Insight into demand-driven research through synthesis

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Executive Summary

The Adaptive Communities Node (ACN) evolved over the life of the NSW Adaptation Research Hub 2013 – 2018. This report assembles outputs from ACN projects and from research conducted to support the work program of OEH's Impacts and Adaptation Team into a cohesive set of insights on the process of adaptation research that is demand-driven and situated at the interface of government policy and operations.

The ACN was a unique undertaking, adopting a demand-driven approach to research, allowing for research to emerge from the complex interplay of climate events, knowledge demand from government, and the broad array of theoretical approaches supporting adaptation research.

The focus of the research was community adaptation within New South Wales (NSW). The research was led by the Institute for Sustainable Futures (ISF) at the University of Technology Sydney (UTS) in collaboration with CSIRO and was funded by the NSW Office of the Environment and Heritage (OEH). The ACN was one component of a larger Adaptation Research Hub that included two other nodes:

- Biodiversity node led by Macquarie University with CSIRO, and
- Coastal processes node led by UNSW Water Research Laboratory and the Sydney Institute of Marine Science

We know that many of the impacts of climate change and variability have been or will be felt on a local scale affecting communities, governance structures and key natural and physical assets. As such, the overall aim of the ACN was to explore pathways to increasing the capacity of communities to adapt to such impacts and investigate how government can service the changing and ongoing needs of adapting communities. Specifically, the research aimed to:

- Expand knowledge of how communities adapt to current climate variability and future climate change,
- Explore government requirements for communities to become more resilient to the impacts of climate change, and
- Explore options for government to engage with communities and support community action.

In doing so the research focused on three key sub-themes which included:

1. *Improving the community-policy-science interface*: A central aspect of this sub-theme was to work with target communities, decision-makers and researchers to establish the most effective options for improving climate change adaptation action.
2. *Transformational adaptation and meta-learning for community adaptation*: This sub-theme explored the pathways and tools needed to enhance community level adaptation in NSW. It focussed on what theory tells us about systems that are resilient, in transition towards transformation, and the applicability of theory to social systems.
3. *Regional Innovation Systems* (RIS): This sub-theme focused on the analysis of businesses and organisations in selected communities in NSW

to investigate local RIS and assess the pre-conditions within these communities for transformative change.

To reveal learning from the activities of the ACN over five years, synthesis was integral and an iterative activity. As the opportunity to study this type of process is rare, our focus was on learning about the process of research in a demand-driven model, rather than a synthesis across specific project findings.

The aim was not to *evaluate* the outcomes of research, rather it is to identify and understand the emergence of the research as a product of factors associated with knowledge demand, and how ACN researchers sought to meet this demand by negotiating supply-side constraints.

The research of the ACN was underpinned by six theoretical approaches: vulnerability assessment, transformative adaptation, adaptation pathways, transition management, regional innovation systems and operationalisation.

As the synthesis of the Node was undertaken after Phase 1 and during Phase 2, a mixed method approach was utilised, which included development of a project database (ENTREQ method), detailed output analytics from web-based and social media sources, conceptual modelling of the emergence of and interconnections among Node projects, and a participatory workshop with project partners.

A key finding was that a demand-driven model has intrinsic key challenges and advantages over more traditional approaches to the research-policy interface. We believe that the ACN represents a unique example of deliberate efforts to improve the alignment of knowledge supply and demand in applied social research. We sought to reveal tacit knowledge of regional stakeholders in adaptation because the data and modelling systems needed to support capacity building for local-scale adaptation are rarely available and often need to be constructed locally. We developed strong collaborative linkages with NSW and local government staff involved in operational dimensions of climate adaptation through joint management of research to ensure projects were co-designed and knowledge co-produced to improve salience, credibility and legitimacy of research outputs and that social learning for capacity building was prioritised. In addition, the content and design of research outputs were guided by government stakeholders to ensure they effectively translated research findings into a language accessible to decision makers, which often took precedence over more traditional academic outputs such as journal publications.

From a policy perspective, it is not easy to justify the commitment of precious resources to a program of work which is not well specified and relatively unpredictable. Part of managing this issue for the Adaptive Communities Node was earning and retaining the trust of others in the policy environment. If these hurdles are surmountable within the policy domain, then the ultimate outputs of the research are much more applicable to real-world policy contexts. Wherever possible, the Node sought to ‘value-add’ data outputs, such as the regional climate projections from the NSW and ACT Regional Climate Modelling (NARCliM), to deepen engagement processes with stakeholders, thereby accelerating the progress to regional transformation. One of the key observations of policy professionals involved in this synthesis report was that they did put the research into practice. Ultimately, this will be a key criterion on which the performance of the ACN should be evaluated.

From a research perspective, there are a parallel set of challenges. The demand driven approach may not result in the spoils and rewards of traditional academic

research. The pathway to increasing publication metrics is opaque; however, the opportunity for impact is significant. As much as anything, the Node was an amazing social network of its own, beginning with pre-existing social networks among and between researchers and policy makers, which expanded during the life of the Node. Moreover, the Node produced innovative methods which will likely continue to underpin future research endeavours far beyond climate adaptation in NSW. Above all, the benefit to researchers was that the outcomes of their efforts were translated into real world applications, which was the rationale for those researchers getting involved in the Node in the first place.

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Introduction

This report aims to use synthesis techniques to better understand how the research program of the Adaptive Communities Node (ACN) evolved over the life of the New South Wales (NSW) Adaptation Research Hub. It assembles outputs from ACN projects and from research conducted to support the work program of NSW Office of Environment and Heritage (OEH) Impacts and Adaptation Team into a cohesive set of insights on the process of adaptation research that is demand-driven and situated at the interface of government policy and operations.

The research of the ACN emerged from the complex interplay of climate events, knowledge demand from government, and the broad array of theoretical approaches supporting adaptation research.

1. Node background

Over five years from 2013, the ACN examined the process of community adaptation within New South Wales (NSW). The research was led by the Institute for Sustainable Futures (ISF) at the University of Technology Sydney (UTS) in collaboration with CSIRO, and was funded by the NSW Office of the Environment and Heritage (OEH). The ACN was one component of a larger Adaptation Research Hub that included two other nodes:

- Biodiversity node led by Macquarie University with CSIRO, and
- Coastal processes node led by UNSW Water Research Laboratory and the Sydney Institute of Marine Science

Rationale for Adaptive Communities

Many of the impacts of climate change and variability have been or will be felt on a local scale affecting communities, governance structures and key natural and physical assets. The overall aim of the ACN was to explore pathways to increasing the capacity of communities to adapt to such impacts and investigate how government can service the changing and ongoing needs of adapting communities. Specifically, the research aimed to:

- Expand knowledge of how communities adapt to current climate variability and future climate change,
- Explore government requirements for communities to become more resilient to the impacts of climate change, and
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In doing so the research focused on three key sub-themes which included:

1. *Improving the community-policy-science interface*: A central aspect of this sub-theme was to work with target communities, decision-makers and researchers to establish the most effective options for improving climate change adaptation action.
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focussed on what theory tells us about systems that are resilient, in transition towards transformation, and the applicability of theory to social systems.

3. *Regional Innovation Systems* (RIS): This sub-theme focused on the analysis of businesses and organisations in selected communities in NSW to investigate local RIS and assess the pre-conditions within these communities for transformative change.

During the first three years of the ACN, the set of inter-related research projects was prolific in producing a diverse range of outputs and outcomes across the three research themes. Outputs have included multiple case study reports, technical briefs, journal papers, and conference papers, in addition to an equally diverse set of policy briefings, stakeholder presentations, workshops and conference presentations, along with media stories. In the short time frame of the Node, outcomes are more difficult to identify but have included new and expanded research collaborations, local government policy changes, and support for adaptation in local and state government.

2. What is *synthesis*?

The Oxford English dictionary lists several definitions for the term synthesis. Of most relevance is synthesis as *the combination of components or elements to form a connected whole*. The term is closely linked to the philosophy of Hegel (the *Hegelian dialectic*) as *the final stage in the process of dialectical reasoning, in which a new idea resolves the conflict between thesis and antithesis* (or more simply problem-reaction-solution). The term is contrasted with *analysis*, the process of separating something into its constituent elements.

In research, 'synthesis' generally refers to a process of conducting surveys of previously published material (for example through literature review). It is frequently associated with the terms research synthesis, research review, and systematic review, though as Cooper et al (2009) suggested these terms sometimes have subtly different meanings. Synthesis researchers generally seek greater learning by combining multiple studies on the same problem or hypothesis (often dispersed geographically or across disciplines) that may have taken place over many years. Quantitative (statistical) and qualitative (e.g. coding) techniques to perform this style of 'synthesis' increasingly are well defined (Cooper et al 2009).

In this report, to reveal learning from the activities of the ACN, we draw on the concept of synthesis as an integral and iterative component of the study of an open system (Barton and Haslett 2009) (Figure 1). In this way individual projects conducted under the Node form the analysis where new data is generated, and synthesis is used to facilitate the emergence of new knowledge with increased power of explanation. Because studies of this type of process are rare, our focus is on learning about the process of research in a demand-driven model, rather than a synthesis across specific project findings.

We also draw on the large body of literature dealing with the theory of knowledge (or epistemology), and the function of learning, knowing and understanding through being. This is significant because to undertake this synthesis we need to explore the tacit knowledge of participants in the ACN (information users, project partners, researchers) and their subjective experience of 'events' that led to specific opportunities.

According to Reis and Schopenhauer, as “knowing subject(s)” we must first learn about the world we currently live in (Schopenhauer 1966, Reis 2001). Our perception of the world is confined within a specific time and space; our world then is created continuously through a vagary of references, lenses, perspectives and memories we each hold (Mannheim 1960, Reis 2001). Within this conscious mind we co-create, either consciously or unconsciously, our world through the “mirror effect” of the inner and outer states of being (Ferguson 2003). We can only imagine what we know, or different arrangements of what we know, as such ‘utopia’ is a collection or pastiche of elements that currently exist represented in a new way (Reis 2001).

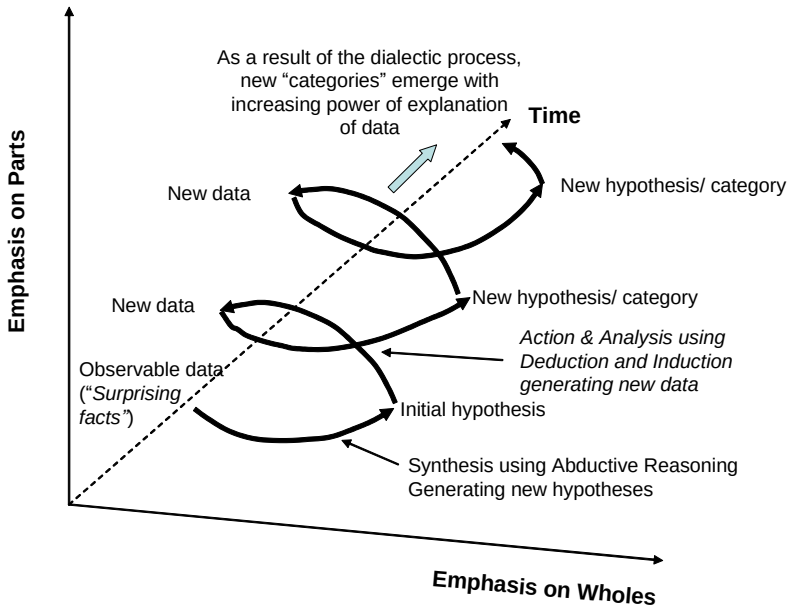

Figure 1: The Scientific Method as a dialectic between analysis and synthesis (from Barton and Haslett 2009)

Schopenhauer claimed that as individuals perceive the world, the perception becomes manifest (Schopenhauer 1966, Reis 2001). These perceptions are enacted within the lived moment, or as Ernst Bloch states during the “Dunkel de gelebten Augenblick” – the “darkness of the lived moment” (Bloch 1986, pp 290-300).

