WET TROPICS
NRM CLUSTER

CLIMATE CHANGE IN AUSTRALIA

IMPACTS & ADAPTATION
INFORMATION
FOR AUSTRALIA'S NRM REGIONS

Uptake of climate change adaptation pathways and opportunities into Wet Tropics Cluster NRM Plans

System building in progress

May 2015

Citation

Hill, R., Pert, P.L., Lyons, I., Turton, S.M., Moran, C. Eds. (2015) Uptake of climate change adaptation pathways and opportunities into Wet Tropics Cluster NRM Plans: System building in progress. May 2015. CSIRO Land and Water Flagship and James Cook University, Cairns.

Contributing authors to each section:

Executive Summary	Turton, S.M. and Hill, R.
1. Introduction	Hill, R., Pert, P.L., Lyons, I., Turton, S.M., Moran, C., and Curnock. M.
2. Research approach: Interactive science-practice partnerships for knowledge uptake	Hill, R., Pert, P.L., Lyons, I., Turton, S.M., Moran, C., and Curnock. M.
3. Results	Moran, C., Lyons, I., Curnock. M., Turton, S.M. Hill, R., Pert, P.L. and Biggs, K.
4. Planning by Doing with Social-Ecological Cultural Systems for Adaptation Pathways in Cape York NRM Region	Standley, P.-M. and Preece, L.
5. Discussion and conclusion	Turton, S.M. and Hill, R

Copyright

Disclaimer

Front cover: Participants in a regional climate change adaptation planning workshop held in February 2014 in Mackay, organised by Reef Catchments NRM in collaboration with James Cook University and CSIRO. **Photo**: M. Curnock

Contents

List of Tables

List of Figures

Acknowledgements

We would like to acknowledge the support of the Australian Government's funding through the Department of Environment's climate change adaptation program. James Cook University and CSIRO Land and Water Flagship also made invaluable cash and in-kind contributions to this project. We would also like to acknowledge the invaluable in-kind support and contributions from the Wet Tropics Cluster NRM organisations including the Torres Strait Regional Authority, Cape York NRM, Terrain NRM and Reef Catchments NRM. We thank the many participants in the knowledge partnership for their efforts in framing, compiling and reviewing this report and in developing a collaborative process that works for all parties. In particular, we acknowledge the efforts of Robyn Bell, Gavin Kay, Luke Preece, Peta-Marie Standley, John Rainbird and Penny Scott.

The report was edited by Rosemary Hill, Petina L. Pert, I. Lyons, Stephen M. Turton and Catherine Moran. The authors of each section are listed at the start of the section. The design and delivery of the knowledge partnership is a joint product of all members of the team.

Executive Summary

In the Wet Tropics Cluster (WTC) region of the Australian Government's Regional NRM Planning for Climate Change Program, a partnership "Knowledge to manage land and sea: a framework for the future" has been established to support uptake of climate science. The partnership engages the Torres Strait Regional Authority, Cape York NRM, Terrain NRM, Reef Catchments NRM, James Cook University (JCU) and CSIRO. Our approach to facilitate knowledge uptake is delivered through a brokering hub, a co-research cycle for knowledge integration and co-production, and employment of a Knowledge Broker. Our report provides an update on progress towards *uptake of adaptation pathways and opportunities into NRM plans and processes* through this WTC partnership.

This document is designed to capture progress and explain the underlying ideas about how knowledge sharing can support adaptation. We first present our interactive model which we are using to develop, conduct and evaluate the uptake of knowledge, and the methods we are using to collect data relevant to evaluating outcomes. The interactive model facilitates shared learning and collaboration between Streams 1 and 2. Importantly, our approach draws on the proposition that adaptation pathways need to move away from being conceptualised as a series of pre-determined decision points, and instead be conceptualised as ongoing pathways of change and response.

The results section of the report provides details of our interactions: knowledge brokering activities that have occurred; some examples of co-produced knowledge products; and an overview of progress in each NRM region distilled from in-depth interviews and documentary analysis. The WTC NRM organisations are transitioning, through diverse strategies, from a traditional "plan" to an innovative "planning system". Our approach strengthens their capacity to deliver innovative climate adaptation strategies in the planning systems they are building. We propose that ongoing adaptation decision-making is best supported through systems of ongoing knowledge co-production and exchange.

In this report we are pleased to also highlight the exciting transformations underway in the Cape York region through a special section *Planning by Doing with Social-Ecological Cultural Systems for Adaptation Pathways in Cape York NRM Region.* Cape York Peninsula is a highly diverse region ecologically, socially and culturally; it is distinguished by complex interactions between major environmental, social and political issues, and a deep heritage of traditional cultures with a low population base over a large expanse of land. The *"Planning by Doing"* enables the community opportunity to inform action based on their knowledge and experience of these unique Cape York socio-cultural ecological environments and learn from each other through NRM initiatives that are already underway. An Indigenous led co-generative research approach has contributed to enabling Indigenous led planning and co-generation of solution spaces, drawing on experiences in responding to the wicked problem of fire management.

The full analysis and evaluation of knowledge uptake has yet to be completed, as data is still being collected, and a number of stakeholder workshops still need to be facilitated. This report therefore provides an overview of the research methods, a summary of activities undertaken and preliminary results to date. We conclude with a discussion of issues and implications for climate adaptation.

Stephen M. Turton and Rosemary Hill

1. Introduction

Hill, R., Pert, P.L., Lyons, I., Turton, S., Moran, C., and Curnock. M.

A critical factor underpinning the success of climate change planning for Natural Resource Management (NRM) organisations is their uptake of new knowledge in ways that enable end-users to learn and adapt decisions accordingly (Armitage et al., 2008).

In the Wet Tropics Cluster (WTC) region of the Australian Government's Regional NRM Planning for Climate Change Program, a knowledge partnership "Knowledge to manage land and sea: a framework for the future" has been established to support such knowledge uptake. The partnership engages the Torres Strait Regional Authority, Cape York NRM, Terrain NRM, Reef Catchments NRM, James Cook University (JCU) and CSIRO (Bohnet et al., 2013). The approach to knowledge uptake is delivered through a brokering hub, a co-research cycle for knowledge integration and co-production, and employment of a Knowledge Broker (Turton et al., 2014). This report provides an update on progress towards *uptake of adaptation pathways and opportunities into NRM plans and processes* through this WTC partnership.

The approach adopted herein draws on a recent proposition: that adaptation pathways need to move away from being conceptualised as a series of pre-determined decision points, and towards being conceptualised as ongoing pathways of change and response (Câmpeanu and Fazey, 2014; Wise et al., 2014). The Wet Tropics Cluster NRM organisations are transitioning from a traditional "plan" to an innovative "planning system". The knowledge partnership aims to similarly move from "adaptation decisions" to "ongoing adaptation decision-making systems". We propose that ongoing adaptation decision-making is best supported through systems of ongoing knowledge co-production and exchange.

Co-production of knowledge, whereby decision-makers actively participate in scientific research programs from the onset, ensuring that the goals of the research are developed to meet their current requirements, is emerging as a powerful approach to ensure new knowledge is appropriately used (Shiue et al., 2015). Pohl et al. (2010) argue that such knowledge co-production is a *prerequisite* for research for more sustainable development paths. Transdisciplinary research methods, that bring researchers and practitioners together, are now being applied to solving environmental sustainability problems across diverse topics including climate adaptation, water allocation and land-use planning (Harris and Lyon, 2013; Lang et al., 2012; Renner et al., 2013).

Nevertheless, co-production encounters issues of joint world-view construction, interpretive flexibility and competing knowledge claims that can be challenging to negotiate in real-world contexts (Van Opstal and Huge, 2013). The conditions under which knowledge partnerships and co-production are effective have been poorly evaluated (Fazey et al., 2014). Recent cross-case analysis of biodiversity conservation partnerships identified that effective knowledge co-production is assisted by multi-scalar brokering, the use of boundary objects, enhanced multi-stakeholder peer reviews, interactive spatial platforms, and Indigenous-driven planning (Hill et al., 2015 (accepted)). Negotiating the boundaries between science and Indigenous knowledge is particularly challenging, and has been demonstrated to require: meaningful participation in agenda setting, efforts by both Indigenous and non-Indigenous staff to broker interactions, and the production of collaboratively built boundary objects (e.g., plans) that helps to coordinate local action between co-managers (Robinson and Wallington, 2012).

In this report, we first present our approach to understanding the mechanisms and outcomes of uptake of adaptation pathways and opportunities into NRM plans and processes, followed by details of the methods deployed. We then present the results at this stage of the project, including an overview of activities underway, and early analysis of relevant interviews. We are pleased to then also highlight the exciting transformations underway in the Cape York region through a special section on their planning approaches and application. We conclude with a discussion of issues and implications for climate adaptation.

2. Research approach: interactive science-practice partnerships for knowledge uptake

Hill, R., Pert, P.L., Lyons, I., Turton, S., Moran, C., and Curnock. M.

The exchange of information between researchers, resource managers, decision makers, has long been recognized as a critical need in natural resource management. However, approaches to such knowledge exchange have long been dominated by an "information deficit" approach that assumes the goal is to transfer knowledge from those who perceived as having it (often scientists) and others who don't. The interactive model shifts the focus to the diverse knowledges that are held by all parties and the processes of interaction that can support knowledge-sharing to enable mutual goals to be reached.

2.1 Interactive model

A recent analysis of 135 peer-reviewed papers, presenting evaluations of knowledge exchange from diverse disciplines and sustainability challenges, highlighted a diversity of approaches with varying efficacy (Fazey et al., 2014). The review highlighted the need for tailoring the evaluation approach to the context, noting that 'catch-all' approach to evaluation is neither appropriate nor desirable. Five broad principles for evaluation design were also identified: (i) design for multiple end users; (ii) be explicit about why a particular approach to knowledge exchange is expected to deliver its outcomes; (iii) evaluate diverse outcomes; (iv) use evaluations as part of the process of delivering knowledge exchange; and (v) use mixed methods to evaluate knowledge exchange. These principles helped shape our evaluation design.

Table 2-1 Contrasting knowledge transfer and interactive models for knowledge uptake in science-practitioner partnerships. Adapted from Groffman et al. (2010)

ASPECT	KNOWLEDGE TRANSFER MODEL	INTERACTIVE MODEL
Major influence on knowledge uptake	Science literacy with or versus practical experience	Values, trust, identity, social networks.
Proposed solution to inaction	Improve science uptake into practical actions	Connect knowledge and practice while building trust and participation.
Communication is a process of..	…transmission, that means simplifying and targeting technical information that flows from experts to the public	…dialogue and the two-way exchange of perspectives; both the scientists and the practitioners learn from this process.
The definition of "knowledge uptake"	Increasing the amount of technical information available to and used by practitioners	Reframing a complex issue around familiar and relevant dimensions; engaging in workshops and dialogues.
Scientists and their organisations…	…are under attack in society and communication failures are based on public ignorance and antagonism	…hold almost unrivalled trust, authority and respect and need to use it wisely.
Practitioners and their organisations	…have valuable experiential knowledge that can contribute to the science endeavours	…are equal partners who can work with scientists to frame problems in ways that enable solutions to be developed and implemented.
The ultimate goals	To improve scientific understanding and thereby solve problems	To enable and empower mutual solutions and ensure a legacy where people can solve problems themselves.

Discussions among the science and NRM organisations in our brokering hub led to us making explicit our a interactive approach, contrasting it to the more usual knowledge transfer model, and detailing the expected outcomes, adapting the approach of Groffman et al. (2010) (Table 2.1). Designing for multiple end-users was shaped by recognition that the NRM plans target multiple (agriculture, mining, tourism, urban development); government (local, state, national); community (landcare, environment, farming) organisations; and Traditional Owner groups.

The interactive model (Table 2.1) involved both engaging in knowledge brokering and co-production activities, while at the same time seeking to investigate and interpret their effectiveness or lack thereof. The NRM organisations were clear that the focus should be on supporting activities rather than on evaluating uptake; instead the evaluation should provide for shared learning.

2.2 Methods

The overall proposition being tested is:
That knowledge exchange and co-production activities in NRM climate-change planning generates uptake of realistic adaptation pathways of change and response into plans and planning processes.

