptions                                                                                                                           |
|------------------------------------------------------------------------------------------------------------------|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Emergence of leaders prepared to champion the process                                                         | P and O                         | Leaders emerge as policy entrepreneurs and engage politically to take and create opportunities for action                                              |
| 2. Trust created amongst key stakeholders                                                                        | P and O                         | Trust generated amongst stakeholders                                                                                                                   |
| 3. Empowerment of communities                                                                                    | P and O                         | Marginalised community members empowered, particularly women                                                                                           |
| 4. Vision and goal for an alternative pathway                                                                    | O                               | Leaders champion an alternative vision for development planning                                                                                        |
| 5. Cross-scale social networks                                                                                   | P and O                         | Social networks established to enable self-organisation, bridge scales to mobilise resources and knowledge for problem-solving, and engage politically |
| 6. Enhanced knowledge of the problem                                                                             | P and O                         | Stakeholders engaged to enhance a systems understanding of poverty and community adaptation                                                            |
| 7. Different knowledge types successfully integrated and accepted                                                | O                               | Stakeholders' knowledge of poverty and adaptation successfully integrated and accepted                                                                 |
| 8. Questioning of values, norms, routines and governance underlying the problem, and awareness of its complexity | O                               | Double- and triple-loop learning identifies systemic causes of community vulnerability, and systems understanding                                      |
| 9. Creative solutions and innovations                                                                            | O                               | Tim Kolaboratif develops adaptation pathways and systems analysis skills and tools; innovative adaptation strategies developed and trialled            |

**Table 4**

Indicators for ACM preconditions and outcomes to evaluate Theory of Change assumptions in Phase 2 enabling policies and programs (see Fig. 4).

| Indicator                                                                                                   | Precondition (P) or outcome (O) | Theory of Change assumptions                                                                                                                         |
|-------------------------------------------------------------------------------------------------------------|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Management plans and/or agreements                                                                       | O                               | Development plans produced for case studies; policies and programs introduced to enable adaptation throughout NTB                                    |
| 2. Enabling changes to/or new institutional arrangements                                                    | O                               | Adaptation pathways and ACM adopted by case studies' musrenbang; policy changes create windows of opportunity to transform musrenbang throughout NTB |
| 3. Cross-scale social networks expanding to mobilise knowledge and resources                                | P and O                         | Expanding social networks between participants, new partners and Tim Kolaboratif                                                                     |
| 4. Resources made available for implementation                                                              | P and O                         | Adaptation strategies funded in case studies' musrenbang; resources committed to support musrenbang transformation throughout NTB                    |
| 5. New partnerships and cooperative initiatives                                                             | O                               | New partnerships between Tim Kolaboratif and stakeholders create windows of opportunity                                                              |
| 6. Outgrowth from the initial arrangements to address additional issues within or beyond the problem domain | O                               | Policies and programs introduced to enable adaptation more broadly in NTB                                                                            |

**Table 5**

Indicators for ACM preconditions and outcomes to evaluate Theory of Change assumptions in Phase 3 implementing adaptation (see Fig. 4).

| Indicator                                                                                              | Precondition (P) or outcome (O) | Theory of Change assumptions                                                                                               |
|--------------------------------------------------------------------------------------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| 1. Implementation of innovations in arenas that trial, monitor and learn                               | P and O                         | Adaptation strategies implemented in case studies and other sub-districts within a monitoring and learning framework       |
| 2. Enabling changes to/or new institutional arrangements                                               | O                               | Musrenbang transformed throughout NTB to adopt adaptation pathways and ACM                                                 |
| 3. Cross-scale social networks expanding to mobilise knowledge and resources                           | P and O                         | Social networks expanding between original and new partners, communities and Tim Kolaboratif                               |
| 4. New partnerships and cooperative initiatives                                                        | O                               | New partnerships providing resources for implementation of adaptation pathways, ACM and adaptation strategies              |
| 5. Enhanced community self-organisation that matches scales and anticipates external drivers of change | O                               | Project goal achieved: enhanced stakeholder adaptive capacity and reduced community vulnerability to future adverse change |
| 6. Enhanced community capacity to live with uncertainty and change                                     | O                               | Project goal achieved: reduced community vulnerability to future adverse change                                            |