3. Demand-driven Research

There has been much glib rhetoric about the vast benefits that social science can offer if only policy makers paid attention. Perhaps it is time for social scientists to pay attention to the imperatives of policy-making systems and to consider soberly what they can do……..to improve the contribution that research makes to the wisdom of social policy.

(Weiss 1979 p431)

The US National Research Council conducted reviews in 1979 and 2012 into the use of social science studies in policy making (National Research Council 2012). Their 1979 report, *Knowledge and Policy: The Uncertain Connection,* found that, there was little systematic evidence that social science studies were of relevance to, or were used in, policy interventions, despite much effort to improve in these areas. The 2012 follow-up report suggested that little had changed. They found that the wide-spread adoption of evidence-based policy and practice, focused on

improving understanding of “what works,” had influenced the *production* of scientific knowledge, but had made little contribution to understanding the *use* of that knowledge.

Sarewitz and Piekle Jr (2007) called for reconciliation of the relationship between the supply and demand of research for climate change knowledge to improve science policy decision–making for societal outcomes. They posed the question, ‘how can we know if one research portfolio is better than another?’ They developed a ‘missed opportunity’ matrix (Figure 2) in which the lower left and upper right quadrants of the matrix represented a mismatch between research supply and demand, whether through development of an inappropriate research agenda (supply side) or through barriers to the use of information (demand side).

DEMAND: Do users have specific information needs?

SUPPLY: Is scientific information produced?		**YES**	**NO**
	YES	***SUPPLY & DEMAND RECONCILED:*** Users’ information needs reconciled with the production of scientific information.	***MISSED OPPORTUNITY:*** Research priorities misaligned or users are unaware of possible utility of information produced.
	NO	***MISSED OPPORTUNITY:*** Research priorities need modification in order to respond to users’ information needs.	***SUPPLY & DEMAND RECONCILED:*** Information not produced nor needed by users.

Figure 2. Missed opportunity matrix (Source: Sarewitz and Pielke Jr in McNie et al 2016)

McNie (2007), in her review of science supply-demand reconciliation, suggested that after identifying knowledge users’ demands, researchers must then be responsive to decision makers by conducting research targeted to those needs; and, ensure that their research is sensitive to the scale of the problem and the scale of the research. She identified several attributes of research that could improve the alignment of knowledge supply and demand:

1. **Inclusion of stakeholders** in the decision-making process to improve buy-in for the policy decision, facilitate the contribution of tacit ‘local’ knowledge and improved cost effectiveness
2. **Improved relationships** between researchers and decision makers by creating trust, respect, and cooperation between stakeholders and produce more effective interactions between researchers and decision makers
3. **Actively manage the boundaries** at the interface between the two cultures (research and policy) to produce a two-way flow of useful and relevant information for decision makers, thereby increasing the salience, credibility and legitimacy of the research.
4. **Develop collaboration** between researchers and decision makers in which knowledge co-production is central, and internal and external networks sustain ongoing flows of information and participation among diverse stakeholders.
5. **Communication** that effectively translates research findings into a ‘common language’ more easily understood by decision makers.

6. **Development of a theoretical framework** for enhancing linkages between science and decision makers, founded on social learning, in which researchers learn alongside stakeholders in the recognition that the participation and presence of researchers in the process of knowledge production will affect the outcome of the entire system.

The ACN sought to embed these six elements, wherever appropriate, in research activities with the aim of ensuring that research supply and demand were well matched. However, the fundamental question remains, how we can know in a demand driven model that the best portfolio of research emerged, given all the possible directions research could progress. As with most adaptation research, arguments for or against a set of research activities become counter-factual (Bours et al 2014). However, we can seek to identify, post-hoc, the factors that led to a particular course being followed in an attempt to explain, and learn from, the research process. Such learning should have wider application to the science–policy interface. The aim in this paper then, is not to *evaluate* the outcomes of research, rather it is to identify and understand the emergence of the research as a product of factors associated with knowledge demand, and how ACN researchers sought to meet this demand by negotiating supply-side constraints.

Methods

Theoretical underpinnings of Node research

The research of the ACN was underpinned by five theoretical approaches:

1) **Vulnerability Assessment**: Communities differ in their vulnerability (exposure, sensitivity and adaptive capacity) (Figure 3) to climate impacts due to a diverse range of biophysical and socioeconomic factors (Biesbroek and Lesnikowski, 2018) that vary considerably across the NSW landscape (e.g. Jacobs et al 2014).

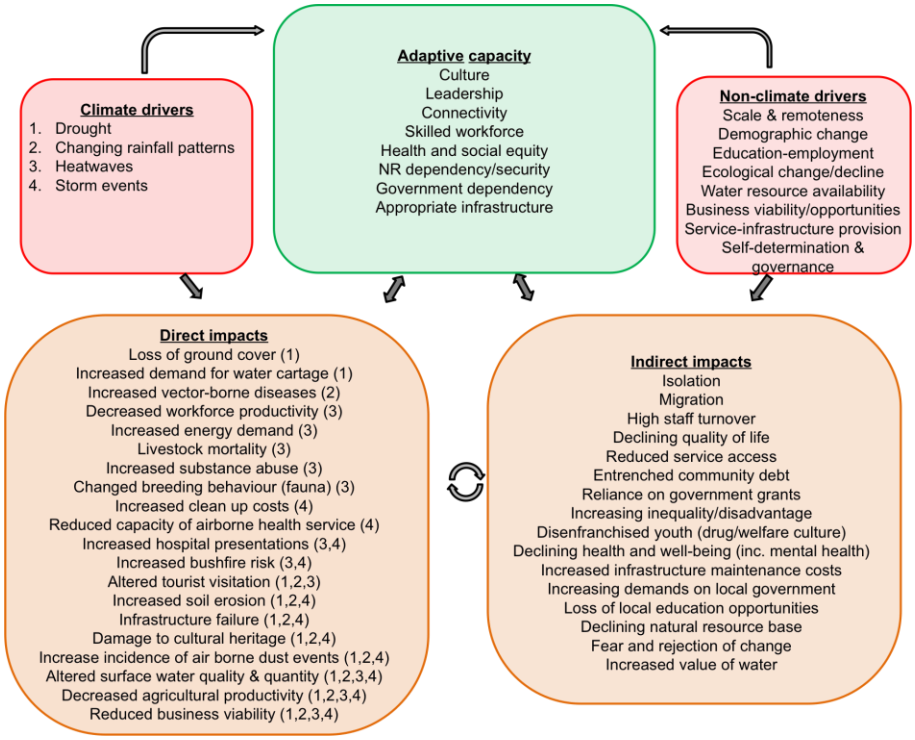

Figure 3: A model of regional vulnerability developed through the Enabling Regional Adaptation (ERA) Project.

2) **Transformative adaptation**: A conceptual model of adaptation to hazards (Figure 4) that lies on a spectrum of change leading to reduced vulnerability through resilience, transition or transformation depending on the degree to which adaptation supports an existing system's structure and function or enables more fundamental processes of change in governance or social reform (Pelling 2010). Community adaptation is viewed as a continuous, dynamic and scalable process. It is the net result of myriad decisions made daily by individuals, households, organisations and businesses. Things as simple as how to travel to work, whether to recycle household waste, where to locate a factory, whether to live in a small community or seek the advantages offered by larger population centres, accumulate to set individual trajectories of change being followed by communities throughout NSW.

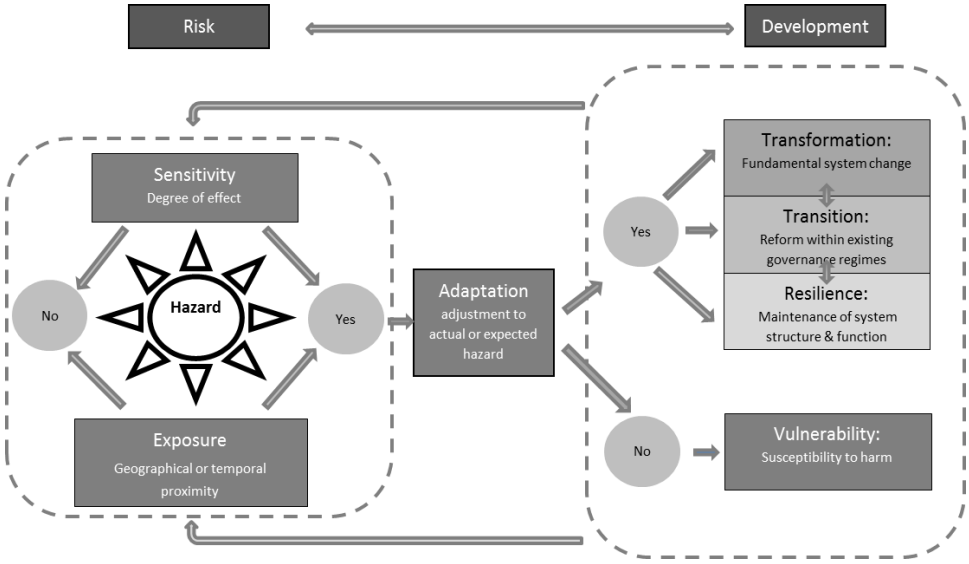

Figure 4: Pelling's model of adaptation (after Pelling 2010)

3) **Adaptation pathways**, which enable flexible planning under deep uncertainty and help prioritise adaptive actions in a dynamic risk environment (Kwakkel et al. 2015).
4) **Transition management** (Geels, 2002) and the economics of increasing returns to positive path dependency (Arthur, 1989) to promote transformational change. The socio-technical transition processes used featured articulation of a 'guiding vision' that translated abstract anticipation of the future into an agenda for stakeholder action (Spath and Rohracher, 2010; Poli, 2012), and assisted in strategic planning for transformation (Figure 5).

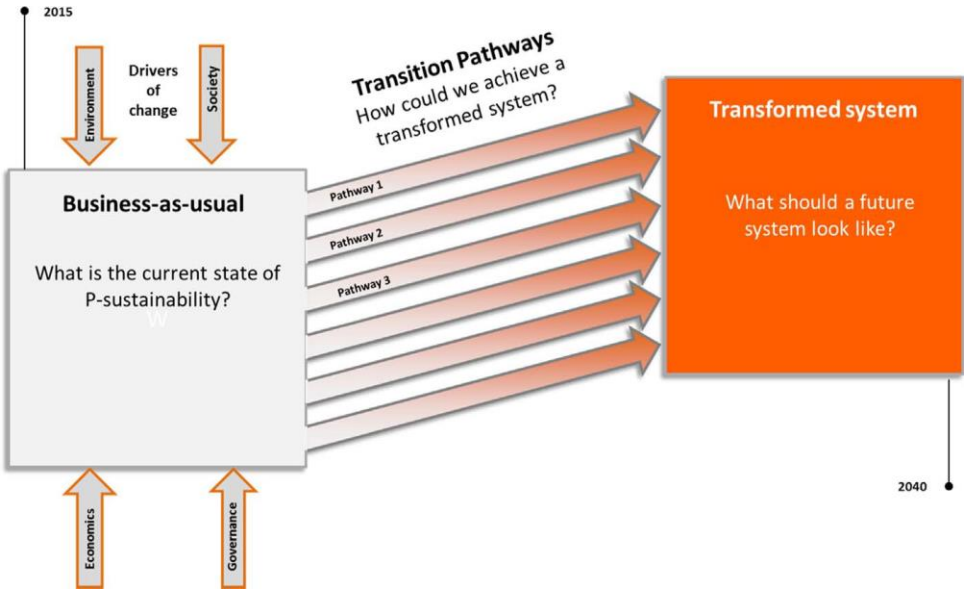

Figure 5: Conceptual model of system transformation used in ERA. Source: Jacobs et al (2016)

5) **Regional Innovation Systems** (RIS) is an approach to investigating innovation in businesses that aims to capture how technological development takes place within a territory. A RIS is 'a set of interacting private and public interests, formal institutions, and other organizations that function according to

organizational and institutional arrangements and relationships conducive to the generation, use, and dissemination of knowledge' (Doloreux and Parto, 2005 pp. 134-135). It is a widely used analytical framework that generates the empirical foundation for innovation policy making. RIS is a useful complement, from a business perspective, to assessments of regional vulnerability because changes in climate will also likely drive the need for business to adapt (Figure 6).