Action co-research methods enable science-practice partners to subject their emergent theories (propositions) to systematic critique and review, while applying them in real-world contexts (Hill, 2011; Kemmis and McTaggart, 2003). Reflection-in-action is at the heart of systematic critique (Schön, 1995), but it is also aided by application of externally-derived criteria, and by convergent triangulation of data sources (Creswell and Miller, 2000; McNiff and Whitehead, 2006).

Data to contribute to the evaluation in our study were identified as:

1. Knowledge brokering and collaboration activities and products including:

- Records of the activities.
- PowerPoint slides co-produced for presentations to stakeholders at the Terrain technical and community workshops.
- Fact sheets on five themes (Biosecurity, Biodiversity, Sustainable industries, Resilient coastal communities and Water quality and supply) developed by summarising and integrating information from the Impacts report (Hilbert et al., 2014), Adaptation report (two volumes: (Moran et al., 2014a; Moran et al., 2014b) and Stream 2 presentations developed for Terrain workshops.
    - Each fact sheet will include a summary of issues, impacts and adaptation options associated with climate change. The focus will be on practical management implications rather than higher-level principles.
    - Climate risk maps used by Traditional Owners to communicate their values and concerns for their country (Reef Catchments)

2. NRM groups' recordings of workshops/meetings (through minutes and notes) - primarily for Terrain & Reef Catchments NRM's.

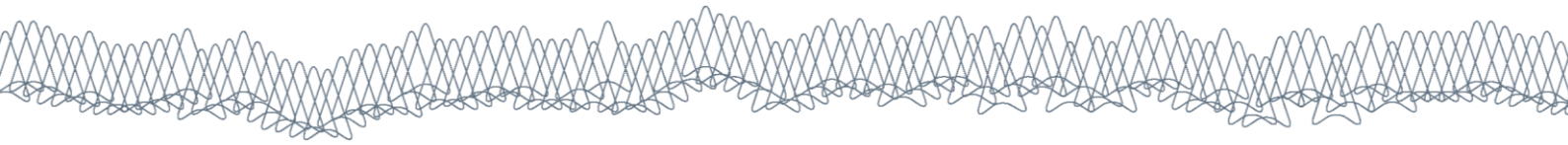
3. Guided reflections on the workshops afterwards by members of the brokering hub teams addressing questions such as:

- What knowledge was shared?
- How was it shared?
- What was the outcome?

4. In-depth interviews particularly where co-generated activities are limited, including TSRA and Cape York NRM that focused on:

- Capturing informal interactions between knowledge broker/Cape York NRM in relation to points in 3 above.

The interviews were designed to enable investigation of changes that had occurred since the project began in



February 2013, when an assessment of current practices to use climate science knowledge in NRM plans and processes was made (Lyons et al., 2013). The interview guide can be found at Appendix A.

5. Participant observation e.g. minutes and notes taken at workshops.

6. Documents related to NRM climate planning and processes.

Data will be analysed using qualitative techniques of theme identification and clustering. Validity will be tested through congruent triangulation between these six data sources, and argumentation logic in relation to the proposition under consideration.

Externally-derived criteria for effective knowledge-partnerships are few and tend to be quite high-level. For example, Reed et al. (2014) recently identified five principles from an investigation of knowledge partners across 13 environmental management projects:

i. Knowledge exchange needs to be designed into research;
ii. The needs of likely research users and other stakeholders should be systematically represented in the research where possible;
iii. Long-term relationships must be built on trust and two-way dialogue between researchers and stakeholders in order to ensure effective co-generation of new knowledge;
iv. The delivery of tangible benefits early on in the research process helps to ensure continued motivation and engagement of likely research users; and
v. Knowledge exchange is a flexible process that must be monitored, reflected on and continuously refined, and where possible, steps should be taken to ensure a legacy of ongoing knowledge exchange beyond initial research funding.

These principles essentially represent the process factors that have influenced our design. We have used these to influence our determination of the sort of outcomes we expect from a successful knowledge partnership that implements these principles. These outcomes are detailed in the column headed "Interactive model" in Table 2.1. Using these as criteria would require assessing the extent to which the knowledge partners:

- Takes into account the influences of values, trust, identity and social networks;
- Connects knowledge and practice while building trust and participation;
- Supports communication as a dialogue and the two-way exchange of perspectives; both the scientists and the practitioners learn from this process;
- Reframes a complex issue around familiar and relevant dimensions; engaging in workshops and dialogues;
- Scientists recognise they hold almost unrivalled trust, authority and respect and use it wisely;
- Practitioners are recognised and supported as equal partners who can work with scientists to frame problems in ways that enable solutions to be developed and implemented; and
- Achieves the ultimate goal of enabling and empowering mutual solutions and ensuring a legacy where people can solve problems themselves.

Discussions are ongoing within the partnership about whether these or other criteria will be useful in the final evaluation.

3. Results

Moran, C., Lyons, I., Curnock. M. Turton, S. M. Hill, R., Pert, P.L. and Biggs, K.

Interactions between the science team, NRM partners and the Knowledge Broker have varied among NRM organisations, tailored to meet their specific needs and requests. Scientist-practitioner interactions have included: joint participatory workshop design and delivery; science and practitioner teams working closely together to co-produce knowledge products; and more informal dialogues developing advice, referral and exchange of information and ideas. Knowledge brokering through the Hub, and the role of the Knowledge Broker, have been key to all these activities.

3.1 Knowledge brokering and collaborative activities

A diverse array of knowledge brokering activities has occurred since the partnership commenced. Table 3.1 summarises these activities. Note that the "Science team" are those funded through the Stream 2 of the Australian Government's NRM Climate Change Adaptation Program, and the "Practitioner team" are those funded through the Stream 1 or other NRM-related programs. TSRA did not receive funding from the Stream 1 program. NRM planning and implementation processes are ongoing, and analyses of the uptake of climate science into NRM adaptation are continuing through 2015, and will contribute to a peer-reviewed paper by end 2015.

Table 3-1 Knowledge brokering and collaborative activities undertaken by the Wet Tropics Cluster Brokering Hub

Activity and date	Goals	Details of collaborative work	Key Science team	Key NRM team
Reef Catchments *Envisaging possible futures* - Multi-stakeholder workshops. Mackay & Proserpine, February 2014	The workshops aimed to bring together stakeholders representing industries, conservation, economic development, government, Traditional Owners and other community members to identify key issues and drivers of change in the region, together with strategies for achieving longer-term preferred futures. Using 2030 and 2050 time frame for climate change adaptation planning.	-Development of a factsheet on participatory scenario planning; -Dialogue at planning meetings; -Development and delivery of presentations during the workshops on climate change projections and participatory scenario planning; -Facilitation of group discussions, summarising and reflecting workshop discussions.	CSIRO	Reef Catchments
Establish Wet Tropics Cluster Spatial Group. February 2014	To foster collaboration between NRM partners around approaches and on common challenges and solutions involving spatial data in climate change adaptation planning.	-Establish inter-agency group -Partners dialogue at meetings -Maintain contact through dropbox, email etc	JCU	Terrain Reef Catchments Cape York NRM

Table 3.1 Knowledge brokering and collaborative activities undertaken by the Wet Tropics Cluster Brokering Hub (continued)

Activity and date	Goals	Details of collaborative work	Key Science team	Key NRM team
Reef Catchments follow-up *Futures* multi-stakeholder workshop. Mackay, June 2014	To review and agree on outcomes from previous workshops, collaboratively identify and prioritise strategies for achieving sustainable futures, and identify potential working groups. Effort was made to gain representation from the mining sector in addition to representatives from sectors listed above.	-Dialogue at several planning meetings; -Participatory planning with Traditional Owners in preparation for the workshops; -Participatory preparation of posters summarising key messages from Stream 2 *Climate change Impacts and Issues* report; - Development and delivery of presentation on planning work with Traditional Owners; -Facilitation of group discussions, summarising and reflecting workshop discussions.	CSIRO	Reef Catchments
Building links to AdaptNRM	Presentation given at a Brokering Hub meeting Sep 2014. To make connections with AdaptNRM and provide more information to NRM groups and seek input to their products.	Followed up with requests for reviewing Weeds and Biodiversity reports and interviews to evaluate their work.	CSIRO JCU	Reef Catchments Terrain Cape York NRM TSRA
Reef Catchments *Incorporating climate change* staff workshop, June 2014	To improve awareness of information coming from this project and facilitate uptake of climate change projections and adaptation information into Reef Catchments' internal plans and processes.	-Dialogue at several planning meetings; -Facilitation of the overall workshop; -Co-development and delivery of presentations on Reef Catchments' climate plan, Climate projections, Outcomes of stakeholder workshops, and Planning with Traditional owners; -Facilitation of group discussions.	CSIRO JCU	Reef Catchments
Adaptation pathways and opportunities for the Wet Tropics NRM cluster region reports. November 2014.	This two-volume report aimed to inform the participatory planning processes used by NRMs to develop regional climate adaptation plans. The report provides a synthesis of high-level scientific information, together with practical examples where possible, about adaptation pathways and opportunities in the NRM cluster region.	-Workshop during Brokering Hub to develop a framework for the report i.e., key content, structure and process. Subsequent interactions over email; -Development of first drafts of each chapter by authors; -Review of first drafts by NRM partners; -Redrafting of chapters by authors; -Second review by NRM partners.	JCU CSIRO	Reef Catchments Terrain Cape York NRM TSRA

Table 3.1 Knowledge brokering and collaborative activities undertaken by the Wet Tropics Cluster Brokering Hub (continued)

Activity and date	Goals	Details of collaborative work	Key science team	Key NRM team
Climate change in northern Australia short film	To communicate essential messages from the *Climate change impacts and issues* report to general audiences. This project involved development of a short film on the impacts of climate change and need to take action. Using 2050 time frame for climate change adaptation planning	-Engage with JCU creative media studies to develop scope of desired projects; -Review student project proposals; -Comment on proposed run sheet, narrative, shot list etc; -Comment on draft film.	CSIRO JCU	Reef Catchments Terrain Cape York NRM TSRA
Torres Strait regional community planning workshops	Focus on regional (rather than local) issues using an integrated vulnerability assessment framework based on five core capitals. Discuss key components of developing adaptation pathways (e.g., framing). Involved researchers, local Councils, Torres Strait Regional Authority board members, State Gov.	Information from *Climate change impacts and issues* report was used during workshops	JCU/Cairns Institute	TSRA
Advanced Climate Projections for Impact Assessment Tool training and webinars	To access the Climate Futures Details Projections tool to explore the projections from all models (including downscaled results) and for all variables. Access the sophisticated Representative Model Wizard to identify models to represent key cases tailored to the needs of individual detailed impact assessments	Three-day face-to-face training conducted by CSIRO/BoM for CSIRO/JCU and NRM groups in Cairns as well as preceding webinars.	CSIRO BoM JCU	Reef Catchments Terrain Cape York NRM TSRA
Useful accompanying information to the Adaptation report Brokering Hub Workshop. September 2014	To collaboratively identify useful ways to summarise and present information from the *Adaptation pathways and opportunities* report.	Workshop of the contents and intensive dialogue during Brokering Hub meeting	CSIRO JCU	Reef Catchments Terrain Cape York NRM TSRA

Table 3.1 Knowledge brokering and collaborative activities undertaken by the Wet Tropics Cluster Brokering Hub (continued)

Activity and date	Goals	Details of collaborative work	Key science team	Key NRM team
Climate change in the Cape York region public presentation October 2014	To present information on projected climate changes for the region in a public forum organised by one of the Cape York NRM's stakeholders	Develop and present an hour lecture on projected impacts of climate change in this region suitable for a general audience; answer questions and feedback.	JCU	Cape York NRM
Cape York NRM stakeholder information and awareness	To increase awareness of climate change impacts and adaptation information and to gather information on knowledge and observations of climate changes.	-Use information from *Climate change issues and impacts* & *Adaptation pathways and opportunities* reports in adapted information products, including on-line; -Distribute key message fact sheet from *Impacts* report.		Cape York NRM
Opportunities for Stream 2 integration with NRM project plans Brokering Hub meeting. February 2015	To collaboratively identify useful ways for Stream 2 members to work with NRM partners in order to support their projects.	-Discussion centred around two areas: i) How to adapt information from the Element 1 project's Cluster report for use with NRM stakeholders. This lead to a decision to hold a workshop on framing the information and developing specific tools to present key information; and ii) Ways Stream 2 members can participate in NRM stakeholder engagement events. Conversation mostly centred around Terrain's plans.	CSIRO JCU	Reef Catchments Terrain Cape York NRM TSRA
Climate change information for NRM stakeholder engagement. Skype workshop. February 2015.	To develop an agreed way forward for development of appropriate climate change communication tools/products useful for NRM groups in their upcoming planning and stakeholder engagement .	Workshop over Skype. Discussion around framing climate change impacts and adaptation information, leading to development of a series of ideas for useful 'products' for communicating key information to NRM stakeholders.	CSIRO JCU	Reef Catchments Terrain
Risk and the business of climate change fact sheet	Based on discussions during Climate change information workshop, as well as interactions during Annual Stream 2 workshop, and May 2015 Brokering Hub meeting.	In development. Dialogue at brokering hub meeting.	CSIRO JCU	Terrain Cape York NRM TSRA