## Results

### Indicator scores

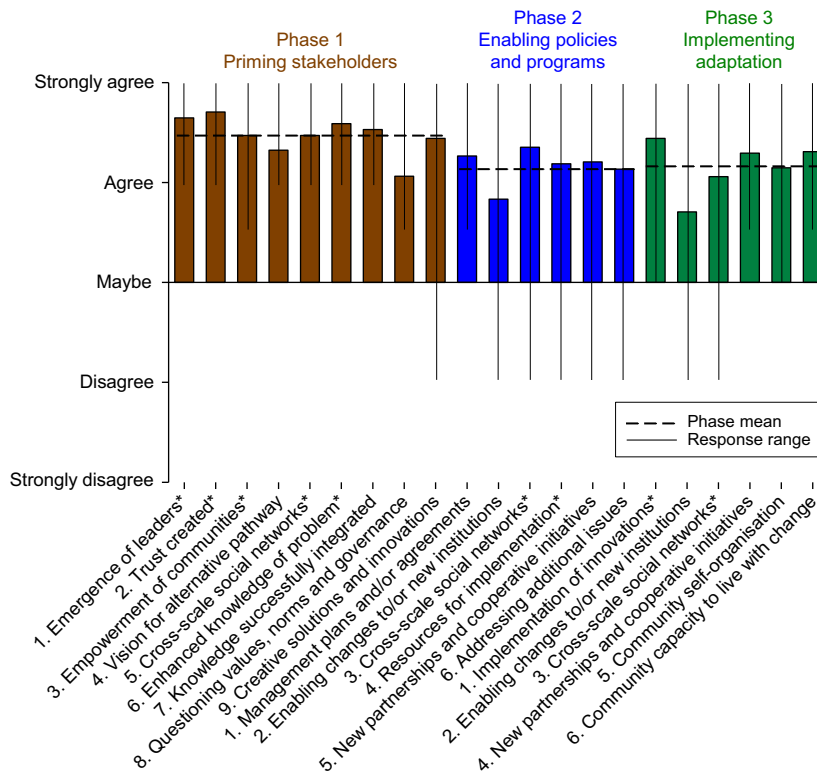
Seventeen stakeholders were interviewed, comprising nine Tim Kolaboratif members, four provincial government, two NGO and two village level participants. The highest mean score was for Phase 1, with the average response lying mid-way between 'agree' and 'strongly agree' (Fig. 5). The highest-scoring indicator was 'trust created amongst key stakeholders', followed by 'emergence of leaders prepared to champion the process'. Both were ACM preconditions and outcomes. The lowest-scoring indicator, although still positive, was 'questioning values, norms, routines and governance'. One respondent disagreed that 'creative solutions and innovations' had occurred, and one recorded a 'don't know' score.

Phases 2 and 3 had similar mean scores, lying slightly above 'agree' (Fig. 5). For Phase 2 the highest-scoring indicator was 'cross-scale social networks', followed by 'management plans and/or agreements'. The former was an ACM precondition and outcome. The lowest-scoring indicator, although still positive, was 'enabling changes to/or new institutional arrangements'. Six respondents disagreed on four indicators, and there were five 'don't know' scores.

For Phase 3 the highest-scoring indicator was 'implementation of innovations in arenas that can trial, monitor and learn', followed by 'enhanced community capacity to live with uncertainty and change', which was one of the project goal indicators (Table 5). The former was an ACM precondition and outcome. As for Phase 2, the lowest-scoring indicator, although still positive, was 'enabling changes to/or new institutional arrangements'. One respondent disagreed on two indicators, and there were no 'don't know' scores.

### Interviewees' responses

Summaries of interviewees' responses are collated below, and explain several of the highest-scoring plus the lowest-scoring indicators for each phase.



**Fig. 5.** Mean scores for each indicator given by the interviewees ( $n = 17$ ), ranges for their responses, and mean scores for all indicators in each phase. \* denotes indicators that are ACM preconditions and outcomes.

*Phase 1 Priming stakeholders*

*Trust created amongst key stakeholders (highest-scoring):* Interviewees highlighted the increased trust that emerged amongst the Tim Kolaboratif, especially from different organisations. One commented: “this project opened an opportunity to know other people or experts from other study backgrounds, and has initiated ideas that can be followed up and realised in other projects. This has opened the team’s mind about working across disciplinary expertise”. Trust was also evident in collaborations forged between the Tim Kolaboratif and the WFP, and with farmers involved in the adaptation strategy trials.