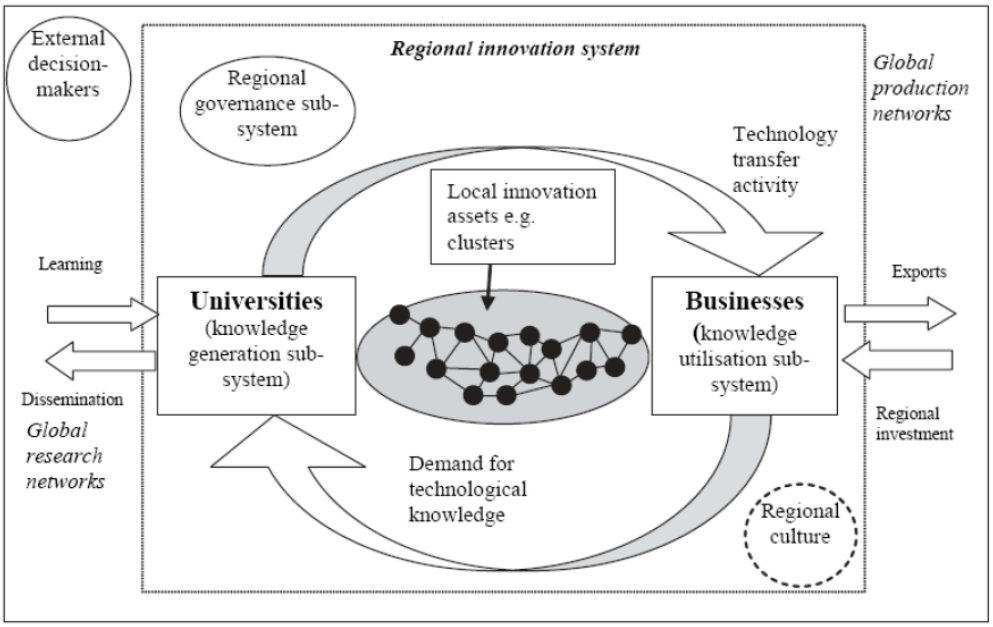

Figure 6: A conceptual model of a Regional Innovation System (RIS). Source: Schrempf, et al (2013) as adapted from Cooke and Piccaluga (2004)

6) **Operationalising theory** through participatory processes with a focus on eliciting the tacit knowledge of the public sector and regional communities according to the SECI model (socialization, externalization, combination, internalization) (Nonaka and von Krogh 2009, Figure 7). ACN sought to deliver policy-ready outputs that addressed the needs of NSW communities.

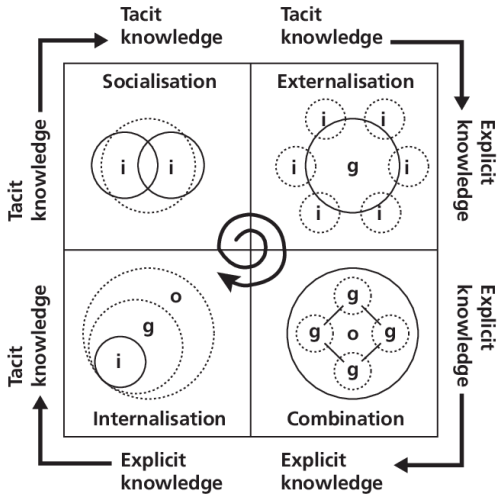

Figure 7: Nonaka's SECI model of knowledge dimensions. Source: Nonaka et al 2000.

Synthesis approach

Synthesis of the type we describe in this document is rare in the academic literature for several reasons:

1. Fully operationalised demand-driven research, although often aspired to, is rarely achieved in practice,
2. The breadth of projects conducted through the ACN across three research themes is wide and increases the complexity of the analysis (in this regard it is like a CRC),
3. Peer-reviewed methods for synthesis are still emerging in the academic literature (e.g. McNie 2016), and
4. Research is most often completed, funding expended, and staff dispersed before wider-learning from research *processes* can be effectively captured.

As the synthesis of the Node was undertaken after Phase 1 and during Phase 2, a mixed method approach was utilised, which included an adapted ENTREQ method, detailed output analytics from web-based and social media sources, conceptual modelling of the emergence of and interconnections among Node projects, and a participatory workshop with project partners. Each of these elements will be discussed in this section.

1. Enhancing Transparency in Reporting the Synthesis of Qualitative Research (ENTREQ)

We employed the Enhancing Transparency in Reporting the Synthesis of Qualitative Research (ENTREQ) method for conducting the synthesis. The ENTREQ framework was developed in a medical context to aid meta-synthesis and is focused on bringing together data and findings across different contexts, generating new theoretical or conceptual models, and providing evidence for the development, implementation and evaluation of health interventions. At the heart of this framework is a systematic approach to comparing findings between different types of studies against a checklist developed by health researchers (Tong et al 2012). We adapted ENTREQ as a tool to collate information on 24 measures (Table 1).

Table 1: Adapted ENTREQ data fields

1	Item Title	15	Key audiences
2	Aim	16	Key messages
3	Topics covered	17	Software employed
4	Qualitative methodology	18	Quality control of report
5	Quantitative methodology	19	Illustrative quote
6	Sample characteristics	20	Outputs
7	Geographic characteristics	21	Outcomes
8	Key economic sectors	22	Lessons
9	Fieldwork Timeframe	23	Informed Subsequent research
10	Report authorship	24	Adapted in other projects

11	Field work team		
12	Coding conducted by		
13	SNA conducted by		
14	Report uptake and usage		

2. Output Analytics

To assess reach and potential effectiveness of communication channels for ACN Phase 1 outputs, we collated available metrics from multiple sources including citations, website traffic (on Adapt NSW website and UTS Adaptive Communities page) and media reports.

a) Citations

Statistics on citations for scholarly publications on adaptation by ACN researchers were obtained from Google Scholar during the week of 1 October 2018. A complete list of publications is included at appendix 1.

b) Website Traffic

In order to understand reach of ACN outputs, website traffic was monitored from both the ADAPT NSW Adaptive Communities website and the Adaptive Communities Node url hosted by UTS-ISF.

c) Media Report Case Study

A number of projects undertaken with the ACN received significant media interest. Rather than importing a compendium of each instance of media coverage, within the report we offer a case study of a single project. We report on the media activity for four months following the release of the “Where are all the trees’ report (Horticulture Australia Limited and 202020Vision) as an example of traditional media (radio and press) interest in climate adaptation.

3. Conceptual approaches to synthesis

To synthesise the ACN outputs over time, we conceptualised the research process in two ways: ‘across domains’ (Figure 8) and ‘along pathways’ (Figure 9).

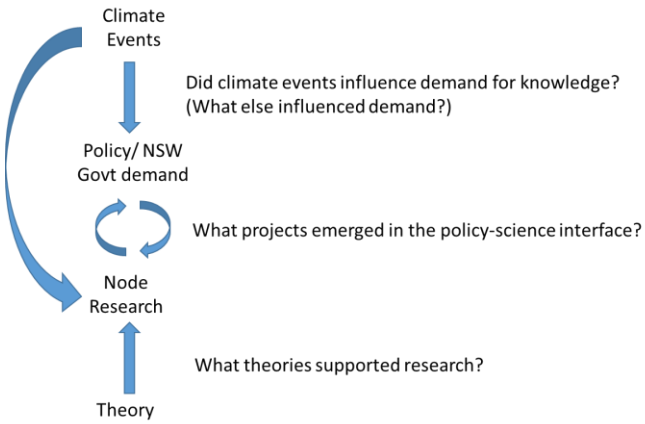

Figure 8: Conceptual model of synthesis depicted as occurring across domains: climate events, policy demand, research response and adaptation theory.

A cross-domain perspective (Figure 8) allowed us to understand the factors that drove emergence of projects over time. This approach allowed for exploration of the interaction among climate impacts, theoretical approaches to adaptation and response of demand-driven research.

A research pathways perspective (Figure 9) allowed us develop a network diagram of the connections among projects within each of the three ACN themes. Significant research pathways were then selected for a 'deep-dive' into the factors that led to the formulation of key ACN projects along the pathway. These factors included the influence of knowledge antecedents from research that pre-dated the ACN, other projects within the Node suite of research and any additional research that succeeded, but may not have been directly related to, Node-funded projects.

Conceptual models were then tested and enhanced in a participatory workshop with project partners.

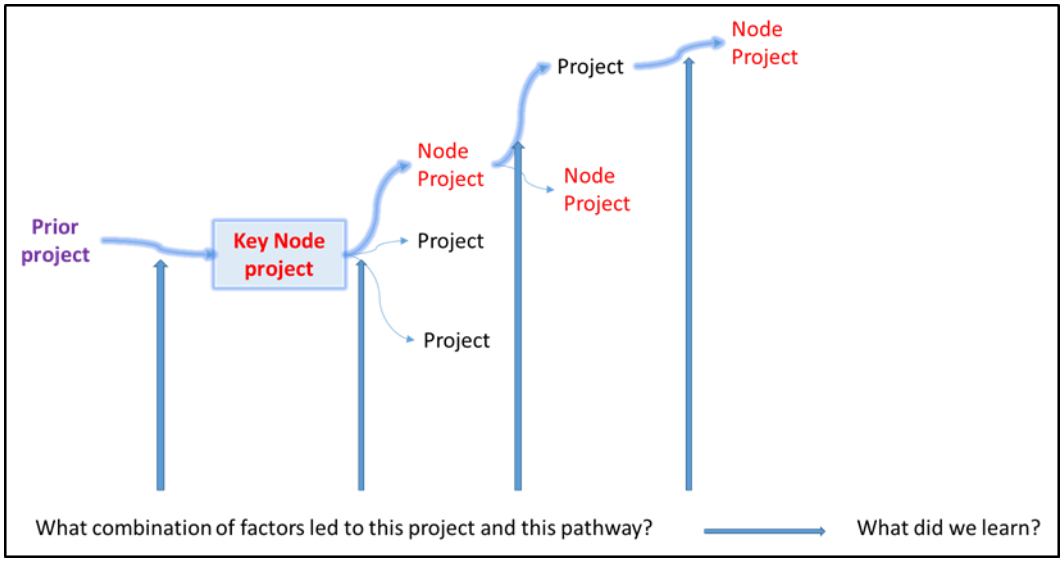

Figure 9: Conceptual model of synthesis depicted as deep dive along a key project pathway.

4. Participatory workshop with project partners

The aim of the workshop was to capture the tacit knowledge of key ACN partners of how the research activities developed over time under the demand-driven model. We were particularly interested to determine the combination of circumstances (policy, theory, climate events, funding opportunities, connections among people) that led to a line of research being followed, or the establishment of an individual project, over the possible range of other options. We conceptualised the workshop approach as a positive application of the 'Swiss cheese' model (Reason 2000) (Figure 10).

The conceptual models and workshop validation of them were designed to complement, visually, the information captured in the ENTREQ database. We envisioned information presented in these multiple forms would provide an invaluable supplement to any later formal evaluation process of the Adaptation Research Hub, in addition to informing future adaptation research initiatives by the NSW Government, other jurisdictions and so on.

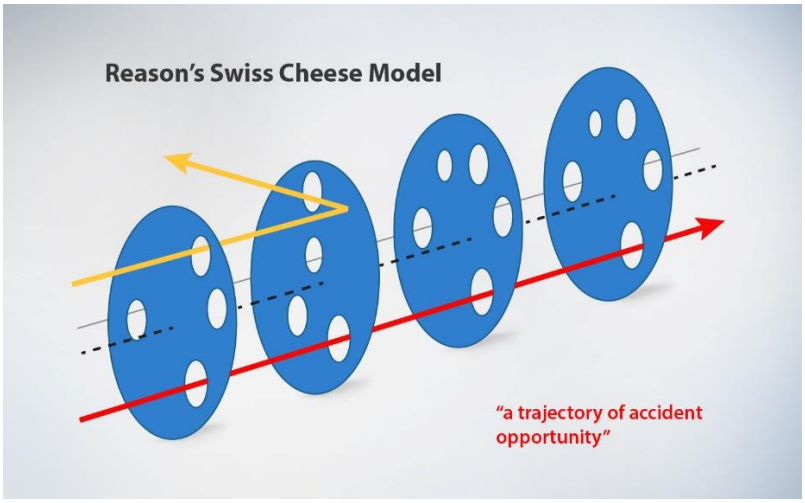

Figure 10: Model of the sequence of events leading to a positive or negative outcome. (Reason 2000)

The workshop involved key informants drawn from OEH staff involved in the establishment of the Adaptation Research Hub, local government, and researchers from UTS-ISF and CSIRO. The workshop agenda and activities are detailed in Appendix A.