Table 3.1 Knowledge brokering and collaborative activities undertaken by the Wet Tropics Cluster Brokering Hub (continued)

Activity and date	Goals	Details of collaborative work	Key science team	Key NRM team
Thematic fact sheet series	Integrate information from the *Adaptation opportunities and pathways* report into 5 themes: • Biosecurity • Biodiversity • Resilient coastal systems • Sustainable industries • Maintaining water quality and supply	In development Will use information developed for presentations at Terrain's regional technical workshops (below) Drafts discussed at May 2015 Brokering Hub meeting	CSIRO JCU	Terrain Reef Catchments
Terrain Regional Technical workshops	To increase awareness of Terrains *Plan for people and country* process, to provide key climate impacts and adaptation information and to discuss implications for management, priorities and strategies. A series of workshops was held on different themes: Biosecurity, Biodiversity, Coastal systems, Sustainable industries and Water. Workshops involved people and organisations with technical expertise in the topic, including Federal, State and Local government planners and managers, conservation, Traditional owners, researchers and other community members.	-Participate in pre-workshop planning workshops; -Develop presentation on climate change projections for the region for adaptation to workshops; -Co-development and delivery of presentations on implications for management relating to workshop theme; -Develop key messages to form basis of workshop discussions; -Participate in workshop group discussions; -Post-workshop focus/working groups.	CSIRO JCU	Terrain
Timeline of climate change knowledge and responses	To graphically present accumulation of scientific knowledge about climate change, with global and Australian policy responses.	In development. Presented and discussed at May 2015 Brokering Hub.	CSIRO JCU	Terrain Reef Catchments.
Reef Catchments sectoral engagement process	To meet with representatives from individual sectors (e.g., cane growers, landcare, Local Government planners) to discuss implications of climate change projections and adaptation information for each specific sector.	-Using information in *Climate change impacts and issues* report and *Adaptation pathways and opportunities* report; -Using Climate Futures Tool to develop downscaled projections		Reef Catchments

Table 3.1 Knowledge brokering and collaborative activities undertaken by the Wet Tropics Cluster Brokering Hub (continued)

Activity and date	Goals	Details of collaborative work	Key science team	Key NRM team
Terrain Local Landscape workshops	To engage with general community members in ten local areas to increase awareness of climate science information as well as to discuss local priorities. This information will feed in to The Plan.	Provide drafts of in-development information tools to be adapted for display at workshops	CSIRO JCU	Terrain

3.2 Knowledge products

Figures 3.1-3.5 are samples of some of the co-generated knowledge products. The development of these products has been characterised by high levels of interactivity among the science team, between the science team and the NRM team, and with the graphic designers.

The first knowledge product presented, the fact sheet on “Adapting invasive species management to climate change” was developed through several different iterations of presentation. The audience is the invitees to a technical workshop hosted by Terrain NRM to focus on invasive species. Complexity in the information arises because: (1) the information is drawn from several sections across the “Impacts and Issues” and “Adaptation Pathways and Opportunities” reports; (2) multiple climate change drivers have multiple interacting effects and impacts on invasive species; and (3) responses to these separate effects resulting from different drivers are often the same. While deceptively fairly simple, the layout in the fact sheet was arrived through a lot of discussion and iteration among the project partners, and by interrogating how the concept of an “adaptation pathway” may assist. This design subsequently formed the basis and template for the other integrative fact sheets.

The second knowledge product presented is simply the title page of two of the presentations developed between the science team and the NRM team. The first presentation of the climate science has been delivered by members of the science team and members of the NRM team, with adjustments as a result to ensure clarity and simplicity without simplification. The second presentation is an example where extensive interaction, including through development of an accompanying fact sheet, resulted in strongly co-produced material.

The third product is still under development, and targets the emergence of the science and policy responses over time. Significant graphic design input and interaction has occurred and is ongoing to communicate the timing and growth of the body of scientific evidence, and the acceleration of global responses.

Figure 3.1 (Draft) Factsheet produced to summarise information on adapting invasive species management to climate change in the Wet Tropics.

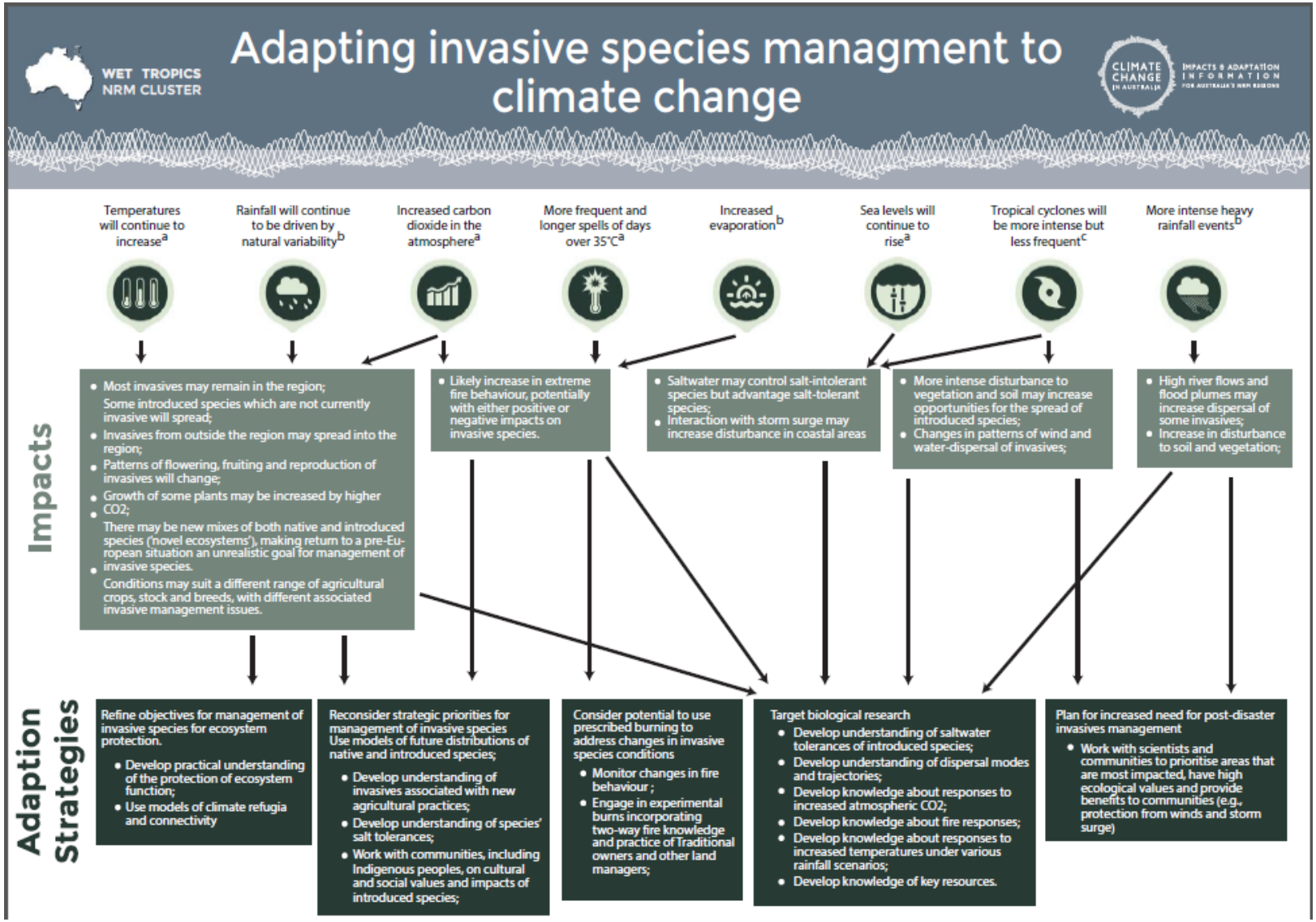


Figure 3.2 An example of one of the powerpoint presentations produced for communicating climate change to NRM groups and stakeholders in the Wet Tropics Cluster region