*Emergence of leaders to champion the process (second-highest scoring):* Eight Indonesian members of the Tim Kolaboratif were identified as champions for the project’s process. Two research assistants also emerged as leaders, and they were recruited by an international NGO and a national eco-tourism business in 2013 to establish new climate adaptation programs for these organisations. The directors of the NTB offices of BMKG and the WFP were also identified as new leaders. Several village stakeholders involved in the adaptation strategy trials were also identified as leaders, including one woman. One was described as follows: “before the project he was just an ordinary participant, but after he became a motivator, a source of information, and a facilitator for other people”.

*Enhanced knowledge of the problem (third-highest scoring):* Tim Kolaboratif interviewees unanimously agreed that their understanding of climate change adaptation and social–ecological systems had increased. One stated: “climate change is much more complex than just climate – it needs to consider all aspects of livelihoods and their drivers”. Through the strategy trials the researchers also learned collaboratively with community members about the realities of local livelihood challenges and the relevance of the strategies. Knowledge exchange and integration about climate and population projections, plus the identification of locally-appropriate strategies was also strongly evident amongst the Tim Kolaboratif and other stakeholders as a result of the planning workshops and trials.

*Empowerment of communities (fourth-highest scoring):* Communities were empowered through two activities. First, the Stage 2 and 3 planning workshops enabled communities to be equitably represented, and to promote their priority strategies to government, NGO and business stakeholders. One interviewee commented: “with the workshops at the sub-district level the community was empowered to cope with their problems. Some of them brought their strategies to the 2013–2014 musrenbang”. Second, through the trials farmers and fishermen were trained, and in two trials women’s groups were empowered through collaborations with the Tim Kolaboratif.

*Questioning of values, norms, routines and governance underlying the problem (lowest-scoring):* There had been some identification of systemic issues by workshop participants, and realisation of the complexity of adaptation and poverty

alleviation. However, this did not extend to political issues such as corruption. In terms of current development planning, one NGO interviewee claimed that “adaptation strategy issues have not been the government’s priority; infrastructure is the government’s priority”. A community representative considered that as a result of the workshops the government “should now consider what we need, because before they have thought only about what they want”.

### *Phase 2 enabling policies and programs*

*Cross-scale social networks (highest-scoring):* There was widespread evidence of expanding social networks between stakeholders, the Tim Kolaboratif and new partners. For example, linkages emerged between farmer groups involved in strategy trials and business sector buyers of produce, facilitated by the Tim Kolaboratif. The WFP also established new networks between two district governments and with UNRAM.

*Management plans and/or agreements (second highest-scoring):* Development plans were produced by the project for all case studies, and trialled strategies were included in the 2013–2014 musrenbang in four case studies. In one case study, UNRAM, BMKG, WFP, the district government and an eco-tourism company signed an agreement to implement adaptation strategies. Facilitated by leaders from the WFP, the adaptation pathways tools were applied to highlight priority sub-districts for the NTB government’s 2012 action plans on food security and climate change. However, the NTB 5 year Development Plan produced in 2014 did not target resources towards transforming musrenbang in the case studies or elsewhere, or support the 2012 action plans.

*Enabling changes to/new institutional arrangements (lowest-scoring):* Other than the inclusion of some trialled strategies in four case studies’ musrenbang, there was no evidence of adaptation pathways practice or ACM being adopted in the case studies. Nor did policy changes occur at the national or provincial government level to create a window of opportunity for transforming musrenbang more broadly. Despite their engagement in project activities, a major impediment was the lack of political will amongst the provincial and district government officers to modify the process because the ongoing subdivision of districts and sub-districts was creating new administrative roles and structures. Several interviewees noted that these officers were unwilling to relinquish control of musrenbang. Others mentioned that the Steering Committee had not effectively engaged with national and provincial politics to generate windows of opportunity for the project to exploit. This was partly attributable to the re-deployment of the CCTF representatives to new positions in the NTB government in 2013, following provincial elections. It was also highlighted that there had been insufficient recognition by the Tim Kolaboratif and Steering Committee of the political importance of district level leaders and officials, who had become increasingly powerful during the project through ongoing decentralisation.