At the end of the workshop we aimed to have:

- A narrative of the factors that helped to identify demand for the establishment of the Adaptation Research Hub with a focus on policy windows (Kingdon 1984) that may have led to the establishment of the ACN. Our initial premise, which was explored in the workshop, was that climate events may have stimulated these opportunities (Figure 11).
- Case studies of the factors that influenced the establishment of specific ACN projects, how those projects fit within the broad suite of research conducted under the ACN (and by the Climate Adaptation Group at ISF generally) and how learning on adaptation and adaptation research evolved over this time.

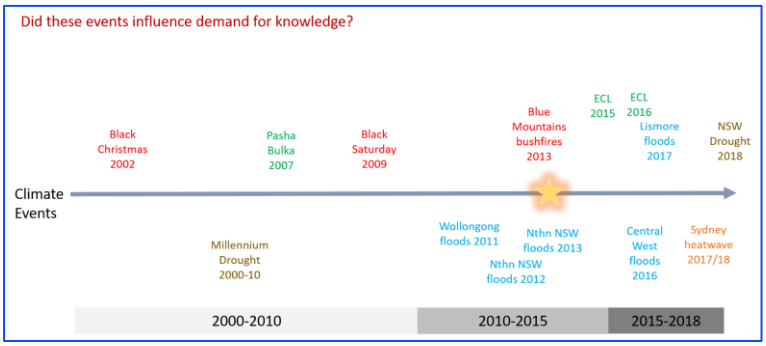

Figure 11: A conceptual timeline of climate events prior to and during research activities. The 'star' denotes ACN establishment in 2013.

Within the workshop, exploration of the 'policy window' around Node establishment was achieved by allowing participants to annotate a projection of Figure 11 with sticky labels (Figure 12) noting additional events from 1999 – 2015 (end of Phase 1 of the Node). Their reflections of these contextual events were elicited through open ended questioning (What factors influenced decisions in

government at this time, be they climate impacts, policy events, political changes etc.) group discussion and focused activities, and mapped onto the projected timeline (e.g. Figure 12). After the workshop, the additions to the timeline were categorised and tabulated according to date, type of event and follow on effects (if applicable) to assist in the reconstruction and visualisation of the policy window.

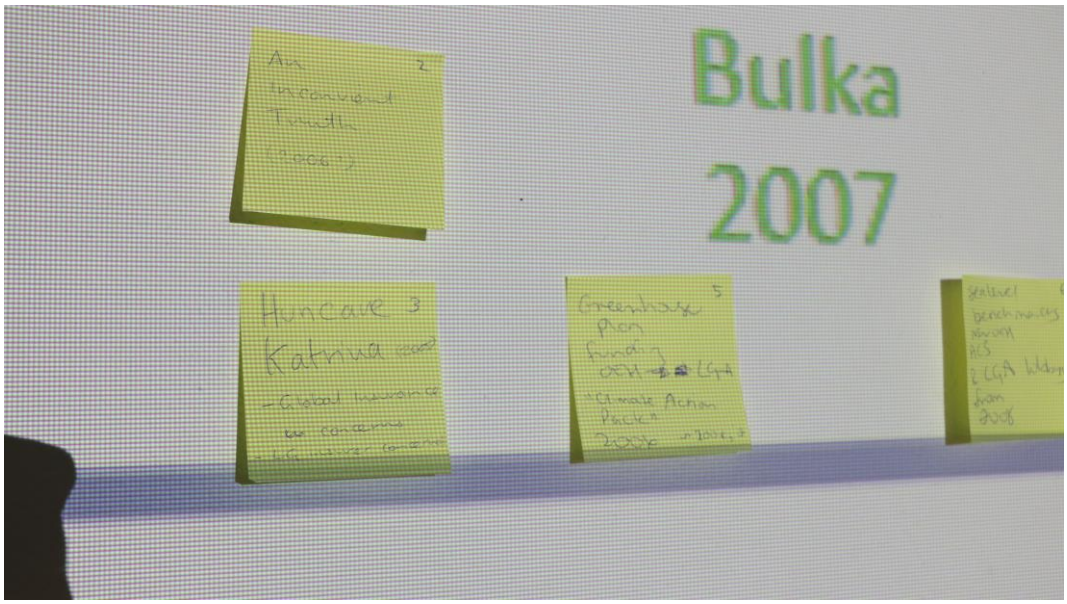

Figure 12: Example of the 'policy window' mapping exercise.

Case studies of specific projects along key project pathways were assembled through semi-structured questioning of key informants from among the workshop participants.

In addition, a series of brief video interviews were recorded with key informants about specific sections of the larger narrative or individual projects where they could offer insight into these events. A short video may be found on the UTS hosted *NSW Adaptation Research Hub - Adaptive Communities Node* Website: https://www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/our-research/climate-change/nsw.

Results

1. ENTREQ database

The ENTREQ database contains details of projects from across the three ACN themes from phase one. The database effectively performs as an archive of information for use in future research on adaptation by the NSW Government. Table 2 illustrates the information available in the database for two projects: the *Riverina Murray Integrated Regional Vulnerability Assessment* (RM IRVA) and the Shoalhaven case study for *Engaging local communities in climate adaptation*.

Table 2: Sample of information contained in the ENTREQ database.

1	Item /Project Title	Integrated Regional Vulnerability Assessment: Riverina Murray: V1	Engaging local communities in climate adaptation: a social network perspective from Shoalhaven, New South Wales, Australia
2	Aim	To present the outcomes of the IRVA process undertaken in the Riverina Murray region of NSW. It describes the key areas of vulnerability to climate change identified by regional participants	To map the formal and informal social networks in the Shoalhaven region exploring the uptake of climate adaptation policy.
3	Topics covered	Establish an understanding of climate change impacts within and between key regional sectors; State of knowledge and intended actions for sectoral stakeholders; Assess barriers to adaptation in key regional sectors; Assess adaptive capacity of the region; Identify main sources of vulnerability for region and each sector within; Identify opportunities to reduce vulnerability and enhance regional resilience	Perceptions of climate change and adaptation; Community concerns and personal experiences; Roles and responsibility for adaptation policy; Adequacy and usefulness of information and community engagement processes; Types of information that interest people the most; potential changes people have made to improve liveability and business efficiency under changing climatic conditions.
4	Qualitative methodology	Participatory workshops with regional stakeholders integration of different roles and positions in hierarchies across governance system; Focus on developing shared understanding and social learning; Pre and post workshop surveys to track change in understanding	Directed content analysis based on adaptive theory
5	Quantitative methodology	Projected changes in rainfall for region	Social Network Analysis

6	Sample characteristics	6 workshops (5 sector workshops, cumulative representation from 40 organisations) plus one synthesis workshop: 45 participants	24 interviews
7	Geographic characteristics	Riverina Murray region: 152,700 square kilometres Population: 279,000	Area 4,531km2 Population: 99,016
8	Key economic sectors	Agriculture (irrigated crops, broad acre crops, rangeland grazing), forestry, freight	dairy farming, beef cattle, manufacturing, tourism.
9	Fieldwork timeframe	2014	March-April 2014
10	Report authorship	Office of Environment and Heritage	Ben Harman, Rebecca Cunningham, Chris Cvitanovic, Brent Jacobs and Tom Measham
11	Field work team	Brent Jacobs, Suzanne Dunford, Liesl Laker, Storm Watson and OEH facilitators.	Rebecca Cunningham, Chris Cvitanovic
12	Coding conducted by	Brent Jacobs	Ben Harman
13	SNA conducted by	not applicable	Rebecca Cunningham
14	Report uptake and usage	Informed Riverina Murray Enabling Regional Adaptation (ERA) project.	Data from UTS (?)

15	Key audiences	Local Councils, Emergency services, CMAs, regional offices of all NSW state agencies	NSW Government Shoalhaven Council, Emergency services, other local councils, and NSW OEH
16	Key messages	Overall decrease in rainfall and water availability in the region, increased storm events Regions vary in exposure and sensitivity to climate. Government services in regional NSW are already vulnerable to multiple drivers of change. Climate change will amplify this vulnerability. Regional capacity for adaptation varies across sectors. Addressing vulnerability requires responses to be integrated across agency policy and operational siloes. Local government is highly exposed and largely unsupported. Centralised decision making contributes to lack of action on adaptation.	Residents primarily shared information within their local Profession/ geographical group only First attempt to show importance of networks for 'regional' adaptation to inform policy/operations.
17	Software employed	Vensim for impact diagrams	UCINET, Key player; NVIVO
18	Quality control of report	OEH internal review, Regional Management Committee review	CSIRO internal review
19	Illustrative quote	"Climate change is scary and unknown and it is hard to understand how it will impact them [farmers]… They don't have the resources [and] they don't know where to go."	"people here mostly they just don't care…I said it myself, I won't live that long. So I won't be seeing this."
20	Outputs	Report, conference presentation	Report, conference presentation
21	Outcomes	Increased understanding of climate impacts and regional vulnerability in Riverina Murray	Increased understanding of formal and informal networks within Shoalhaven shire.

22	Lessons	Vulnerability to climate change is multi-sectorial, and geographically and socially heterogeneous. Addressing vulnerability requires responses to be integrated across agency policy and operational siloes. Local government is highly exposed and largely unsupported.	Snowballing within a small geographical area is best undertaken in situ and in a timely fashion. Saturation may not be reached, but a sufficient sample is possible.
23	Informed Subsequent research	Riverina Murray ERA	Bega and Orange case studies
24	Adapted in other project	subsequent IRVA assessments throughout NSW	Kiribati DAMP

2. Output Analytics

Citations

Table 3 lists the citations of 28 ACN publications according to Google Scholar. It includes peer reviewed journal and conference papers and ISF research reports that are either directly linked to ACN research projects (e.g. 9 and 10), were in support of OEH's Adaptation Team work program (e.g. 2), or were an extension of ACN projects, techniques or concepts to other contexts (e.g. 4 and 15). This table does not include metrics on document 'reads' or 'downloads', which potentially extends the reach of the information beyond formal citations. About 30% of these documents were co-authored by NSW Government staff (OEH and DPI-LLS primarily). In addition, the inclusion of co-authors from CSIRO, from outside the field of adaptation and from international research bodies illustrates the breadth of collaborative networks established through the ACN.

Table 3: Compendium of ACN publications and citation metrics.