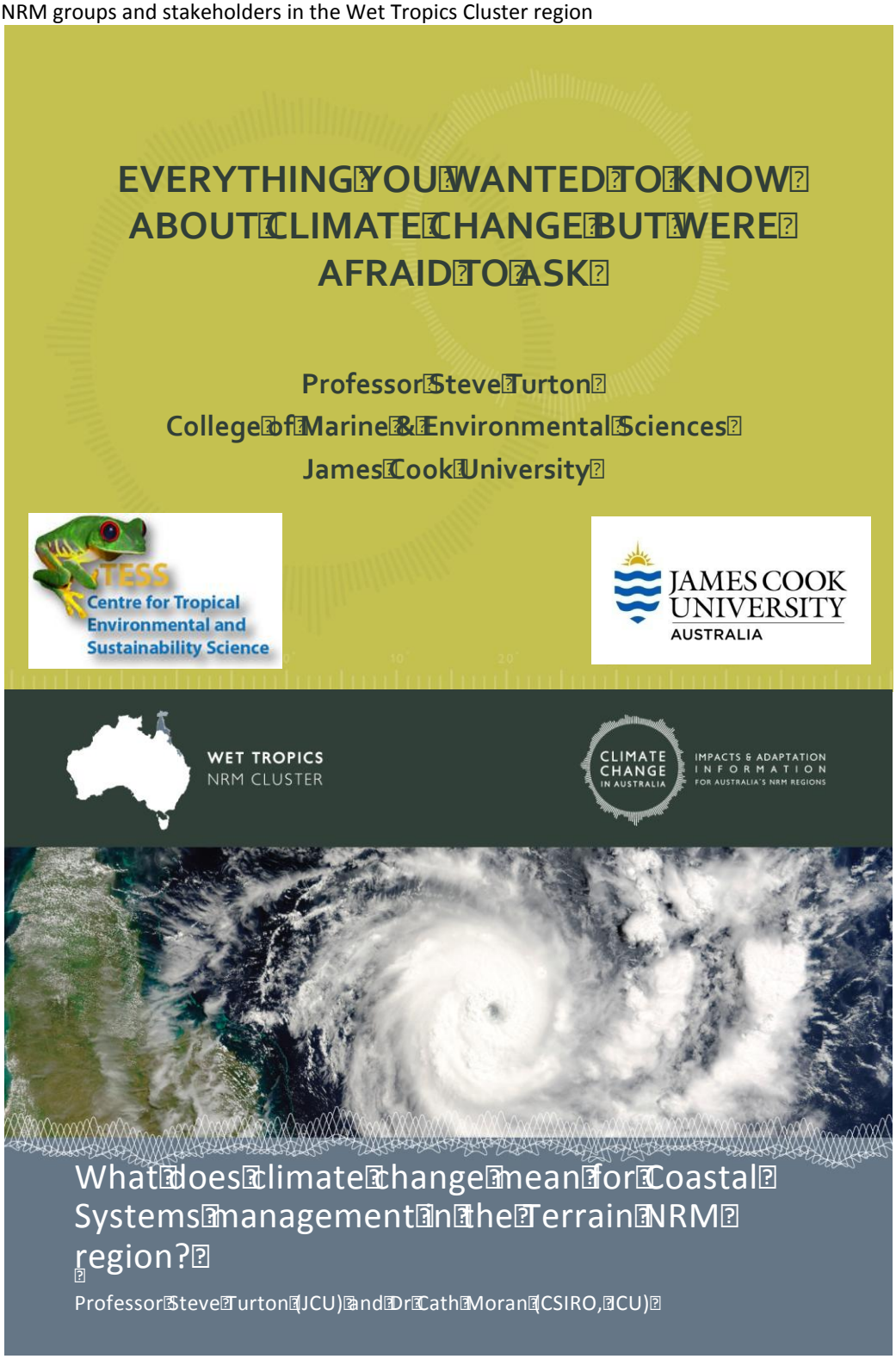
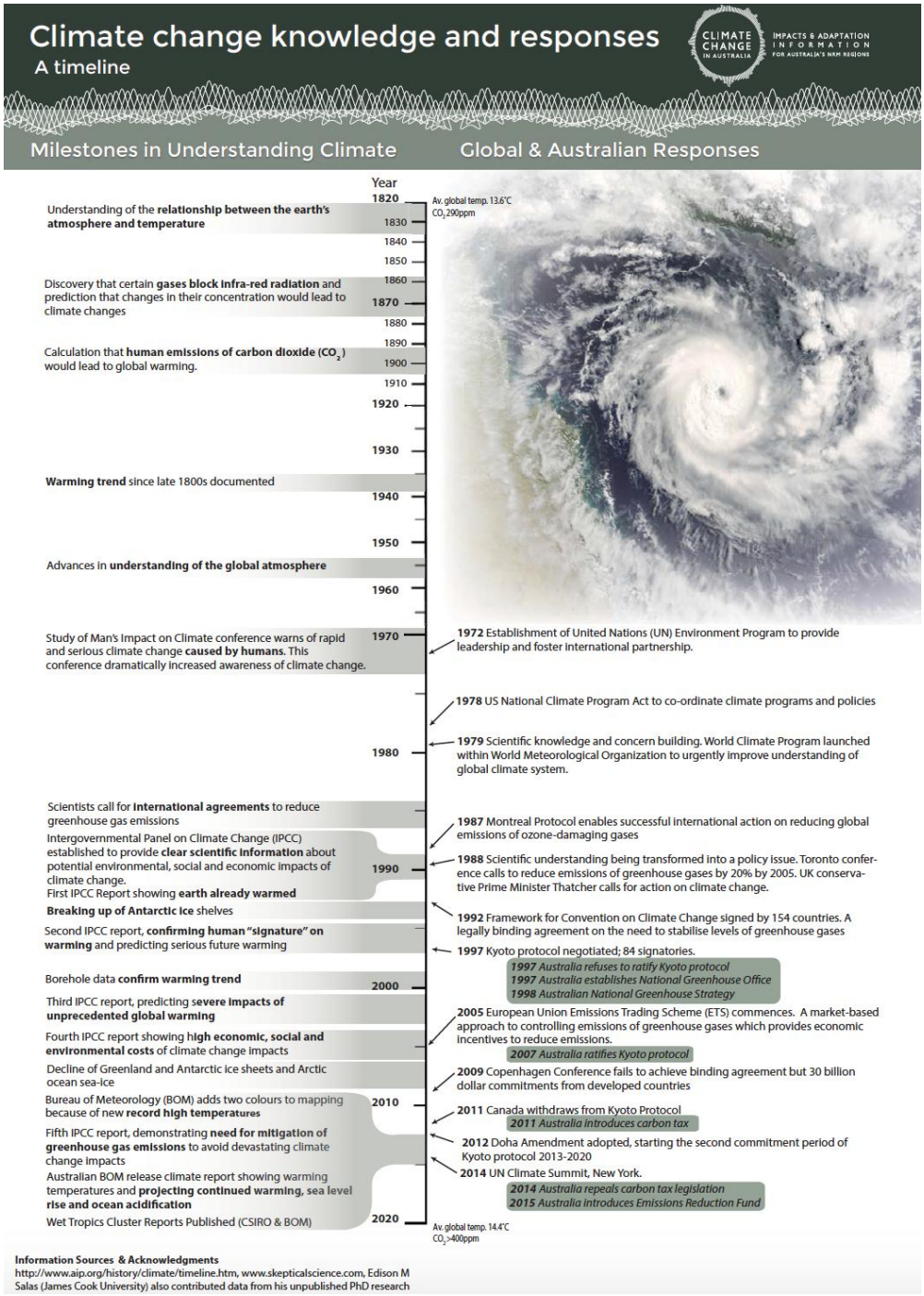


Figure 3.3 (Draft) Timeline factsheet for communicating climate change knowledge and responses



3.3 Progress on knowledge uptake in each NRM region

3.3.1 Uptake of spatial modelling of climate change interactions with ecosystems

Ongoing ecosystem modelling by Stream 2 (Reside et al., in preparation) has been presented to the four NRMs to assist their landscape planning approaches, through examining bioclimatic refuges for native wildlife species under different Representation Concentration Pathways (RCPs) (IPCC, 2013). Outcomes of this research (due to be completed in November 2015) will help to identify priority areas for focussing NRM adaptation efforts, including biodiversity hotspots, areas suitable for carbon sequestration, high priority wetlands, sub-catchments and riparian systems, with the aim to achieve improved ecosystem resilience and catchment water quality. Spatial data generated through this research in progress has been shared with NRM partners at Brokering Hub meetings in 2014/15 and their feedback incorporated into the development of tailored outputs.

3.3.2 Reef Catchments NRM

A series of stakeholder planning workshops hosted by Reef Catchments NRM were held in 2014/15 (*NB. with one remaining workshop to be held on 11 June 2015*), with Stream 2 planning input (Bohnet, Curnock, Moran, and Pert) and scaled climate forecasts and communications materials (co-developed and presented by Turton, Moran, Bell) contributed to the development of a draft NRM plan that was released for public comment in late 2014. Favourable feedback on the draft NRM plan was received from key regional stakeholders. The draft plan is due to be finalised and implemented in June 2015. The involvement of regional Indigenous Traditional Owners in the above planning workshops and their contributions to the identification of culturally important sites/areas represents an important achievement by Reef Catchments NRM, with Stream 2 support in cultural mapping (provided by Lyons et al.).

The delayed launch of the *Climate Futures* website http://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/introduction-climate-futures/ and spatial tools by Stream 2 Element 1 (to February 2015) was noted as an impediment to Reef Catchments' scenario analysis process with key stakeholder groups in late 2014. This information and these tools have been needed to assist Reef Catchments' and stakeholders' strategic prioritisation of adaptation actions and trade-offs. Such activities led by Reef Catchments NRM are therefore ongoing.

3.3.3 Terrain NRM

From early 2015, Terrain NRM has coordinated a series of themed, technical stakeholder workshops encompassing biosecurity (26th February), biodiversity (17th March), coastal systems (24th March), and sustainable industries (8th May), with additional workshops to be held on regional landscapes, water quality and supply to come. Stream 2 researchers have contributed to each of the above technical workshops, presenting summaries of relevant climate modelling, anticipated impacts and adaptation options (including those arising from the 2014 Adaptation Pathways report). Stream 2 participants at these workshops have also gathered feedback, as participant observers and through debriefing interviews, to assist with the assessment of climate information tools/products and the knowledge co-generation processes contributing to climate change adaptation.

Local Landscape workshops for individuals and groups of all backgrounds and interests will also be run from across the region from 28th April – 14th May in the evenings from 5:30-9:30pm. The findings from these workshops will be used to further develop the Wet Tropics Plan, which is a community based online information 'portal', due to be launched later in the year. Not only will the Plan present facts and figures about the region for information and input, it will also

be a critical tool for prioritising upcoming natural resource and cultural grant funding highlight the community's priorities. Topics such as soils, native vegetation, sustainable agriculture, pests and weeds and water quality will be discussed at these local landscape workshops. The workshops will also be an opportunity for the community to hear about some of the latest regional scientific information and mapping including climate forecasts.

3.3.4 Cape York NRM and Torres Strait Regional Authority

Cape York NRM and TSRA are both developing regional strategies that refer to other plans in each region respectively. Apart from the land and sea management strategy, TSRA is also developing a regional adaptation resilience plan that is based on island adaptation resilience plans. The island plans were developed through integrated vulnerability assessments. The vulnerability and risk assessments are the basis of developing adaptation options and resilience strategies in the regional. Community groups, including leaders, assessed the climate risk for each of their capital – infrastructure, economic and financial capital, social capital, human capital, and environmental capital. A vulnerability score for an item under a capital is a combination of risk and adaptive capacity assessment. Plans address resilience and climate change across the different capitals. The objectives of the climate change component of the TSRA regional adaptation resilience plan focuses on the impacts and responses to sea-level rise, temperature increase and extreme weather events.

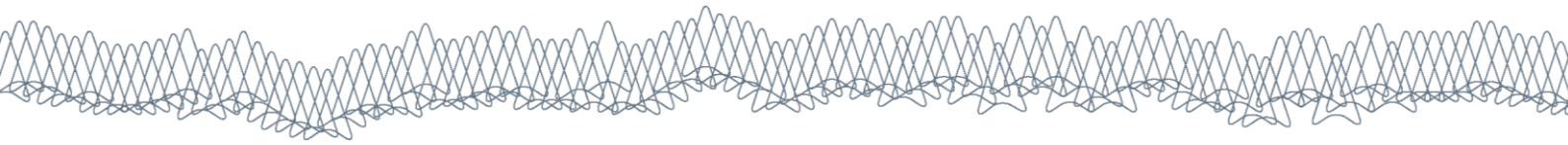
Cape York NRM is undertaking a 'planning-by-doing' process with Cape York elders, community groups and industry sectors to develop the NRM plan. Cape York NRM has engaged with the community through project delivery partners and workshops to collate and synthesise secondary material to define the regional priorities and issues for the Cape NRM plan. The six theme areas of the Cape York NRM plan, were developed from workshopping the results of the synthesis exercise with regional stakeholders.

The Cape York planning process draws on more than 100 plans from the region that range from property, pest management plans to other regional plans. Cape York NRM will develop a 12-page NRM plan based on regional stakeholder priorities. The Cape York Atlas is a key component of the NRM plan, supporting information on the key priorities, community projects supported by Cape York NRM and is repository of public documents, data and information for land managers and Indigenous groups. The ATLAS also supports stakeholder access to planning tools.

For Cape York NRM, the WTCC project commenced in the same year as their new investment strategy came into effect. Until recently, the climate communication and adaptation work embarked on by Cape York NRM was based on existing staff knowledge, resources and practice.

Cape York NRM involved their sector and Indigenous directors early to develop targeted fact sheets from the draft WTCC Stream 2 climate impact and adaptation reports. These fact sheets have been utilised with regional partners in community meetings and by Cape York NRM in their community engagement for their NRM plan. The climate messages have been reviewed with stakeholders through community forums including the Cape York NRM Regional Investment workshop, through NRM ADAPT stories meetings and have also been utilised to raise awareness among high school children, including information related to reading country and fire management. Involvement of Cape York NRM staff in the WTCC climate futures training has introduced new capacity in the agency to tailor climate projections for specific industries and localities. Staff also reported better understanding of climate science and hence greater confidence to discuss climate change in the region through the use of the Climate Change in Australia (CIAA) tools.

The hub has been valuable in delivering climate change impacts and adaptation reports that were used to develop communication materials such as adaptation options and fact sheets, and also in supporting learning and discussions across groups about the approaches



used, tools applied and perspectives from different industries. Resources sent through e-mail of other climate related sites have also been used to consider the design of communication materials. The climate film developed under the WTCC project is a resource that has been posted on the Cape York NRM YouTube and is included on its Facebook pages. April Reside's (JCU) modelling work has been evaluated by Cape York NRM and its partners to assess its relevance for their approach to assess ecosystems services for carbon. Other spatial layers Cape York NRM is considering include sea-level rise, burn history, savannah burning methodology, burn recommendations for ecosystems and corridors.

Tools/approaches used by Cape York NRM to incorporate climate science into their planning process include:

- Adapt stories and Your climate engagement and place that have been designed to gain an understanding of what people currently know about change generally, not just climate change (e.g. the peninsula road, mines or weed spread);
- Targeted fact sheets were developed from the first WTCC impact reports;
- Synthesis and communication products were developed from the WTCC impact reports in the Your Climate session of the Regional Investment Strategy (RIS) workshop;
- Theme based climate impact and adaptation key messages and a climate projections section in the NRM plan derived from the WTCC project resources; and
- Education and awareness across communities on change - climate variability, climate change, and new and on-going changes in general.

A co-hosted Cape York NRM and South Cape York Catchments climate forum delivered key climate impact and adaptation messages developed from the WTCC project. Dr Turton's involvement in the climate impacts section of the forum was praised. Projections from the WTCC project have also been utilised to develop materials delivered through social media and to schools.