### *Phase 3 Implementing adaptation*

*Implementation of innovations in arenas that trial, monitor and learn (highest-scoring):* All of the strategy trials had been implemented in the case studies, and 6-monthly evaluations were carried out by the Tim Kolaboratif to provide on-going reflection and learning. The national Ministry for Regional Development also signed agreements with UNRAM to scale-out two trialled adaptation strategies to other sub-districts. However, none of the other priority strategies included in each case study’s development plan had been included in their 2013–2014 musrenbang, or implemented.

*Enhanced community capacity to live with uncertainty and change (second-highest):* This was the highest-scoring indicator reflecting the project’s goal. All interviewees stated that through the planning workshops community participants had increased their awareness of climate change and other future issues, and that the trials had equipped them with new skills and opportunities for livelihood diversification. However, these impacts only related to the case studies, and not to other communities.

*Enabling changes to/new institutional arrangements (lowest-scoring):* Through the trials some local informal institutions had been altered, such as the organisation of cassava growing and processing by women, and co-management of a river catchment. Interviewees agreed that musrenbang had not yet been modified in NTB.

## **Discussion**

Mainstreaming climate change and future uncertainty into rural development planning in the developing world presents numerous challenges. Stakeholders must first understand adaptation pathways concepts, and then existing planning processes must be modified to adopt these concepts within an adaptive governance framework which can account for limited capacity, power asymmetries and institutional flux caused by rapid change. We conducted a 4 year governance experiment that applied ACM principles as a priming mechanism to modify the existing community development planning process (musrenbang) to include adaptation pathways practice. A ‘learning architecture’ was created to engage multi-level and musrenbang stakeholders in activities designed to generate community empowerment, collaboration, leadership, trust, cross-scale social networks, knowledge integration and innovation. The project’s ToC assumed that as a result of these activities, the trialled adaptation strategies, development plans and adaptation pathways tools would be adopted in the case studies. Through leaders and ‘policy entrepreneurs’ cultivated by the process, policy windows of opportunity would be precipitated to transform musrenbang in the case studies and throughout NTB.

Our evaluation results suggest that within the 4 year life of the project the experiment was unsuccessful. Although some of the trialled adaptation strategies were implemented by musrenbang in four case studies, the prioritised strategies that

formed the development plans were not. The adaptation pathways tools and ACM principles were not adopted in the case studies, or more broadly in NTB. For the case studies, a simple explanation is that once the adaptation pathways tools and planning process had been completed, the project only had time to engage with one musrenbang cycle in 2013–2014. Also, the anticipated policy windows did not materialise within the case studies or at higher jurisdictional levels. Several interviewees commented that the Steering Committee did not link effectively with political processes to precipitate policy windows. This was exacerbated by the re-deployment of the CCTF representatives in 2013 following a provincial election, curtailing their potentially influential role. The importance of engaging district government politicians and officials was also not recognised until the ex-post evaluation interviews.

The unpredictability of policy windows is not unusual in ACM. In the Kristianstad wetlands of Sweden, the second stage of ACM only progressed once four political issues had converged over a period of 1–2 years (Olsson et al., 2004b). For the ACM of conflict between seal conservation and salmon fishery interests in Scotland, the policy window emerged 5 years after the initial exogenous shock (Butler et al., 2015a). Kingdon (1995) emphasised that policy windows occur irregularly because they are both problem-driven (i.e. a pressing problem that needs a solution) and politically-driven (i.e. problems that justify attention because they meet the incumbent government's political agenda). While the establishment of the CCTF in 2010 reflected the former, sub-optimal political engagement by the project failed to create the latter. Also, interviewees suggested that the lack of a political response was exacerbated by the institutional flux caused by decentralisation, and the desire by government officials to maintain control of musrenbang.