Date Search	Reference	Publication Date	Citation Number
1	Jacobs, B., Schweitzer, J., Wallace, L., Dunford, S., and Barns, S. (2018). Climate Adapted People Shelters: A Transdisciplinary Reimagining of Public Infrastructure Through Open, Design-Led Innovation. In *Transdisciplinary Theory, Practice and Education* (pp. 257-274). Springer, Cham.	2018	1
2	Jacobs, B., Boronyak, L., Mitchell, P., Vandenberg, M., & Batten, B. (2018). Towards a climate change adaptation strategy for national parks: Adaptive management pathways under dynamic risk. *Environmental Science & Policy*, *89*, 206-215.	2018	1
3	Jacobs, B., Cunningham, R., Boronyak, L. (2018) Climate Adapted People Shelters: Field Assessment, UTS:ISF, Australia.	2018	0
4	Dunford, S. (2018). Attributes of good governance for effective adaptation action, and regional transitions (5470). In *Proceedings of the 4th Practical Responses to Climate Change Conference:* (p. 63). Engineers Australia.	2018	0
5	Jacobs, B., Cordell, D., Chin, J., & Rowe, H. (2017). Towards phosphorus sustainability in North America: A model for transformational change. *Environmental Science & Policy*, *77*, 151-159.	2017	5
6	Esham, M., Jacobs, B., Rosairo, H. S. R., & Siddighi, B. B. (2017). Climate change and food security: a Sri Lankan perspective. *Environment, Development and Sustainability*, 20(3), 1017-1036.	2017	1
7	Cunningham, R., Jacobs, B., Measham, T., Harman, MP Cvitanovic, C. (2017) *Social network analysis: a primer on engaging communities on climate adaptation in New South Wales, Australia*, UTS:ISF, Australia	2017	0

8	Cordell, D. J., Dominish, E., Esham, M., & Jacobs, B. (2017). Towards Phosphorus and Climate Smart Agriculture in Sri Lanka. UTS:ISF	2017	0
9	Rowe, H., Withers, P.J., Baas, P., Chan, N.I., Doody, D., Holiman, J., Jacobs, B., Li, H., MacDonald, G.K., McDowell, R. and Sharpley, A.N., 2016. Integrating legacy soil phosphorus into sustainable nutrient management strategies for future food, bioenergy and water security. *Nutrient cycling in agroecosystems*, *104*(3), pp.393-412.	2016	65
10	Jacobs, B., Lee, C., Watson, S., Dunford, S., & Coutts-Smith, A. (2016). Adaptation planning process and government adaptation architecture support regional action on climate change in New South Wales, Australia. In *Innovation in Climate Change Adaptation* (pp. 17-29). Springer, Cham.	2016	7
11	Cunningham, R., Cvitanovic, C., Measham, T., Jacobs, B., Dowd, AM., (2016) Engaging communities in climate adaptation: the potential of social networks, *Climate Policy* 16 (7) 894-908	2016	14
12	Harman, B.P, Rylance, K., Brown, P.R, Cunningham, R., Jacobs B. and Measham, T. (2016), *Engaging local communities in climate adaptation: a social network perspective from Orange Valley, New South Wales, Australia*, CSIRO, Australia.	2016	2
13	Wynne, L., Cordell, D., Chong, J., & Jacobs, B. (2016). Planning tools for strategic management of peri-urban food production. Royal Institute of Chartered Surveyors (RICS).	2016	3
14	Jacobs, B., Boronyak-Vasco, L., Moyle, K., & Leith, P. (2016). Ensuring Resilience of Natural Resources under Exposure to Extreme Climate Events. *Resources*, *5*(2), 20.	2016	1
15	Boronyak-Vasco, L., & Jacobs, B. (2016). Managing natural resources for extreme climate events: Differences in risk perception among urban and rural communities in Sydney, Australia. In *Climate Change Adaptation, Resilience and Hazards* (pp. 181-194). Springer, Cham.	2016	3
16	Khalil, M. B., Jacobs, B. C., & Kuruppu, N. (2016). Grassroots Technologies and Community Trust in Climate Change Adaptation: Learning from Coastal Settlements of Bangladesh. In *Innovation in Climate Change Adaptation* (pp. 297-311). Springer, Cham.	2016	0
17	Harman, B.P., Cunningham, R., Cvitanovic, C., Jacobs B. and Measham, T. (2015), *Community based perspectives on climate change and adaptation in the Shoalhaven region, New South Wales, Australia*, CSIRO, Australia.	2015	1
18	Harman, B.P, Cunningham, R., Jacobs B., Measham, T. and Cvitanovic, C. (2015), *Engaging local communities in climate adaptation: a social network perspective from Bega Valley, New South Wales, Australia*, CSIRO, Australia.	2015	2

19	Dunford, S., Lee, C., Jacobs, B., and Neirinckx, A. (2015). The Towards a Resilient Sydney project: from Collective Assessment to Strategic Frameworks. State of Australian Cities Conference 2015.	2015	0
20	Jacobs, B. and Boronyak-Vasco, L. (2015) *Natural Resources Planning for Climate Change: Extreme Climate Events and Communities*, report prepared for South East Local Land Services. ISF.	2015	2
21	Jacobs, B., Nelson, R., Kuruppu, N., and Leith, P. (2015). An adaptive capacity guide book: Assessing, building and evaluating the capacity of communities to adapt in a changing climate. UTAS.	2015	14
22	Cunningham, R. Cvitanovic, C., Measham, T., Jacobs, B., Dowd, AM, and Harman, B. (2014) *A preliminary assessment into the utility of social networks for engaging local communities in climate adaptation policy*: working paper prepared for NSW Office of Environment & Heritage, Sydney, Australia.	2014	2
23	Cvitanovic, C., Clunn, R., Jacobs, B., Williams, C., and Measham, T. (2014). *An Introduction to Social Networks for Engaging the Community in Climate Policy*. Node for Adaptive Communities report to New South Wales Office of Environment and Heritage.	2014	2
24	Measham, T., Jacobs, B., and Brown P.R. (2014). *Meta Learning from past adaptation*. Node for Adaptive Communities report to New South Wales Office of Environment and Heritage.	2014	1
25	Jacobs, B., Boronyak, L., Dunford, S., Kuruppu, N., Lewis, B. and Lee, C. (2014). '*Towards a resilient Sydney – supporting collective action to adapt sub national government services to regional climate change'*, 3rd International Conference on Climate Change & Social Issues, Colombo, Sri Lanka, 30 July - 1 August 2014.	2014	1
26	Jacobs, B., Boronyak-Vasco, L. and Mikhailovich, N. (2014) Enabling adaptation in the Australian Capital Territory: Final report. ISF	2014	1
27	Jacobs, B., Lee, C., O'Toole, D., & Vines, K. (2014). Integrated regional vulnerability assessment of government services to climate change. *International Journal of Climate Change Strategies and Management*, 6(3), 272-295.	2014	14
28	Jacobs, B., Mikhailovich, N., & Delaney, C. (2014). Benchmarking Australia's Urban Tree Canopy: An I-Tree Assessment, Final Report to Horticulture Innovation Australia	2014	19

Website Traffic

To understand the reach of ACN outputs, website traffic was monitored from both the Adaptive Communities Node url hosted by UTS-ISF (Table 4, Figure 13) and the ADAPT NSW Adaptive Communities website (

Table 5).

Table 4: University of Technology Sydney hosted – NSW Adaptation Research Hub - Adaptive Communities Node Website analytics*

Dates: 3rd October 2013 – 9th Oct 2018		
Source	Page Views	Unique Page Views
Google	1098	646
Mq.edu.au	710	452
Climatechange.environment.nsw.gov.au	323	258
Direct links	194	130
TOTAL	*2325*	*1486*

* Note: due to a restructure of the UTS website in 2016 there may be some under-reporting of website visitation. https://www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/our-research/climate-change/nsw

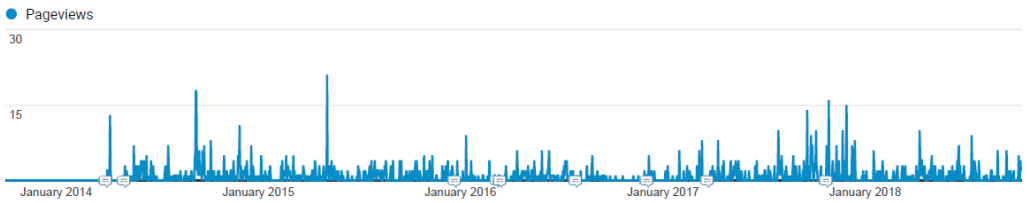

Figure 13: University of Technology Sydney hosted – NSW Adaptation Research Hub - Adaptive Communities Node Website external traffic page views

The majority of website traffic remained consistent throughout the life of the Node (~10 views per day). There are noticeable peaks after report releases, or public events such as “Where are all the trees” report (June 2014), “Monitoring Climate Adaptation People Shelters” report (January 2018) and Adapt NSW annual forums (around November annually).

Table 5: Adapt NSW – Office of Environment and Heritage hosted – Adaptive Communities Node website* analytics

Dates	Total number of unique entries
06 September 2014 – 12 September 2017	635
14th Sept 2017 to 3rd Oct 2018.	77
TOTAL	712

* https://climatechange.environment.nsw.gov.au/adapting-to-climate-change/adaptation-research-hub/adaptive-communites-node

Media Reports

In 2013-2014 UTS:ISF conducted research to explore urban heat in two Sydney LGAs. The resulting report "*Where are all the trees*?" was released in June 2014.

The media following this report was tracked over a 4 month period from the release of the report. At that time, urban greening and urban heat generated media interest in print, radio and on external websites. Figure 14 outlines the cumulative media interest over this time period.

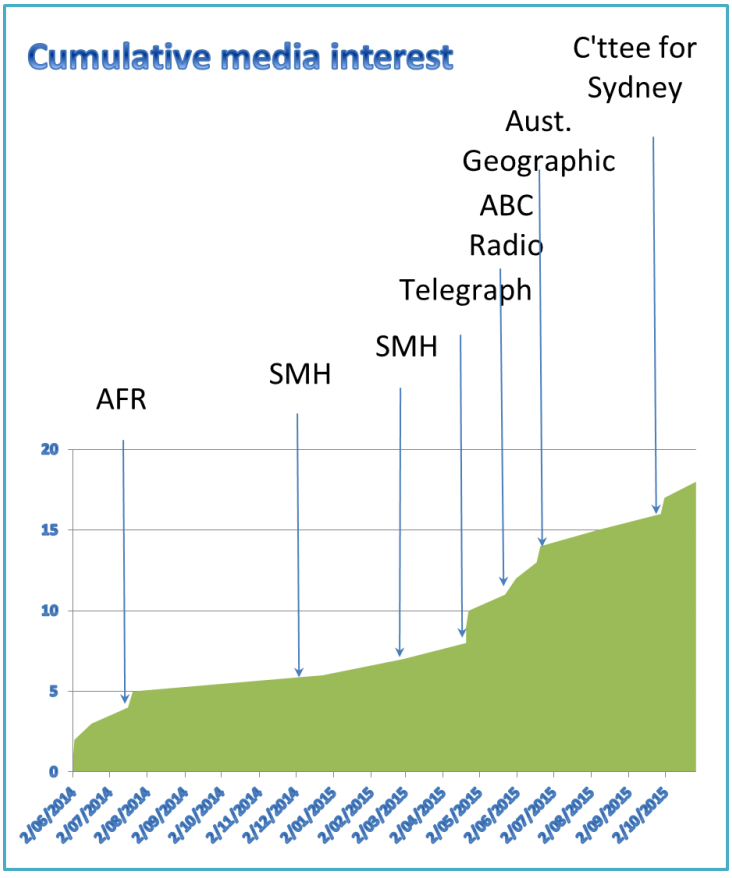

Figure 14: Media interest in '*Where are all the trees?*'

3. Conceptual models of research emergence

Cross-domain model

Figure 15 conceives the interface between research demand and supply as being ‘sandwiched’ between climate events, as a driver of government knowledge demand, and adaptation theory, as providing theoretical approaches to inform research response. For example, the need to understand the impact of climate change on government service delivery and the adaptive capacity of administrative regions throughout NSW was an early driver of adaptation research, which resulted in the state-wide program of Integrated Regional Vulnerability Assessments (Jacobs et al 2016). While each NSW region differs in the climate events of concern, in Sydney the immediate climate drivers were the incidence of heat waves and storms caused by East Coast Low (ECL) pressure systems. To meet that need, ACN researchers drew on participatory approaches to regional vulnerability assessment (e.g. Jacobs et al 2014) and adaptive capacity (e.g. Brown et al 2010) in a public sector context (Jacobs and Leith 2010).