For TSRA, most of the climate change and impact studies was undertaken prior to the WTCC project, however work with the CSRIO projections team has been valuable in considering other environmental data sets for future use, such as heat impact, the number of days you might expect minimum temperature. The synthesis report from the hub has been a worthy reference document for TSRA. The main limitation for TSRA in the broader application of hub material relates to the island community context TSRA works in and that ecological and land-use issues faced be mainland communities are different to the islands.

Suggestions from representatives from both NRM agencies to improve the role of the hub partnership were:

- Continue holding the brokering hub meetings;
- Information on types of tools and processes NRM groups can consider, including information on vulnerability assessments and prioritisation exercises to assist planning;
- Consider some involvement of the social science group for CYNRM work;
- Information on monitoring approaches and tools to set up useful, practical and relevant monitoring systems for ecological shift indicators;
- Discussion and information on new technologies for monitoring, such as drones, which may be more cost effective over large area. There was great interest to use imagery to capture information; and
- Consider climate change in context of other drivers of change.

Cape York NRM is using CSIRO/BOM downscaled projections to produce information for the NRM plan, print materials for the community and for community meetings. The CCIA website is used to strengthen staff

understanding of climate change and to build projections for particular industry topics in the Cape. The CCIA website will also be used to develop the climate section for the Cape York NRM best management practice workshops. Information from the climate futures tool also feeds into the CYNRM Atlas.

TSRA use region-specific downscaled projections from two other separate CSIRO projects for their planning. The climate futures tool has been a useful communication tool to discuss climate change projections and impact in the region including mainland Australia.

Steps forward for Cape York NRM to address climate change adaptation in the region will be to:

- Extract key regional-relevant messages, for each sector, from the WTCC reports and provide opportunity to stakeholders to review and add to them;
- Develop communication materials for different delivery mechanisms through face-to-face meetings, social media and e-mail;
- Compare key messages and identified adaptation pathways in the Stream 2 report with the information gathered through extensive regional engagement over the past eighteen months; and
- Incorporate of adaptation options and climate change mitigation strategies into the Cape York Atlas.

Most adaptation options in Cape York NRM are also best practice, such as appropriate burning and grazing. The CCIA website will be used to develop climate scenarios in the context of best management practice.

For TSRA, involvement in the hub has not changed its practice, as most of the actions that can be undertaken by communities to reduce pressures on the ecological systems have been identified in the working on-country and community plans and in local intervention. TSRA had systems in place before the WTCC project e.g.:

> *'what we're doing in the environmental space is what we've always done and what we'll continue to do and that is really try and reduce pressures on systems as much as possible so they have the best chance of keeping their functionality and health'.*

Few of the adaptation options discussed in their community vulnerability assessment forums related to NRM, as pathways focused on social issues and outcomes, such as community employment. However the shared learning and support across groups in the hub has been a valuable outcome of participating.

Establishment of participatory monitoring programs is at an early stage for the Torres Strait. However, long term monitoring programs have began , and include use of Fulcrum software to capture images of changing beach profiles, as well as remote systems such as sea surface temperature loggers in the region and tide gauges and remote sensing stations to monitor turtles and birds. Both Cape York NRM and TSRA seek to establish long-term spatial and image based monitoring programs. TSRA staff expressed a strong need for ecological monitoring to support decision-making and adaptation to environmental change that could include the option to consider species relocation.

Workshops and informal discussions with stakeholders, such as the Your Climate Engagement and Place, are the main forums used by the NRM agencies to learn and understand changing concerns and priorities. Cape York NRM intends to use learnings from their field to update their plan priorities and plan. TSRA pointed out that social learning for climate adaptation with community groups is an on-going conversation that will continue to address change and strategies for action. Building community capacity to sustain the adaptation conversation is crucial to their plan. TSRA established a community resilience champion project that will support an individual in each community to drive their local adaptation plan. Other community level work TSRA is engaging in includes support to locally driven projects that address change and build resilience at the community level. TSRA also have a long established land and sea ranger program http://www.tsra.gov.au/the-tsra/programs-and-

output/env-mgt-program/land-and-sea-ranger-program.

Both regional group representatives reported increasing levels of engagement in the hub. Most interaction Cape York NRM has had from Stream 2 has been through e-mails and responses to questionnaires, feedback on reports and involvement in hub meetings. The TSRA representative highlighted the critical need for iterative dialogue between users and researchers to reveal underlying assumptions of their actions and requests. Furthermore, he reiterated the importance of this investment by government to resource groups to consider the impacts of climate change in their business.

4. *"Planning by Doing"* with the Cape York Community: Social-Ecological Cultural Systems for Adaptation Pathways in Cape York NRM Region

Standley, P.-M. and Preece, L.*

* The authors acknowledge the Cape York NRM board, staff, researchers, consultants and communities and land managers engaged in NRM in Cape York.

Cape York Peninsula, Australia is a diverse place, ecologically, socially and culturally and is a complex region, with major environmental and political issues, and a low population base over a large expanse of land. In this chapter we present some of the adaptation pathways adopted by Cape York Natural Resource Management (NRM) to respond to these unique characteristics, and some of the early results of our work with stakeholders to plan for climate change.

Climate change adds to the layers of complexity in the region, but is sometimes perceived as a low priority on the list of issues that residents face. Several issues were identified through community engagement in 2013, including: complex governance structures, shifts in land tenure, complex Indigenous tenure arrangements, the benefits and impacts of mining and agricultural developments, the need for and impacts of infrastructure, challenges with access and high costs of living, vegetation thickening from changed fire practices, vegetation clearing, intense late season wildfires, weed infestations, species declines, the effects of the monsoon season, a lack of resources for management, low local capacity and skills, limited employment opportunities and operating in remote environments[1]. While climate change will have an effect on these issues, other issues have a more immediate consequence. There are indications that segments of the community understand some of the climate change impacts, however there are also those who think climate change is not happening.

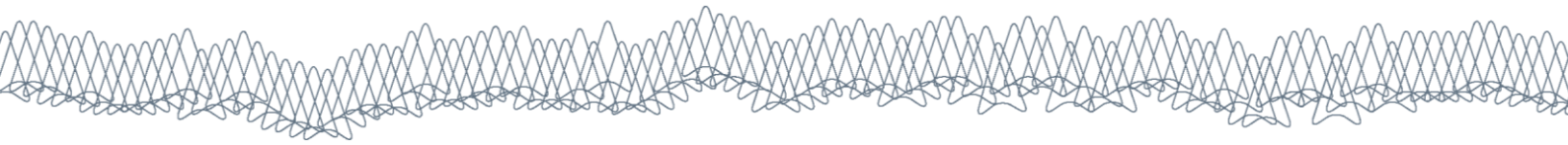
The 'planning by doing' process was formally initiated in February 2013 through an application to the Australian Government NRM Plan (Stream 1) funding. Once successful, a series of internal workshops commenced from May 2013. These workshops included communicating and refining the key focus of the project will all staff, research and community partners. This was important, as Cape York NRM program activities are a key engagement pathway of the NRM planning by doing process. This also resulted in the identification of service providers within Cape York to deliver key activities and outputs and further develop engagement and planning pathways, along with identification of appropriate consultants that could develop the digital ATLAS. The planning by doing framework emphasises that engagement with the community is integral to identification and mobilisation of adaptation pathways.

4.1 Governance

The establishment of the Cape York Natural Resource Management board in October 2010 was a result of extensive consultation with the community. This consultation has continued in the form of an extended social conversation by the Cape York NRM Board and through its current business model where its regional investment is delivered though working with community partners. To provide some context, the organisation's current mission is "to help people work together to care for the natural environment and to promote the sustainable use of Cape York's natural resources". It's vision is that "Cape York Regional Body is recognised as having contributed strongly to the creation of a community that cares for its natural environment and practises sustainable use of its natural resources". The organisation's values include:

- Being transparent, and having open and accountable processes;

[1] In 2013 Cape York NRM identified 23 Big Concerns from analysis of several documented community consultations, which were then re-evaluated and prioritised at a Regional Investment Strategy workshop in March 2013. These can be accessed at http://plan.capeyorknrm.com.au



- Being consultative, approachable, engaging and supportive;
- Being trustworthy and always acting with integrity;
- Acting inclusively, and take a collaborative approach in all that we do;
- Being proactive, solutions oriented and innovative; and
- Respecting and valuing diversity.

Cape York NRM recognises that natural resource management involves people. Cape York people and their values are an integral part of the management of the landscape. Success in managing natural resources is dependent on people and their delivery of works on country. The organisation has also adopted the United Nations Declaration on the Rights of Indigenous Peoples as a guide to the way in which it relates to, engages and works in partnership with the Indigenous people of Cape York. The board has recently begun a process to review the mission, values and vision as part of its adaptive governance processes.

4.2 Planning

The process of identifying pathways to adapt to climate change is part of Cape York NRM's planning framework. The Cape York NRM planning process is based on: 1) socio-cultural-ecological systems, rather than assets; and 2) planning by doing – which recognises current efforts underway to tackle NRM issues across Cape York communities.

The approaches taken to develop regional adaptation pathways are embedded in the planning by doing methodology being developed by Cape York NRM with the Cape York NRM community. In an attempt to build resilience, Cape York NRM is moving away from a traditional 'plan, then do' approach to an iterative process that involves collective learning. Mitchell *et al.* (2014) provide an emerging framework for planning by doing, one that centres on capacity building. While our approach is somewhat similar to this, we make some key additions and changes to this framework. We see planning by doing as harnessing and building on existing capacity and increasing resilience through experience and collective learning. Planning by doing adds value to on-ground actions by using tools and principles to foster *listening* and *learning* together, then *looking* for options and *linking* people and resources together for effective natural resource management. The 'planning by doing' approach must be supported by strong adaptive governance and adaptive management. Adaptation cycles provide opportunities to pause and *reflect* on the process and the outcomes.

4.3 Listening

The process of climate change planning has provided an excellent opportunity to *listen* to the Cape York community and *reflect* on the existing system and how Cape York works. Planning for climate change provides opportunities to tweak ideas and reprioritise investments, for example increasing weed management and quarantine or focussing on grazing and agricultural sustainability. One example of this reflection came from community identified adaptation pathways at the Regional Investment Strategy (RIS) review workshop in Cooktown, October 2014. The participants at the workshop reviewed the regional investment strategy developed for 2013-2018[2], reflected on learning from the project delivery over the past eighteen months and considered climate change impacts on the identified NRM priorities. The discussion of climate change impacts allowed the group to reflect on the current concerns and think about how to tackle the problem when the current issues exacerbate under different climate conditions. The participants at the workshop expressed interest in climate change impacts and adaptation options and discussed the proposed community priorities for resource management with consideration of potential impacts of climate change.

[2] Cape York NRM Regional Investment Strategy (RIS) 2013-2018 was developed in March 2013, through analysis of existing Cape York plans' engagement across Cape York NRM sectors through workshops, community-identified priorities and existing regional projects.

The 'planning by doing' framework is facilitating community identified cultural and local knowledge responses to climate change resilience, risk and adaptation. Each of these components works togethers to inform Natural Resource Management planning for the region. This approach enables Cape York NRM to deliver multiple outcomes in collaboration with the communities of Cape York through the integration of current local knowledge of climate change un the planning process whilst simultaneously supporting and building community capacity to adapt to change, supported by western science. 'Planning by doing' also enables the community opportunity to inform actions based on their knowledge and experience of Cape York socio-cultural ecological environments and learn from each other through NRM initiatives that are already underway.

The NRM Plan development is in itself an adaptive process, one where Cape York NRM practices reflection in action through dialogue with community delivery partners, land managers and investors. The plan process is described conceptually as a 'living' plan, showcasing on-ground actions through a digital ATLAS - Toolbar, which brings together best available scientific and local knowledge relevant to Cape York. Information available includes:

- Biodiversity and climate information;
- Interactive mapping and data layers;
- Community plans ('Who Plans Here');
- Indigenous climate stories and community case studies;
- Best practice NRM materials; and
- Community monitoring data analysed at the sub-regional and regional scale.