This is corroborated by Wollenberg et al. (2007), who found in another Indonesian province that during a similar period of political upheaval the chaotic institutional environment undermined trust and the legitimacy of decision-making. In this situation, Wollenberg et al. (2007) resorted to establishing 'spontaneous cooperation' on the periphery of formal governance processes. In NTB, rather than expecting whole-sale changes to musrenbang, it may have been more realistic to focus on establishing informal 'livelihood innovation niches' which create safe arenas for innovation in governance and technology, allowing transformative practice to develop amongst more fluid and emergent rules, and without penalty for failure (Butler et al., 2014). These could act as 'bridgeheads' for ACM to expand into formal planning processes when conditions allowed. To some extent this was achieved by the adaptation strategy trials, which created nascent ACM around natural resource management in the case studies, including the emergence of community leaders, cross-scale social networks, knowledge integration, empowerment, learning-by-doing and changes to local institutions.

Despite the lack of political progress, the evaluation did reveal many positive ACM outcomes, indicating that stakeholders had been successfully primed to transform musrenbang. The mean score for Phase 1 priming stakeholders lay mid-way between 'agree' and 'strongly agree'. All individual indicators' mean scores were positive, with strong evidence of trust, leadership, enhanced knowledge of the problem and community empowerment. Together with a fifth, the establishment of cross-scale social networks, these were also preconditions for the ACM process to continue (Fig. 5). Interviewees' responses identified a broad range of evidence for these preconditions. In particular, leadership emerged within the Tim Kolaboratif, a national government agency, the WFP and amongst communities, suggesting that policy entrepreneurs had been established at multiple jurisdictional levels. Hence the capacity to precipitate or exploit policy windows may have been created at several levels in the system, increasing the likelihood of future progress.

Furthermore, the positive mean scores for Phase 2 enabling policies and programs and Phase 3 implementation adaptation indicated that the ACM process had evolved further than expected, particularly within the case studies. However, the lower mean phase scores and higher frequency of disagreements and 'don't knows' relative to Phase 1 indicated that outcomes were nascent and more variable. Importantly, there was evidence of three ACM preconditions being established: cross-scale social networks (Phases 2 and 3), resources for implementation of adaptation strategies (Phase 2, see Fig. 5), and the implementation of innovations in the case studies within a monitoring and learning framework (Phase 3). As a result, the project's goal had been partially achieved by increasing case study communities' self-organisation and capacity to live with uncertainty and change. The unexpected progress of Phases 2 and 3, in spite of the absence of policy windows, reflects the unpredictable and emergent nature of ACM (Plummer, 2009). This also validated the project's design, which deliberately engaged stakeholders at multiple levels of the system, sowing the seeds for outcomes to emerge through several impact pathways (Stone-Jovicich et al., 2015).

Other than changes to institutions, the weakest outcome was the 'questioning of values, norms and governance' in Phase 1. While several interviewees indicated that government stakeholders had reconsidered their focus on infrastructure, there was little evidence of double- and triple-loop learning that challenged the underlying systemic causes of community vulnerability. This was corroborated by the scenario planning workshops, where despite the identification of numerous systemic drivers by participants, few transformative strategies were designed to tackle them (Butler et al., 2016b). Similarly, in the subsequent sub-district integration workshops, the vast majority of prioritised strategies were incremental rather than transformative (Wise et al., 2016). It is well established that social learning (Cundill, 2010; Armitage and Plummer, 2010; Burns, 2012) and resulting transformative action (Feola, 2015) evolves slowly, and requires numerous action-learning cycles (Brown, 2008; Plummer et al., 2012). We have concluded that our series of planning workshops was too brief to fully achieve this (Butler et al., 2016b; Wise et al., 2016). In this sense, our 4 year timeframe did not meet the governance experiment design principle of allowing adequate time to develop and adapt learning processes.

Many of the successful outcomes were founded on the establishment of the Tim Kolaboratif as the fulcrum for the process. Both the ACM and action research literature acknowledge that researchers can be important catalysts for systemic

change (Ballard, 2005; Wollenberg et al., 2007; Cundill and Fabricius, 2010; Baird et al., 2014). Also, scientists are themselves actors within a system, who have specialised knowledge that should be integrated with other stakeholders' perspectives (Brown, 2008). This philosophy is reflected in agricultural 'research for development', which acknowledges that innovation is an emergent property of scientists working in an equal partnership with other stakeholders, and the social learning that occurs (Hawkins et al., 2009; Mbabu and Hall, 2012; Stone-Jovicich et al., 2015). The evaluation interviews clearly demonstrated that the first year's focus on building the trans-disciplinary skills of the Tim Kolaboratif paid dividends by creating trust, leadership, collaborations and new adaptation pathways and systems analysis skills amongst the team, which subsequently emanated throughout the other project activities. However, Cundill and Fabricius (2010) have demonstrated in South Africa that if resourcing of such brokers and facilitators is not maintained, nascent ACM quickly dissipates.