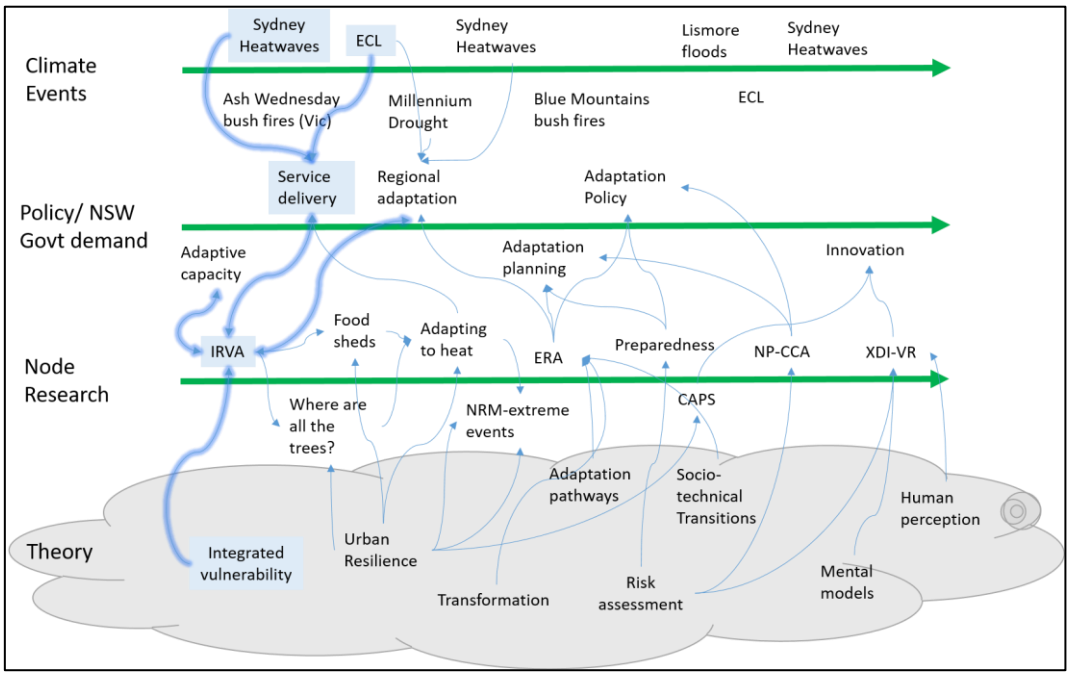

Figure 15: Conceptual model of the interaction of climate events, research demand, supporting adaptation theory and research response. Green arrows represent timelines for events, demand and research response. Theory is represented as existing within a ‘knowledge cloud’.

Research pathways model

To understand the fine detail associated with the breadth of adaptation research conducted under the ACN, we developed a network model of all projects within each Node thematic area: transformational adaptation (Figure 16), community-policy-research nexus (Figure 17) and regional innovation systems (Figure 18). In these models, research projects were connected over time (moving from left to right in the diagram) because they emerged in some way from preceding research activities, such as by drawing on findings or similar approaches. Each project network is made up of combinations of research by Node investigators that occurred outside the field of climate adaptation and that predated the ACN

(green text), research that was part of OEH's broader adaptation work plan (purple text), ACN phase 1 (light red) and phase 2 (dark red) projects and adaptation research conducted by ACN researchers that was funded from other sources (black text).

Both the number of projects within each network and balance among the types of projects varied across themes. The transformational adaptation theme was the most 'mature' network consisting of about 40 projects spread across all types. The CPR-nexus theme contained fewer projects, with none of the research pathways extending into ACN phase 2. In contrast, the RIS theme projects were heavily skewed towards ACN phase 2 because delays in phase 1 required the carry-over of research activity into future years. Consequently, the RIS theme also has fewer 'spin off' projects funded from sources other than the Adaptation Research Hub.

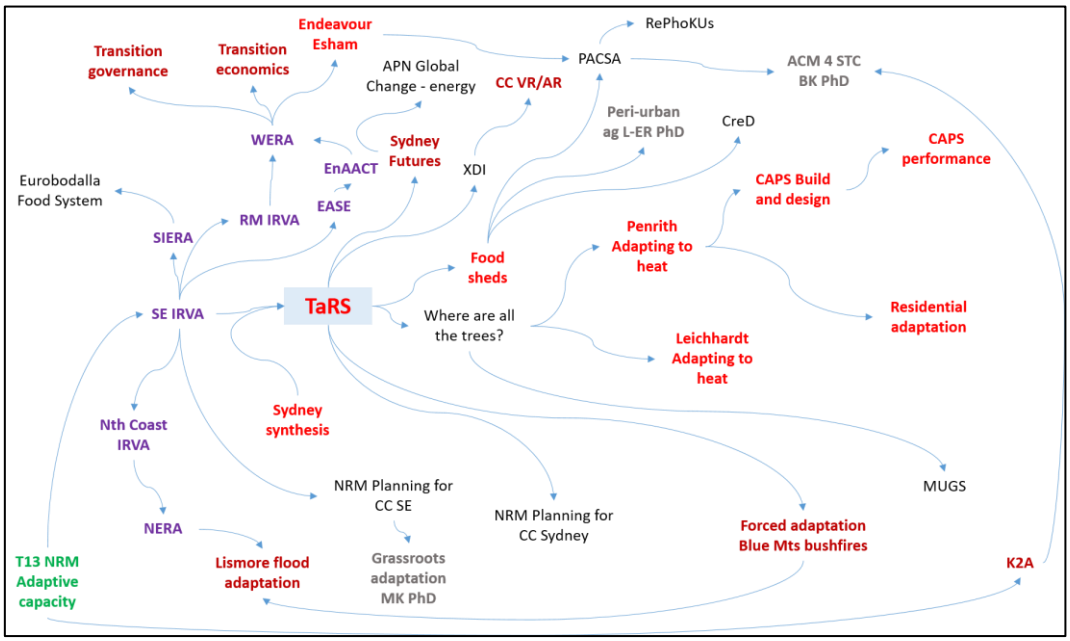

Figure 16: Connections among projects in the transformational adaptation theme.

For both the transformational adaptation and CPR-nexus themes, there was a key project in the network that drew on a large body of preceding adaptation research and was influential in later research activity. For transformational adaptation and CPR-nexus the key network nodes were Towards a Resilient Sydney (TaRS) and Social Network Analysis respectively. TaRS, for example, drew on the latest climate projections (*Sydney Climate Snapshot*), learning from the South East IRVA (the first project in the state-wide regional vulnerability assessments) and OEH-commissioned reviews by sectoral experts on climate impacts for Sydney (*The Sydney Synthesis*) to inform a series of workshops with local and state government decision makers. These workshops were influential because, for the first time, they allowed cross-sectoral interaction among government decision makers focused collectively on climate change vulnerability and adaptive capacity in greater Sydney; and, they encouraged, and OEH supported, the development of social networks that spanned government hierarchies and Sydney's geography.

The connections established through TaRS and the interest it focused on Sydney's vulnerability coincided with increased demand for adaptation research. Increased demand led to a number of ongoing research pathways for the ACN, such as urban greening (*Where are all the trees?*), urban heat islands (*Adapting*

to Heat) and food security (*Food Sheds*). These pathways, in turn led to international adaptation research opportunities such as *Phosphorus and Climate Smart Agriculture* in Sri Lanka (PACSA), *Phosphorus vulnerability of the UK Food System* (RePhoKUs) and several international PhD topics (in Bangladesh, Sri Lanka and Pakistan).

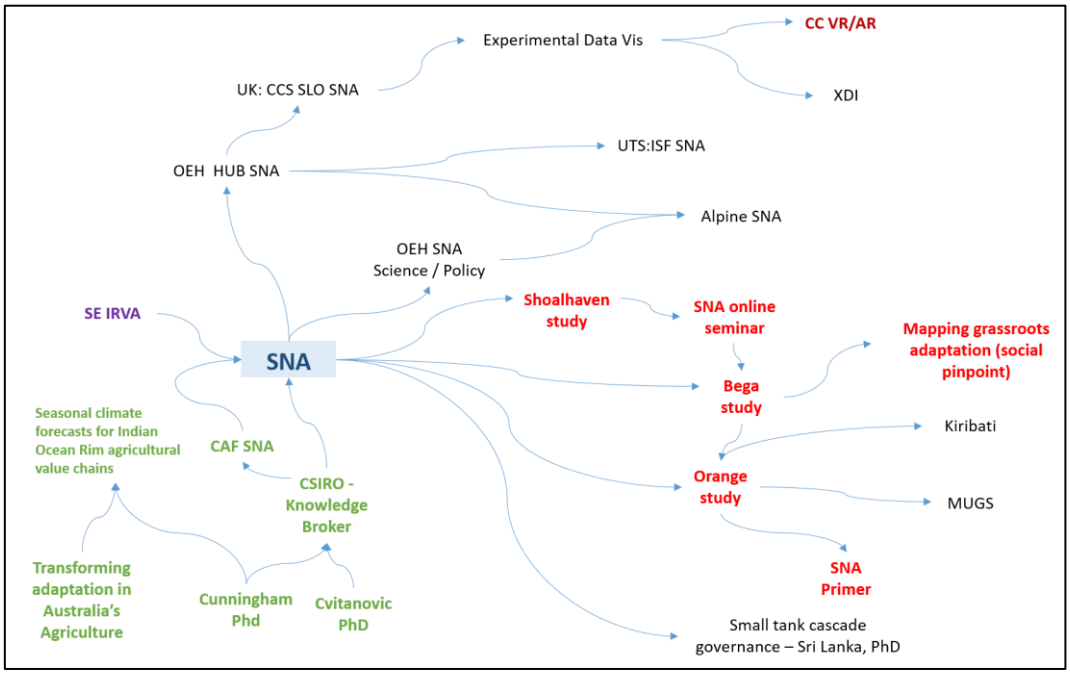

Figure 17: Connections among projects in the community-policy-research nexus theme.

For the CPR-nexus theme, the number of ACN projects (six out of 26) reflects the budget allocation to this theme (which was relatively small) and broader demand for the techniques outside of the ACN. The central project explored the use of social network analysis (SNA) in understanding information flow within regional communities and the potential of social networks for engaging residents in climate adaptation. The project was informed by knowledge from past research shared from collaborators in CSIRO's Climate Adaptation Flagship (disbanded soon after the inception of the ACN). The project consisted of mapping the sources of information about climate adaptation, as well as the ways that residents shared information in each of the three regional case studies (Shoalhaven, Bega and Orange). Each of the case studies was valuable in its own right in terms of understanding the distinct local patterns of information exchange, providing key insight into effective channels for engaging residents in those communities. Considering the set of case studies together provided additional valuable insight for research and policy alike. In each case study, the networks for receiving information about climate adaptation were very different, (with virtually no overlap) to the networks for passing information on. The patterns of information sharing were of strong interest, not only in terms of revealing the processes by which to engage residents, but also in terms of identifying gaps in networks, or where the networks lacked resilience in terms of strong dependency on certain key nodes whether they represent individuals or institutions (Harman et al 2015a; Harman et al 2015b; Harman et al 2016; Cunningham et al 2016).

The Shoalhaven and Bega studies used local government connections established through the SE IRVA in its snowball sampling method. These case studies were followed by the development of a *SNA primer* to explain how the analysis outputs could be interpreted, and a project to map community adaptation actions in an on-line platform (*Mapping Grassroots Adaptation*). In common with

the transformational adaptation theme, some international opportunities to use SNA techniques emerged in Kiribati and Sri Lanka.

The antecedents of the RIS theme included the regional IRVAs and their later incarnation as the Northern and Western Enabling Regional Adaptation projects (NERA and WERA). The RIS theme contributed information to the IRVA process through regional *Shift-share Analysis.* A series of place- and sector-based case studies on aspects of business adaptation link to the central project via three sub-projects established in ACN phase 1 (forced adaptation , industry transformation and adaptation finance mechanisms).