The ATLAS – Toolbar will enable the community to access localised planning materials relevant in delivery of NRM in Cape York. The NRM plan document is a high level strategic document that builds on this information gateway. The ATLAS will showcase flexible and responsive knowledge that assists to:

- Set regional priorities;
- Build and disburse resources and enable capacity;
- Support and encourage planning at local scales; and
- Identify key on-ground actions that support adaptation and mitigation to climate change.

The need to develop an alternative to intensive planning followed by periods of action or *"no-action*[3]*"* was identified by the Cape York NRM community, reflected in the planning fatigue expressed by them in the wake of the Cape York Peninsula Land Use Strategy (CYPLUS) planning process and frustration at the consultation approach of the 2015 Draft Cape York NRM plan. This standard approach of planning to 'plan then do' was no longer tenable.

4.4 The importance of community - Learning

'Planning by doing' is an alternative to 'plan, then do', whereby the focus is on the doing, listening, learning and reflection. While there are times where one could only do 'planning', the larger process is built on concurrently planning and doing, which might be a step-by-step, iterative or cyclic process while working on activities, actions and projects. In this way, both Cape York NRM and the people of Cape York are learning skills and knowledge to improve the effectiveness of natural resource management actions.

Through meaningful engagement, a representative board structure, effective communications program, and demonstrable skills and knowledge to deliver projects, Cape York NRM are building and maintaining legitimacy. Trust building is a strong part of building cooperation and collaboration and something we work on continuously - a part of our organisational culture.

The planning process continues to incorporate key ideas from the community through extensive engagement

[3] Often expressed sentiment of Cape York Residents of the unattained outcomes from CYPLUS. The ATLAS will showcase what has changed since this process on the NRM Plan page

and working alongside community delivery partners and land managers practicing NRM. On-ground engagement through the NRM Planning 'Your Climate' project was initiated in late 2013 with the development of a questionnaire that enables Cape York NRM to engage people one-on-one to discuss their values, place, change (both climate and other changes), the functions of their systems both industry and environment and adaptation capacity.

Connecting with different sectors and sub-regions is by one-on-one engagement, cluster approaches, all staff of Cape York NRM involved in engagement and contracted community partners from the Mitchell River Watershed Management Group, South Cape York Catchments, Wenlock Catchment group, Western Cape Landcare, community champions from the Lockhart, West Cape Ranger Programs and land managers from central Cape York areas.

Learning opportunities include field days, workshops, phone conversations, one-on-one meetings, photo competitions, community events, engagement with schools, and careers days, training events and co-delivery of on-ground projects. Mulong Productions and Cape York NRM's Community Engagement Officer travelled Cape York to film Indigenous stories related to climate, which includes topics such as fire, plants, water, traditional ecological knowledge and barriers to adaptation. The results of the questionnaire responses and information collected through all engagements are in the process of being synthesised for analysis, which we anticipate completing in late 2015.

Development of the ATLAS Toolbar of 11 community data portals is an engagement and adaptation pathway. One of these portals, the 'plan' site, represents a living plan of a mid-term (5-6 year) scope. The site will show the history of the planning processes of Cape York, from the days of the Cape York Land Use Strategy (early 1990's) to now, including the changes seen. The plan itself focuses on social-cultural-ecological systems, based around six themes – fire, water, soils, livelihoods, country and biodiversity, and integrated pest management. For each theme, the plan describes the paths to achieving aspirations, a set of actions or projects to do this, and a set of monitoring indicators. As we continue 'doing', by coordinating actions with our partners, we will update the plan tool in the ATLAS - Toolbar through summarising results from listening to community and our collective learning.

4.5 Cape York NRM planning tools - Looking

Two key sentiments from the Cape York community have been *"We want to be able to access knowledge about Cape York in one place"* and *"What happened to all the CYPLUS information?"* We need to be able to provide an option for 'looking' that is providing the tools and information that people need to make decisions and act.

The development of the digital ATLAS -Toolbar is an important component of the framework as it will integrate messages of adaptation options and discuss climate change impacts. The ATLAS will be a central knowledge base for multiple interest groups of the Cape York region to find and communicate information related to natural resource management and to access tools to assist them with their planning. See Table 4.1 below for more information on the Atlas. As part of the ATLAS - Toolbar Cape York NRM are also doing the following:

- Building community-based field monitoring tools and training program, including the use of mobile data collection tools Fulcrum and Cybertracker and purpose-built live data management systems (such as used by South Cape York Catchments and the Western Cape Turtle Threat Abatement Alliance). Monitoring of activities and social and environmental outcomes is an important element in enabling the NRM and Indigenous groups to detect issues and react to changes in their areas, including climate impacts;
- GIS mapping and data management of ecological corridors, carbon, threatened species, water, fire, property mapping, weeds and feral animals. Cape York NRM, its partners

and community groups frequently use these layers for planning and on-ground activities;

- Cape York NRM's communications strategy. Four fact sheets about climate impacts have been developed with the four sectors of Indigenous, Community, Conservation and Primary Industry. The strategy also includes being present at events to gain an understanding of what people value and the changes that they see. Other aspects of the communication strategy include Cape York NRM's website, quarterly newsletters, social media and case studies with individuals and groups across Cape York; and
- Plan synthesis of planning documents across Cape York. There are hundreds of plan documents related to NRM on Cape York, and we have so far collected over 120 plans with scope from local to regional scales. The synthesis will look into vulnerability and resilience to climate change, the actions that people have already identified, looking at the overlap of priorities and identifying where plans have been produced and where planning needs to be supported (which will feed into the Who Plans Here site).

Table 4.1 outlines the multiple planning tools Cape York NRM are using that contribute to the development of adaptation pathways. These tools range from community meetings and questionnaires, review of past planning and priority exercises undertaken in the region, to electronic data collection applications and hardware, and mapping tools. Each tool and method of collecting and processing information is targeted for sections of the Cape York community and aims to better deliver information that address management needs. It is a place to look for information that supports community practice and change and showcases different knowledge sets that contribute to achieving the vision of the organisation.

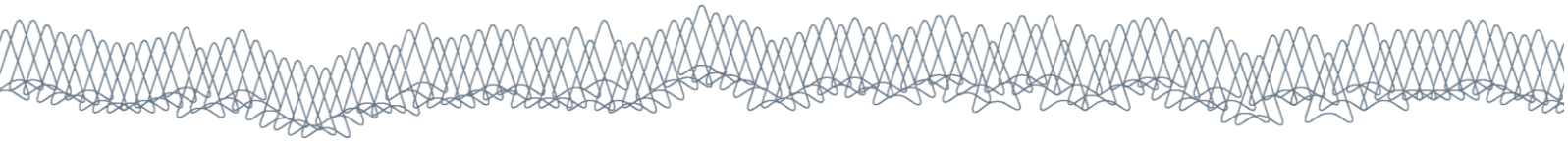


Table 4-1 Cape York NRM planning tools and their respective strengths and weakness to develop adaptation pathways

Tool(s)	Strengths	Weaknesses	Potential improvements
Operations Delivery	Enables opportunities to lean together and listen to each other and country. Coordinated action.	Risk to diverting to business as usual without consideration to climate change.	Identifying scenarios with clusters on relevant NRM delivery areas, Fire, Water, Turtles with delivery partners, using climate scenario tools.
Field monitoring & community monitoring (Fulcrum, Cybertracker and data portals; doing)	Allows users to monitor and react to change Provides immediate feedback on the data collected	Requires on-ground training No platform is perfect, functions need to be traded off	Synthesis and feedback of analysed data to community for them to understand the purpose of monitoring and feel ownership of the data they collected.
Your Climate questionnaire (completing)	Provides avenue for awareness raising; good engagement tool	Requires resources to conduct interviews appropriately and in detail	Redesign for online/postal surveys; follow up with climate information
Stream 2 messages – communications materials	Tailored to interest group/sector; provides a rough overview of key information	Perhaps not useful to all interest groups	Develop audio-visual and info-graphics materials
Atlas portal: - Carbon tool - Land Manager - Who Plans Here - Climate Stories - Corporate site - Fire Knowledge - Living Knowledge Place - Maps and Data - NRM Plan - Water Quality Improvement Plan (In development; some going)	Developed through use-case scenarios so should be useful for multiple types of interest groups; Will provide a central place for seeking and distributing information and data relevant to NRM on Cape York, including adaptation pathways; Supports socio-ecological-systems approach, multiple world-views and a 'living' plan.	Will require a substantial engagement process to ensure it is used and useful to the community (this is also a strength); Will require maintenance	The ATLAS Toolbar has just been launched and requires a substantial amount of time to upload information and promote the sites. We will continue to work on the sites as a core to our engagement and communications strategy.

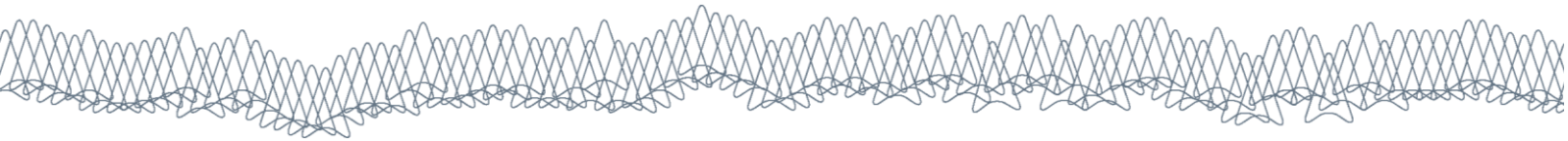
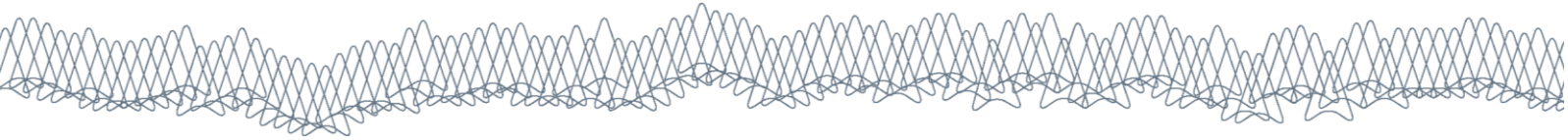


Table 4.1 Cape York NRM planning tools and their respective strengths and weakness to develop adaptation pathways (cont.)

Tool(s)	Strengths	Weaknesses	Potential improvements
Plan synthesis (strategy developed)	Allows for the identification of the key priorities of the region and baseline for understanding what people are thinking and doing about climate change; The approach is bottom-up, which is anticipated to improve buy-in from the community	Will need to work through the existing current plans to incorporate climate change information and adaptation pathways	Will assist in demonstrating what has changed and what is changing with the governance of natural resources on Cape York.
Carbon prioritisation spatial framework (in development)	Excellent avenue for discussing ecosystem services and carbon as alternative livelihood options	Cape York is a data-poor region, so much of the information will be based on modelling.	Develop research projects to improve the evidence base for ecosystem services
GIS, data and maps (continuous)	Provides the community with tools to monitor, plan and implement on-ground actions and identify and map changes (both climate and other changes)	Requires skills and knowledge to interpret data and maps	A central, streamlined database of specific indicators would help to monitor outcomes.
Communications strategy (continuous)	Avenue for distributing information and connecting with our partners and stakeholders	Different stakeholders require different communication mediums (eg. online information, hard copy products, face-to-face meetings)	Utilising the ATLAS Toolbar as a key engagement and communications medium.
Environmental Accounts and land condition surveys (continuous)	Feeds into maps and information about climate impacts and changes	Resource intensive Models Cape York based on limited and geographically restricted data	Alignment with/ difference to State and Federal initiatives for environmental accounts.



4.6 Tailoring planning tools to diverse contexts and stakeholders – Linking

Diverse stakeholder groups are engaged in developing Cape York NRM's adaptation pathways. Cape York NRM works across diverse groups including Traditional Owners, conservation agencies, state government, graziers, the horticulture industry and tourism. An understanding of opportunities and limits of engagement and mutual benefits of collaboration to deliver NRM outcomes is critical to deliver NRM outcomes in Cape York. Limitations to engagement across groups can include commitment of time, different interest, and capacity and resources to establish a working relationship. Engaging with different stakeholders in the region often require specific strategies, due to inherent differences among stakeholders such as interests and views. For instance, engaging with Indigenous groups requires an understanding of the role of traditional governance systems and language, which have been eroded, and economic disadvantage and limited capacity. Engaging with primary producers requires an understanding of the tight time commitments and the political and social alignment with specific groups.