By creating a learning and feedback mechanism amongst stakeholders, participatory evaluation can re-ignite the adaptive and reflexive component of ACM (Cundill and Fabricius, 2009, 2010; Berkeley, 2013), and if repeated over time can galvanise leaders to tackle flagging progress (Butler et al., 2015a). Our ex-post participatory evaluation may have achieved this, but its influence on the process is not considered here. If repeated, the method could be improved in several respects. A disadvantage was the risk of bias due to interviewees' 'acquiescent response styles' (Dolnicar and Grun, 2007), resulting in an exaggeration of affirmative scores. This possibly occurred in our evaluation because nine of the interviewees were Tim Kolaboratif members, and they may have had a vested interest in giving positive scores. To mitigate this, if time and resources had allowed, a wider range of stakeholders from different levels should have been interviewed to capture a broader perspective of ACM outcomes throughout the system. Also, at the community level more direct measures of impact will be necessary, such as Liu et al.'s (2016) economic modelling of household benefits derived from the trialled adaptation strategies. Nonetheless, the process of encouraging participants to reflect on the project may be more important than the accuracy of the indicator scores, which were only intended to illustrate trends in ACM outcomes against the ToC, and highlight issues to be redressed.

## Conclusions

Our study demonstrates the challenge of achieving climate compatible development in the developing world. This 4 year governance experiment applied ACM principles to prime stakeholders in NTB to transform the musrenbang planning process by exemplifying adaptation pathways tools and ACM principles. Although our evaluation showed evidence of stakeholders being primed, policy windows did not materialise to generate systemic change to musrenbang. This suggests that the design of future governance experiments in similar contexts should focus on effective political engagement at relevant jurisdictional levels, and allow more time for double- and triple-loop learning and policy windows to emerge. This has implications for the funding and timeframes of similar adaptation interventions.

Our experience provides useful lessons about the utility of ACM as a governance approach for adaptation in developing countries. First, while ACM can generate collective action, innovation and adaptive capacity, it is not a panacea. This is acknowledged in the literature (e.g. Armitage et al., 2009; Plummer et al., 2012). For climate adaptation, Plummer (2013) recommends that because ACM is most effective when applied at the local scale, ACM processes must 'cascade upward' to hybridise with more centralised forms of governance. In NTB this linkage should involve coordination between the CCTF, the 5 year provincial development plan and musrenbang. Second, opportunities for ACM can be constrained in situations of institutional and political flux, and this was the case in NTB. As a consequence, the clearest manifestations of ACM were generated by the adaptation strategy trials. This may have been expected, since Armitage et al. (2009) suggest that successful ACM usually occurs within well-defined resource systems, with small scale resource use, an identifiable set of social entities with shared interests, and clear property rights to the resource.

Third, most examples of engineered ACM have proven unsustainable (e.g. Cundill and Fabricius, 2010; Smedstad and Gosnell, 2013). This may be because the policy windows required to change institutions are inherently unpredictable, as was evident in NTB. Instead, in conditions of limited capacity and rapid political and social change, we recommend that to enhance priming processes informal livelihood innovation niches should be established as bridgeheads for ACM through activities such as adaptation strategy trials. However, this requires the long term support of trans-disciplinary teams akin to the Tim Kolaboratif, who can act as leaders, brokers, facilitators and policy entrepreneurs to exploit policy windows when they eventuate. Finally, participatory monitoring and evaluation may be a useful tool for re-igniting ACM amongst stakeholders, particularly if timed to follow exogenous shocks or crises occurring after project completion, when conditions for systemic change may be temporarily improved. As demonstrated by our approach, it is important that such exercises measure ACM outcomes which are also preconditions for the longer term achievement of tangible adaptation impacts (Brooks et al., 2011; Bours et al., 2013).

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.crm.2016.01.001>.

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