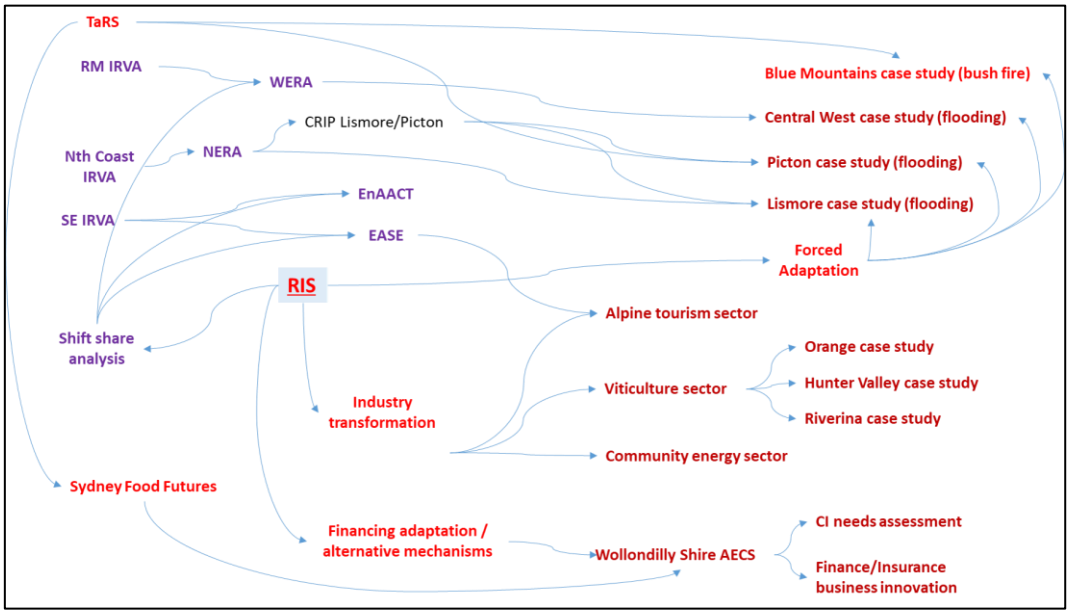

Figure 18: Connections among projects in the Regional Innovation Systems (RIS) theme.

4. Model validation and enhancement

Node establishment – how did it come about?

Workshop participants identified an additional 35 ‘events’ that they believed influenced the policy environment around the establishment of the ACN.

Table 66 lists the events of influence, their timing and significance to NSW. While the climate events that pre-populated the timeline may have been important, participants identified five events of particular significance: the Canberra bushfires (2003), US Hurricane Katrina (2005), the Pasha Bulka storm (2007), the ‘Red Storm’ (2009) and the ‘Angry Summer’ (2012/13). Except for Hurricane Katrina, which was of global significance, all of these climate events directly affected NSW, and received extensive media coverage. Aside from climate events, there was a range of other types of influences, which were organised into four categories: global shocks, information products, research, and policy. Some events spanned more than one category, such as the Garnaut Review that could be considered a policy document and an output of applied economic research.

Table 6: Events that potentially influenced the inception of the NSW Adaptation Research Hub and the ACN, their timing, the type of event and their significance. Colour coded numbers (1-14) represent climate events used to pre-populate an ACN time-line.

#	Year	Event	Category	Significance
1	2001-2002	Black Christmas (NSW)	Extreme climate event	Mainly burnt in Lane Cove, the Royal & Blue Mountains NP, 3,000 km^2 burnt, 121 homes destroyed and 36 damaged, $7m damage.
2	2001-2009	Millennium Drought (Aust)	Extreme climate event	Severely affected major capital cities, the Murray-Darling Basin and virtually all of the southern cropping zones.
3	2007	'Pasha Bulka' storm (NSW)	Extreme climate event	Severe ECL. Public attention focused by ship run aground on Newcastle beach
4	2009	Black Saturday Bushfires (Vic)	Extreme climate event	Most devastating in Australian history; 173 people killed, 414 were injured, more than a million wild and domesticated animals were lost and 450,000 hectares of land burned.
5	2011	Wollongong floods (NSW)	Extreme climate event	Series of floods occurring throughout Wollongong and the Illawarra regions. One death, widespread evacuations, transport links cut.
6	2012	North coast floods (NSW)	Extreme climate event	75 per cent of NSW under flood warnings, forced evacuations and natural disaster declarations.
7	2013	Blue Mountains Bushfires (NSW)	Extreme climate event	Early season (October) bushfires, 2 deaths, 118,000 ha vegetation and 248 houses/structures destroyed
8	2013	Northern NSW floods (NSW)	Extreme climate event	Ex-tropical cyclone Oswald, heavy rainfall and damaging wind gusts, widespread flooding, major flooding Richmond and Clarence rivers
9	2015	East Coast Low (NSW)	Extreme climate event	Severe flooding in Maitland and Dungog, inundating homes and isolating entire communities. Power and water access was restricted for tens of thousands of homes across the wider Hunter Region.
10	2016	East Coast Low (NSW)	Extreme climate event	ECL combined with a King tide brought severe coastal damage - Collaroy and Coogee - with flooding along the east coast
11	2016	Central West Floods (NSW)	Extreme climate event	One person dead, Newell Highway blocked for weeks and >$500 million damage to farms and businesses
12	2017	Lismore Floods (NSW)	Extreme climate event	Tropical Cyclone Debbie delivered extreme rainfall to northern NSW towns, despite having crossed the coast several days earlier and more than 1,200km to the north.
13	2017-18	Sydney heat wave (NSW)	Extreme climate event	Hottest summer on record, Sydney temperatures exceed 40^{o}C
14	2018	Drought (NSW)	Extreme climate event	NSW driest year since 1965
Added by participants				
	2003	Canberra bushfires (ACT)	Extreme climate event	Four people died, over 490 were injured, and 470 homes were destroyed or severely damaged
	2005	Hurricane Katrina (USA)	Extreme climate event	Category 5 hurricane struck the Gulf Coast US, catastrophic damage from central Florida to eastern Texas. Global Insurance concern Local Government insurer concern
	2009	'Red Storm' (NSW)	Extreme climate event	Thousands of tons of soil dumped in Sydney Harbour and the Tasman Sea, dust plume > 500 km wide and 1,000 km

				long in length, covered dozens of towns and cities in two states
	2012/ 13	'Angry Summer' (NSW)	Extreme climate event	123 weather records broken over 90-day period, including the hottest day ever recorded for Australia, the hottest January on record, the hottest summer average on record, and a record seven days in a row when the whole continent averaged above 39°C
	1999	CCP mitigation – AGO Greenhouse Office Guidelines	Policy / Guidelines	Four discussion papers on emissions trading for public comment. Describe the essential features of cap-and-trade emissions trading scheme, differences between this scheme and a carbon tax, and reasons for preferring the former.
	2006	Stern Review *Economics of Climate Change* (UK)	Research-policy information	Discusses the effect of global warming on the world economy
	2006	Adaptation - AGO Greenhouse Office Guidelines	Policy / Guidelines	Promoted a common approach to risk assessment for LG
	2006	*An Inconvenient Truth* released	Information	Climate change entered the public domain and popular culture
	2006	OEH Greenhouse plan funding & LGA "Climate Action Pack"	Policy	Enhance understanding of the impact of climate change impacts on LG's areas of responsibility, assist LG to mitigate and adapt
	2007	Kyoto Protocol Ratified	Policy	Global commitment to mitigation targets
	2008	Global Financial Crisis	Global shock	Re insurance became expensive
	2008	Garnaut Review (Aus)	Policy-research	Examined the impacts of CC on Australian economy, recommended policies and policy frameworks for sustainable prosperity
	2008	Sea level benchmarking NSW OEH and ACS	Policy	2 LGS lobbies from that time
	2008	OEH importance of regional adaptive capacity – NSW MER Targets for NRM	Research	Collaborative link established within DECC (OEH)
	2009	Dust storm (Millennium Drought)	Climate extreme event	Extensive media coverage raised public awareness of climate-related events
	2009	Sea Level Rise policy statement	Policy	Rescinded in 2010
	2009–2010	South East Vulnerability Assessment (IRVA)	Research	Evidence base for regional vulnerability of service delivery.
	2010	Productivity Commission report on climate change End Millennium Drought	Policy	Consideration of cost of climate change
	2010	Climate Impact Profiles coupled to Qualitative Impact Assessment	Policy-Research	Acceptance of tacit knowledge on local climate adaptation as important for service delivery planning
	2010 – 2015	Climate change adaptation impacts: Adaptation Research Strategy	Policy	Set the direction for OEH adaptation agenda

	2011	Statewide Mutual (LG insurer)	Information	Climate-related LG risk assessments
	2011	Barry O'Farrell elected "Failed Green Schemes"	Politics	Opportunity with change of NSW Gov (in context of Federal policy on ETS)
	2011	Global Cities - Chicago, London, New York - adaptation plans	NSW OEH internal report	Encouraged development of Towards a Resilient Sydney (TaRS) project
	2011	NSW and ACT Regional Climate Modelling (NARCliM) Project initiated	Research	No appropriately-scaled Commonwealth data set Essential to adaptation, funding made available
	2012	Waste Levy Funding Wellie Funding	Policy	Long-term funding available for a strategic NSW adaptation research program
	2012 (?)	*What is emerging sectorally*? Hillary Bendice	Research-information	OEH internal epidemiologist report
	2013	Collaborative link established - OEH & UTS & CSIRO	Policy-research interface	Partnership formed the basis of the ACN
	2013	Climate Commission abolished	Policy-research	Independent body established in 2011 by the Federal Government of Australia to communicate "reliable and authoritative information" about climate change in Australia
	2013-2014	Productivity Commission *Barriers to Effective Climate change Adaptation* Report	Research	Examine the costs and benefits of options, assess the role of markets and non-market mechanisms, and the appropriateness of government intervention
	2014	Risk to Resilience Local Government Workshops	Research-engagement	Focused local government on climate risk
	2014	ADAPT NSW WEBSITE (Dec 2014)	Information	Made accessible downscaled climate projections and impacts information.
	2014 – 2015	TARS (Feb 2014/2015) created regional demand for IRVAs	Research-engagement	Brought together NSW and local Government decision makers to consider Sydney's vulnerability to climate change

Visualising the information in

Table 66 on a revised timeline (**Figure 19**) shows a clear concentration of influencing events over about a 10-year period (2003-2013) prior to the establishment of the ACN within the NSW Adaptation Research Hub. The escalation in number of events is particularly evident in the research-policy interface with the release of key international (e.g. Stern Review, Kyoto Agreement), national (e.g. Garnaut Review, Productivity Commission) and NSW (NSW Sea Level Benchmark) policy documents and projects (e.g. inception of the NARClim project). A greater appreciation of climate change risk, particularly by local government, followed the State-wide Mutual Risk Assessment process. Moreover, climate change gained heightened prominence in public consciousness through the release of Al Gore's film, *An Inconvenient Truth*, and the public debate that ensued.

Not all events were public, many were identified as occurring within the OEH policy-operations-science sphere, such as collaborative links between climate adaptation staff (their need to understand social vulnerability) and NRM investments staff (availability of research from the NRM MER state-wide targets on adaptive capacity of natural resource managers – known as Target 13). This link led to the development of the Integrated Regional Vulnerability Assessment process to engage regional government decision makers on the impacts of climate change on service delivery (e.g. SE IRVA and TaRS). Throughout this period, various actors among OEH staff actively sought funding for adaptation research, which was secured ultimately from the NSW Waste Levy Scheme.