Six regional scale adaptation pathways have been developed through engagement with the science community and with stakeholder groups. These address carbon, appropriate fire management, ecosystem services and the Cape York NRM living plan, the Cape York Atlas (see Table 4.2).

To reach the different stakeholder groups on Cape York, Cape York NRM draws information from multiple sources and also utilises various means of communication to tailor information for different sectors in the region. Stream 2 climate messages and information is a key source of information, but other information is sourced from online media and professional networks. The Your Climate questionnaire highlights key community concerns, and the communicating of Indigenous stories highlight the history of change that people have seen, including traditional ecological knowledge. Communications will be directed by the communications strategy, and through engagement processes and the Cape York Atlas. This approach allows targeting of communication methods for different sectors, including written, verbal, visual and audio-visual information. The transformation of scientific information and integration with community-derived information is conducted through workshops and meetings. Stakeholder discussions are the basis of learning and improving communication products.

Adaptation pathways are being designed through collective learning with stakeholder groups by exploring values, place and change (these are also part of priorities and activities of community-based plans). Selected pathways will be framed through engagement in demand-driven processes where information will be shaped to the particular needs of each sector. On-ground engagement is key in this process because Cape York has a small population over large distances. Cape York NRM builds opportunities for people to get together, share knowledge and skills, linking to each other through action and planning tools.

4.7 Brokering climate knowledge

Engagement with the Stream 2 Brokering Hub the National project and NRM Adapt has been core to the identification of adaptation options and pathways. We have been involved in the Brokering Hub meetings since their inception for the past two years and have had the opportunity to comment on the two science synthesis reports ('issues and impacts', and 'adaptation pathways and opportunities'). Cape York NRM were instrumental in collaborating with our cluster NRM partners prior to the call for consortium bids for the Stream 2 project and identifying a set of priorities and gaps for our regions and worked with James Cook University and CSIRO in developing the bid. Cape York Natural Resource

Management have attended the National meetings as representatives from our cluster NRM groups and provided input into the NRM Adapt module development. These collaborations have ensured that the research being undertaken and the materials being produced are reflective of the gaps that have been identified for our region. We are also working on a spatial carbon prioritisation layer for the ATLAS that will identify opportunities and obstacles to sequestration and mitigation methodologies for the region, which has been partly informed by Stream 2.

4.8 Working with the social-ecological-cultural system to build the planning by doing framework

Community led and driven on-country initiatives enable place based, reflective solution responses that assist in adaptation in a continually changing environment. Cape York NRM are supporting communities to come together in naturally occurring socio-ecological communities of action, self identifying roles and responsibilities in the delivery of natural resource management on Cape York. The Cape York NRM planning by doing methodology and framework has been informed by the methodology and analytical framework of an Indigenous led co-generative action research project "*Kuku Thaypan Fire Management Research* project*"* and the analytical framework of its dissertation research *"The Importance of Campfires.*" The methodology utilised in this research project highlighted the need for Indigenous led research and the co-generation of solution spaces to respond to the wicked problem of fire management in Cape York, supported by Western scientific tools. This research project recognised the value of Indigenous knowledge to contemporary natural resource management and the importance of responsibility for the solutions being implemented. It describes an Indigenous led methodology, researcher practitioner model, an Indigenous centred analytical framework and highlights Indigenous knowledge principles for reading country, learnt from specialist Indigenous fire and ecology knowledge holders.

The analytical framework for the research dissertation has at its heart the Indigenous identified knowledge triangle[4] and a researcher practitioner model that has been applied to describe the interconnected elements of the 'planning by doing' framework. In order to utilise Traditional Knowledge as a baseline for applying adaptive management, NRM researcher's and practitioner's need to understand the three sides of the knowledge triangle. Learning through this research has enabled the use of the knowledge triangle as an analytical framing that describes the interconnected elements of the 'planning by doing' framework (Table 4.2).

The Knowledge Triangle as described in the research dissertation:

- "Knowing what it is" - results in a familiarity with environmental cycles and ecosystem function. It is about understanding plant and animal species biology and population ecology
- "Knowing what it does" – Understanding the resultant effects of our interactions as part of the system
- "Knowing how to do it." - Principles that enable responsive management practices that can sustain healthy and resilient ecosystem services and people capable of adaptation to change.

Planning by doing involves learning while doing and on-ground actions that inform adaptive management. Ongoing engagement with the Cape York NRM board, community delivery partners and stakeholders has also

[4] Standley, P., Steffensen, V., George, T., Musgrave, G. (2009) knowledge triangle recorded. The Importance of Campfires dissertation (in progress). Knowledge triangle presented in poster (2011) see reference.

informed the 'planning by doing' framework and reiterated the importance of *listening*, *learning*, *looking* and *linking*, briefly described in the above sections. Each element of the framework requires a more detailed explanation that is outside the scope of this chapter but will be described in future publications. Indigenous and local community knowledge is critical to the Cape York NRM planning approach, and needs to be supported by the best available science and digital tools.

The 'planning by doing' process was formally initiated in February 2013 through an application to the Australian Government NRM Plan (Stream 1) funding. Once successful a series of internal workshops commenced from May 2013. These workshops included communicating and refining the key focus of the project with all staff, directors, research and community partners. This was important, as Cape York NRM program activities are a key engagement pathway of the NRM 'planning by doing' process. This also resulted in the identification of service providers within Cape York to deliver key activities and outputs and further develop engagement and planning pathways, along with identification of appropriate consultants that could develop the digital ATLAS. The 'planning by doing' framework emphasises that engagement with the community is integral to identification and mobilisation of adaptation pathways.

Table 4-2 A framework for planning by doing, showing the path between listening and learning (across) and linking and looking (down), highlighting the interconnected elements of planning by doing through the knowledge triangle.

Link				
Listen	***Knowing what it is***	***Knowing what it does***	***Knowing how to do it***	Learn
	Cultural ecological clusters	Community ownership	Roles	
	Multiple knowledge sets working with our partners	Maintain resilience	Responsibility	
	Doing and Learning	Multiple actions on country	Reflect	
	Reading signals	Difference and Connection	Recognition	
	Co-develop tools and techniques Innovation	Acknowledgement Collective learning Co-generative research	Respect	
	Cyclic processes Adaptive Mngt	(Adaptation) Pathways to change	Reciprocity	
Look				

4.9 Our adaptation pathways

Six regional scale adaptation pathways have been developed through engagement with the science community and with stakeholder groups. These address carbon, appropriate fire management, ecosystem services and the Cape York NRM living plan, the Cape York Atlas (see Table 4.3).

4.10 Where to now?

Now that the stream 2 climate messages are finalised, the next step for Cape York NRM is to ensure that all staff understand what the climate messages mean for Cape York, extract the messages relevant to the region and each sector, communicate them to our stakeholders and those already engaged in the project and provide the opportunity to redevelop or add to the key messages from local expertise and experience. This process will share learning including setting priorities, supporting planning and identifying key on-ground actions that support adaptation and mitigation. This component of the NRM planning framework will also include a comparison of the key messages and identified adaptation pathways in the Stream 2 report with the information gathered through the extensive engagement over the past eighteen months. This refining process and identification of key adaption or mitigation pathways was initiated at our Regional Investment Strategy workshop in Cooktown on the 20th and 21st of October, 2014. The results from this workshop will be analysed in the coming months, but as a preliminary note, the uptake of a selection of draft messages from the Adaptation Pathways and Opportunities report was positive. We held a session with six focus groups to identify adaptation options by theme, which led to some great discussions on what this means for on-ground investment and planning priorities in Cape York. Furthermore, it was apparent from the workshop that ecosystem services and carbon are increasingly becoming a priority.

The 'planning by doing' framework being applied by Cape York Natural Resource Management has been designed to assist in adaptation and mitigation strategies as it has at is heart engagement with the Cape York community. Cape York NRM are working alongside the community, building relationships, recognising and respecting the roles different sectors play and providing a reciprocal service in our partnerships and access to tools, skill development and training. These values of respect, recognition, roles, responsibility, and reciprocity are fundamental in engaging with Indigenous and local people and their knowledge and are universal as principles for engagement with the wider Cape York community. By forming strong partnerships Cape York NRM are able to provide support to communities in the planning process and assist in identifying key actions that will improve decision making and inform on ground actions that respond to climate change. It is imperative that the community own actions identified through the planning process that will support them to adapt to climate change. This ownership is achieved by meaningful engagement. 'Planning by doing' with the community also improves the planning process, continues to build the framework and ensures the plan is a living plan where collective learning occurs and adaptations are ongoing as new information comes to hand. Access to information is now enhanced by the ability of people to go to the online ATLAS -Toolbar, which is also an engagement and communications tool for on-country action.

Table 4-3 Cape York NRM adaptation pathways, the type of change addressed and the limits and opportunities for each pathway

Potential adaptation pathway	Scale	Incremental/ Transformational	Limits/barriers	Opportunities
Appropriate Fire management – cluster approach	Regional	Transformational	Attitude, skills, capacity, resources, focus of land management	Carbon, on-country values, integration across priorities, social and cultural benefits, knowledge
Ecosystem services valuation framework – alternative system for livelihoods	Regional	Transformational	Information, data, scientific backing	Livelihoods change, investment, opportunities for jobs, shift in economy
Identification of areas for carbon plantings	Regional	Incremental/Innovative	Accounting methods, data availability, cross-tenure negotiations	$, ecosystem benefits, social benefits (community involvement), information system
Living knowledge – TEK protection and sharing	Regional	Transformational	Permissions ownerships and IP, cultural barriers to knowledge sharing, distance, time, loss of knowledge	Sharing of knowledge from a community-based process, protection of knowledge that is being lost
Living plan through the Atlas	Regional	Transformational	Out of date plans, top-down government plans, maintaining the Atlas portal	Synthesis of all information, not creating new plan
Wetland and spring management (including Great Barrier Reef)	Regional	Incremental/Innovative	Lack of valuation of services, high costs of restoration, lack of research	Limited knowledge of functions and species, High cultural and conservation values, High ecosystem service potential

5. Discussion and Conclusion

Turton, S.M. and Hill, R.

Our report has provided an update on progress towards *uptake of adaptation pathways and opportunities into NRM plans and processes* through the Wet Tropics Cluster (WTC) partnership. We have attempted to give a flavour of the interactions, outputs and innovations underway to enable uptake of climate change adaptation pathways and opportunities into WTC NRM plans. We are using action co-research methods that enable science-practice partners to subject their emergent theories (propositions) to systematic critique and review, while applying them in real-world contexts. Notably, we have commenced the first steps in testing the proposition that knowledge exchange and co-production activities in NRM climate-change planning generates uptake of realistic adaptation pathways of change and response into plans and planning processes.

We have employed an interactive model (using a co-knowledge approach) to develop, conduct and evaluate the uptake of knowledge, as well as facilitate shared learning and collaboration between NRM Streams 1 and 2. We have recognised that the WTC NRM organisations are transitioning from developing a traditional "NRM plan" to an innovative "planning system" and our approach strengthens their capacity to deliver innovative climate adaptation strategies in their planning systems. We have proposed that ongoing adaptation decision-making is best supported through systems of ongoing knowledge co-production and exchange.

We have summarised the knowledge co-production activities supported through the brokering hub since inception in late 2013, demonstrating a wide range engagement, knowledge brokering, co-produced products, and an innovative process of 'planning system building' by the NRM groups. Activities have included research reports identifying adaptation pathways and opportunities, technical and sectoral workshops with NRM groups, thematic fact sheets, a short film, webinars and *Climate Futures* training courses for Stream 1 and 2 participants. These NRM planning and implementation processes are ongoing, and analyses of the uptake of climate science into NRM adaptation are continuing through mid 2015, leading to the submission of a peer-reviewed paper by end 2015.

The Cape York NRM section provides insights into the emergence of planning tools and approaches to fit a unique social-ecological-cultural context. This comprehensive planning system has identified six regional scale adaptation pathways that have been developed through engagement with the science community and with stakeholder groups. These address carbon, appropriate fire management, ecosystem services and the Cape York NRM living plan, the Cape York Atlas.

In terms of future research, preliminary spatial ecosystem modelling by Stream 2 has been presented to the four NRMs to assist their landscape planning approaches, through examining bioclimatic refuges for native wildlife species under different greenhouse gas emission scenarios. Outcomes of this research (due to be completed in November 2015) will help to identify priority areas for focussing NRM adaptation efforts, including biodiversity hotspots, areas suitable for carbon sequestration, high priority wetlands, sub-catchments and riparian systems, with the aim to achieve improved ecosystem resilience and catchment water quality.

Appendix A Interview Guide

A1. Interview Preamble

This interview is part of the Wet Tropics Cluster project and will inform reporting on the uptake of adaptation pathways and opportunities into NRM plans and processes. In this interview we are particularly interested in **what** is happening, such as, what science or climate tools have been useful, what activities you, and the regional body, are undertaking to incorporate climate science, and what practice changes have occurred as a result of your involvement in the brokering hub. The information from these interviews will feed into federal government reporting for Stream Two and into the hub to consolidate the different activities, tools and processes the Wet Tropics Cluster partners are involved in.

Your responses will be treated as confidential and we will ensure that you are not personally identified in the reporting of the results. However, we would like to include your name in our list of interviewees to illustrate that we have represented key informants. **Is that Okay with you?**

[With your permission, this interview will be tape recorded and your statements summarised. Is this alright with you?]

Our discussion will include:

- Some background on your role and responsibilities in your NRM organisation
- Activities you are doing to update your NRM plan
- Any contribution of the brokering hub to your planning process
- Tools you're using to update your NRM plan
- Types of activities adopted in the agency to support learning

Do you have any questions before we start?

Background

What is your role/s within your organisation?

How long have you been in this role?

A2. NRM Plans

- What actions are you taking now to update your NRM plans and processes in your region (e.g. workshops, discussion workshops, interactive web tools)?
- How are you considering or combining climate science information into your plans and processes?
- Are any of the activities you've just mentioned being supported through the brokering hub partnership (e.g. reports, networks made through the hub, exchange of ideas)?
- Which Activities?

A3. Brokering Hub

- Has your involvement with the brokering hub partnership changed the use of climate science in your region? (e.g. role of knowledge broker, reports)
- What changes have occurred?
- How do you think the brokering hub partnership could be more effective, both in the past and in the next 15 months when Stream 2 concludes in June 2016?

A4. Climate Science Tools

- Are you using climate projections, including the CSIRO/BOM downscale projections?
  - How are the projections being used in your region?
- Are there any activities in your region being supported by the Climate Futures tool?
  - Which activities are these?

- Can you tell me how you are addressing climate change adaptation in your NRM plans (any consideration of adaptation pathways and opportunities?)
  - How are you addressing adaptation?

- What adaptation options, such as pathways and opportunities, are being discussed in your region?

- Can you tell me about any participatory monitoring and evaluation for climate change adaptation that is included in your NRM plan?
  - What activities are included in your plan?

- Are you using any social learning or learning through stakeholder discussions as part of updating your NRM plan in response to climate change?
  - What methods are you using?

A5. Feedback on Hub

- Are you happy to provide us with your milestone reports on progress of the brokering hub partnership?
- Finally, we have adopted an interactive model to uptake of climate science information, rather than a knowledge transfer approach. Do you have any comments to make about that?

Abbreviations

TERM	DEFINITION
BOM	Bureau of Meteorology
CCIA	Climate Change Impact Assessment
CYP	Cape York Peninsula
CYPLUS	Cape York Peninsula Land Use Study
CYSF	Cape York Sustainable Futures
Cape York NRM	Cape York Natural Resource Management
CSIRO	Commonwealth Scientific Industrial Research Organisation
GBR	Great Barrier Reef
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
JCU	James Cook University
NRM	Natural Resource Management
RCP	Representative Concentration Pathways
RIS	Regional Investment Strategy
TEK	Traditional Ecological Knowledge
TSRA	Torres Strait Regional Authority
WTC	Wet Tropics Cluster
WTCC	Wet Tropics Climate Cluster
WTHA	Wet Tropics World Heritage Area

Glossary

TERM	DEFINITION
Adaptation	The adjustment, in natural or human systems, in response to actual or expected climatic changes or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.
Adaptive capacity	The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or cope with the consequences. Adaptive capacity of a system is its capacity to change in a way that makes it better equipped to deal with potential impacts.
Adaptation pathways	Entail future adaptations through understanding how different stakeholders make decisions about adaptation, developing adaptation options suited to different regions and communities, and analysing the benefits (or opportunities) of adaptation and key policy actions through modeling.
Climate scenarios	A plausible description of some future state, with no statement of probability. They are used to enable people to explore the question 'What is such and such were to happen?' and provide alternative pictures of how the future might develop. They may be used to assess consequences, and thus to provide the basis for policies that might influence future developments, or enable businesses and government to cope with the future.
Climate predictions	Are statements that something *will* happen in the future, based on known conditions at the time the prediction was made, and assumptions as to the physical or other processes that will lead to change. Such predictions are seldom certain because present conditions are often not known precisely, and the processes affecting the future are not perfectly understood.
Climate projections	Are sets of future conditions, or consequences, based on explicit assumptions, such as scenarios. Such projections are conditional on the scenario and the models used.
Opportunities	Opportunities to climate change are where adapting to climate change generates new industries (e.g. renewable energy), income, employment or other desirable community outcomes, e.g. carbon sequestration, etc.
Resilience	The capacity of a system to absorb disturbance, undergo change and still retain essentially the same function, structure, identity, and feedbacks.
Vulnerability	Is defined as a function of the character, magnitude, and rate of climate change variation to which a system is exposed, its sensitivity, and its adaptive capacity.

References

Armitage, D., Marschke, M., Plummer, R. (2008) Adaptive co-management and the paradox of learning. Global Environmental Change-Human and Policy Dimensions 18, 86-98.

Bohnet, I.C., Hill, R., Turton, S.M., Bell, R., Hilbert, D.W., Hinchley, D., Pressey, R.L., Rainbird, J., Standley, P.-M., Cvitanovic, C., Crowley, G.M., Curnock, M., Dale, A., Lyons, P., Moran, C., Pert, P.L., (2013) Supporting Regional Natural Resource Management (NRM) Organisations to Update their NRM Plans for Adaptation to Climate Change, in: Piantadosi, J., Anderssen, R.S., Boland, J. (Eds.), MODSIM2013, 20th International Congress on Modelling and Simulation Modelling and Simulation Society of Australia and New Zealand, Adelaide, pp. 2214-2220. Online: http://www.mssanz.org.au/modsim2013/K2217/bohnet.pdf ISBN: 2978-2210-9872143-9872143-9872141. .

Câmpeanu, C.N., Fazey, I. (2014) Adaptation and pathways of change and response: A case study from Eastern Europe. Global Environmental Change 28, 351-367.

Creswell, J.W., Miller, D.L. (2000) Determining validity in qualitative inquiry. Theory into Practice 39, 124-130.

Fazey, I., Bunse, L., Msika, J., Pinke, M., Preedy, K., Evely, A.C., Lambert, E., Hastings, E., Morris, S., Reed, M.S. (2014) Evaluating knowledge exchange in interdisciplinary and multi-stakeholder research. Global Environmental Change-Human and Policy Dimensions 25, 204-220.

Groffman, P.M., Stylinski, C., Nisbet, M.C., Duarte, C.M., Jordan, R., Burgin, A., Previtali, M.A., Coloso, J. (2010) Restarting the conversation: challenges at the interface between ecology and society. Frontiers in Ecology and the Environment 8, 284-291.

Harris, F., Lyon, F. (2013) Transdisciplinary environmental research: Building trust across professional cultures. Environmental Science & Policy 31, 109-119.

Hilbert, D.W., Hill, R., Moran, C., al., e., (2014) Climate change issues and impacts in the Wet Tropics NRM Cluster region. James Cook University, Cairns.

Hill, R. (2011) Towards equity in Indigenous co-management of protected areas: Cultural planning by Miriuwung-Gajerrong people in the Kimberley, Western Australia. Geographical Research 49, 72-85.

Hill, R., Davies, J., Bohnet, I.C., Robinson, C.J., Maclean, K., Pert, P.L. (2015 (accepted)) Collaboration mobilises institutions with scale-dependent comparative advantage in landscape-scale conservation. Environmental Science & Policy.

IPCC, (2013) Summary for Policymakers: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, in: Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (Eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kemmis, S., McTaggart, R., (2003) Participatory Action Research, in: Denzin, N.K., Lincoln, Y.S. (Eds.), Strategies of Qualitative Inquiry, Second Edition ed. Sage Publications, Thousand Oaks, California, pp. 336-396.

Lang, D.J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., Thomas, C.J. (2012) Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustainability Science 7, 25-43.

Lyons, P., Bohnet, I.C., Hill, R., (2013) Synthesis of Climate Change Knowledge and Planning Practices carried out by the Wet Tropics Cluster Natural Resource Management (NRM) Organisations. Report prepared for the Wet Tropics Cluster project collaborators and the Department of Environment. CSIRO Climate Adaptation Flagship, Cairns, Australia.

McNiff, J., Whitehead, J. (2006) All you need to know about action research. Sage Publications, London.

Mitchell, M., Griffith, R., Ryan, P., Walkerden, G., Walker, B., Brown, V.A., Robinson, S. (2014) Applying Resilience Thinking to Natural Resource Management through a “Planning-By-Doing” Framework. Society & Natural Resources: An International Journal 27, 299-314.

Moran, C., Turton, S., Hill, R., (2014a) Adaptation Pathways and Opportunities for the Wet Tropics NRM Cluster region: Volume 1. Introduction. Biodiversity and Ecosystem Services, CSIRO, James Cook University, Cairns.

Moran, C., Turton, S., Hill, R., (2014b) Adaptation Pathways and Opportunities for the Wet Tropics NRM Cluster region: Volume 2. Infrastructure, Industry, Indigenous peoples, Social adaptation, Emerging planning frameworks, Evolving methodologies and Climate adaptation planning in practice. James Cook University, Cairns.

Pohl, C., Rist, S., Zimmermann, A., Fry, P., Gurung, G.S., Schneider, F., Speranza, C.I., Kiteme, B., Boillat, S., Serrano, E., Hadorn, G.H., Wiesmann, U. (2010) Researchers' roles in knowledge co-production: experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal. Science and Public Policy 37, 267-281.

Reed, M.S., Stringer, L.C., Fazey, I., Evely, A.C., Kruijsen, J.H.J. (2014) Five principles for the practice of knowledge exchange in environmental management. Journal of Environmental Management 146, 337-345.

Renner, R., Schneider, F., Hohenwallner, D., Kopeinig, C., Kruse, S., Lienert, J., Link, S., Muhar, S. (2013) Meeting the Challenges of Transdisciplinary Knowledge Production for Sustainable Water Governance. Mountain Research and Development 33, 234-247.

Robinson, C., J., Wallington, T. (2012) Boundary Work: Engaging Knowledge Systems in Co-management of Feral Animals on Indigenous Lands. Ecology and Society 17, 16. Online: http://dx.doi.org/10.5751/ES-04836-170216.

Schön, D. (1995) Knowing in action: the new scholarship requires a new epistemology. Change 27, 27-34.

Shiue, I., Samberg, L., Kulohoma, B., Dogaru, D., Wyborn, C., Hamel, P., Jorgensen, P.S., Lussier, P., Sundaram, B., Lim, M., Tironi, A. (2015) Future Earth Young Scientists Conference on Integrated Science and Knowledge Co-Production for Ecosystems and Human Well-Being (vol 11, pg 11553, 2014). International Journal of Environmental Research and Public Health 12, 2088-2089.

Turton, S.M., Hill, R., Moran, C., (2014) Introduction, in: Moran, C., Turton, S.M., Hill, R. (Eds.), Adaptation Pathways and Opportunities for the Wet Tropics NRM Cluster region. Volume 1 Introduction, Biodiversity and Ecosystem Services. James Cook University, Cairns.

Van Opstal, M., Huge, J. (2013) Knowledge for sustainable development: a worldviews perspective. Environment Development and Sustainability 15, 687-709.

Wise, R.M., Fazey, I., Stafford Smith, M., Park, S.E., Eakin, H.C., Archer Van Garderen, E.R.M., Campbell, B. (2014) Reconceptualising adaptation to climate change as part of pathways of change and response. Global Environmental Change 28, 325-336.

Contact Details

Rosemary Hill
Principal Research Scientist/CSIRO
+61 7 4059 5013
ro.hill@csiro.au
http://www.csiro.au