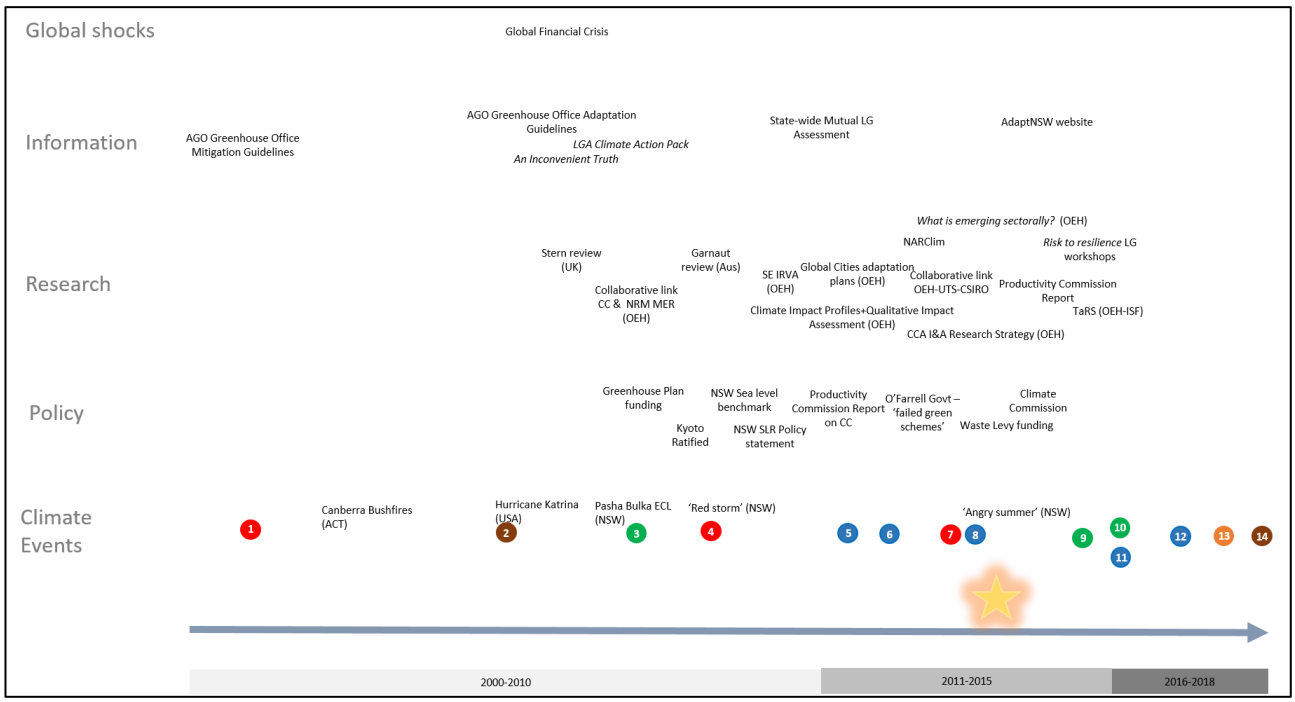

Figure 19: Events making up the policy window around establishment of the ACN (gold star). Coloured dots are extreme climate events used to prepopulate the timeline: bushfire (red), drought (brown), storm (green), flood (blue) and heat wave (orange). Additions to the timeline by workshop participants are shown as text and organised into five categories: climate events, policy, research, information, and global shocks.

Why did we follow particular research pathways?

Workshop participants validated the project network diagrams (Figure 16, Figure 17, Figure 18). We selected a key project pathway from each network diagram, based partly on the significance of the projects in the pathway and partly on the availability of detailed knowledge among the participants at the workshop. From

this discussion, we developed a narrative that explored how this subset of projects emerged and led to further work within the ACN and beyond.

Transformational adaptation theme: from TaRS to CAPS

Towards a Resilient Sydney (TaRS) was a central node in the transformational adaptation theme (Figure 16), which integrated learning from several earlier projects and was a catalyst of subsequent research. One research pathway, *TaRS to CAPs performance* (Figure 20), provides a unique example of project emergence that could occur only in a demand driven research model from the complex interaction of multiple contextual factors.

TaRS brought together local and NSW Government decision makers in a series of participatory workshops specifically to consider Greater Sydney's vulnerability to climate change. Among the climate vulnerabilities identified through TaRS, the loss of green space and flow on impacts of this for Sydney's environment and liveability were viewed as critical issues to be addressed in response to climate change. In addition, TaRS created a network of public sector, climate change actors with a cross-sectoral understanding of the implications of climate change for Sydney and a commitment to action on adaptation.

A follow on ISF project, '*Where are all the trees?*' funded by Horticulture Australia Limited (now HortInnovation) for the *202020Vision* initiative, provided maps of tree cover for every urban LGA in Australia, cemented links with CSIRO green space researchers, and raised the issue in the popular media through multiple print and radio interviews of tree canopy loss as a contributor to urban heat islands (UHI) (Figure 14).

Seed funding from the ACN and Penrith City Council (PCC) facilitated a pilot study of UHI and land surface cover in the St Marys precinct. This project developed from:

- a connection between PCC staff and ACN researchers established during TaRS,
- availability of surface temperature data (2011 heat wave from processed Landsat imagery) from a NSW Environmental Trust-funded CSIRO project, and
- collaborative links between ACN and CSIRO researchers.

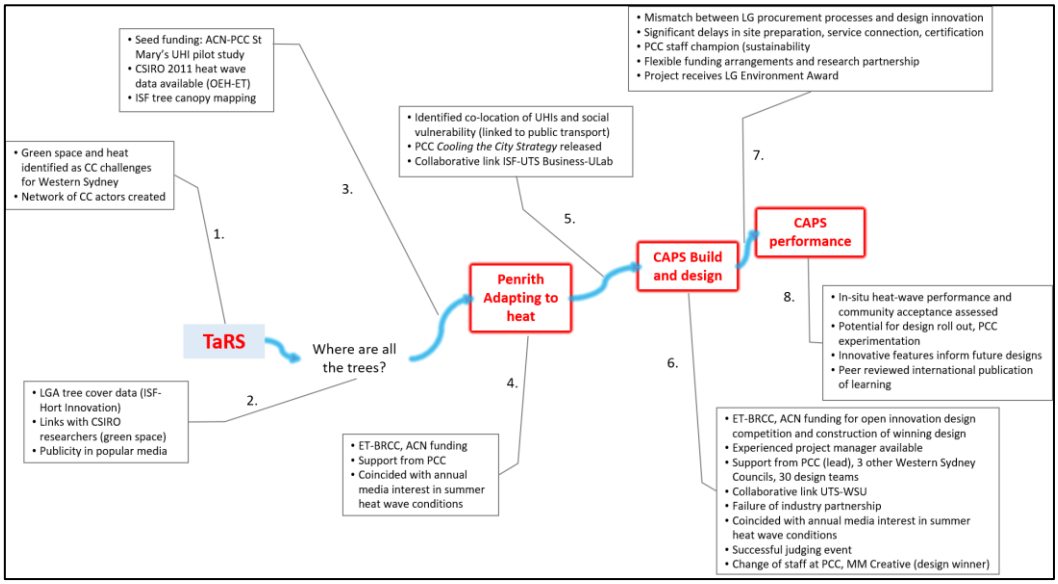

Figure 20: TaRS to CAPS a key project pathway through the transformational adaptation theme.

The results of the St Marys pilot, further seed funding from the ACN, and ongoing support of PCC sustainability staff secured grant funding through the inaugural round of the NSW Environmental Trust's *Building Resilience for Climate Change* (BRCC) Grant scheme, which targeted on ground adaptation action by local government. This project, *Adapting to Heat in Penrith and Leichhardt* mapped UHIs and land cover from aerial imagery, validated the mapping through local case studies, and canvassed local social service providers to understand the social impacts of extreme high temperatures and responses to address social vulnerability in Penrith and Leichhardt LGAs. The project coincided with renewed media interest in annual heat wave conditions in the lead up to summer.

The findings of *Adapting to Heat* revealed the links between UHIs and social vulnerability in Penrith, and provided much of the evidence base for PCC's *Cooling the City* strategy. In particular, a connection was established between exposure to heat waves, the sensitivity to heat of 'disadvantaged' groups within the community, and the dependence of these groups on public transport, especially buses (illustrating limitations in adaptive capacity). This knowledge prompted the development of a follow up proposal to BRCC to design and build an improved bus shelter to better protect the public from extreme weather.

The *Climate Adapted People Shelters* (CAPS) project leveraged a desire for collaboration among UTS researchers (ISF-ACN, UTS-Business School, U-Lab) to explore the connection between design and adaptation. A project was funded by BRCC to conduct an open innovation design competition to design, construct and evaluate a climate adapted bus shelter in partnership with four western Sydney LGAs (Penrith, Parramatta, Canterbury and Ashfield). An experienced public sector manager, on leave from a senior position with Australian Government, was secured to develop and promote the competition and liaise with design teams (30 teams entered) and project partners (UTS, OEH, Western Sydney University). A successful judging event, held at Penrith, gained media attention for participating councils and selected a western Sydney design and fabrication company (MM Creative) as the winner. This company also undertook to build the winning design, which PCC would install on site.

A range of difficulties then impeded construction and installation, including loss of significant staff members at PCC and MM Creative. The perseverance of the replacement sustainability manager at PCC and the flexibility of the research-funding partnership (ACN-LGNSW-OEH) enabled the final stage of the project, assessment of performance, to be conducted successfully about 18 months later than scheduled.

This project received a NSW LGA Environment Award and CAPS formed a case study of transdisciplinary learning for a peer reviewed book chapter (Jacobs et al 2018).

Community-Policy-Science Nexus

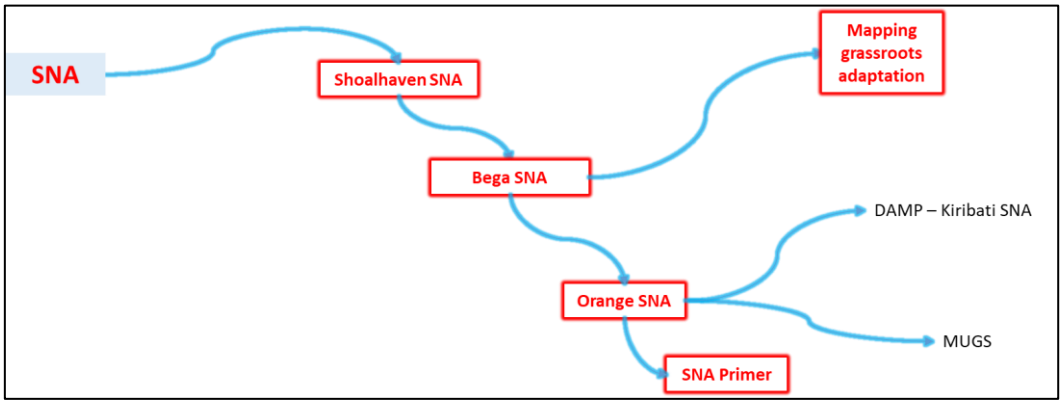

Figure 21: SNA to SNA Primer a key project pathway through the Community-Policy-Science nexus theme.

The decision to utilise a social network analysis was in direct response from policy demand. There was a need to understand and develop effective mechanisms to engage with residents about climate adaptation and social network analysis (SNA) was an appropriate approach. Part of the rationale was to look beyond how information would be expected to flow based on formal roles and institutional responsibilities. NSW Government engagement specialists were interested in the informal processes and unofficial channels through which local residents sourced and exchanged information about climate adaptation to gain a fuller picture of how information flows. In response, researchers working on the CPS theme suggested considering the principle of shadow networks, which were becoming increasingly prominent in the adaptation literature (Pelling et al 2008). Through serendipity, staff working on this theme were connected to experts in the use of social network analysis and designed an appropriate method to be explored in a case study context in early 2014. The location for the first case study of Shoalhaven was selected by NSW government staff due to the size and composition of the region, and also due to the social profile and trajectory of the main towns (e.g. Nowra), which represented a distinct interest from a policy perspective.

At one level, the findings from the Nowra case study confirmed that the informal channels of information flow were extremely important for engaging residents on climate adaptation. At another level, the findings were very surprising because the networks for information sources and information dissemination were distinct, raising key questions as to what was underpinning these differences. In addition, the case study raised the question as to how generalizable the findings were, prompting the demand for a second case study considering a region which was similar in many ways (coastal region of similar size and economic profile). Addressing these questions led to the second case study (Bega) in late 2014, which also sought to expand the type of analysis to include a substantial qualitative focus seeking to understand what was driving adaptation decision making.

The Bega case study highlighted the importance of autonomous informal adaptation, much of which was not called adaptation as such. Rather it was conducted as unplanned, individually initiated action on a ‘no regrets’ basis to help local businesses and organisations deal with changes in climate (even among people who disagreed that climate change was happening). This finding raised the question of how to identify and track the extent of ‘hidden adaptation’ and to developing tools to share lessons among the public about this process in a way that was useful and ethical. These questions took some time to work through

and ultimately were resolved through researchers and NSW Government engagement specialists reviewing all options and settling on a methodology (Social Pinpoint), which had been successfully used to gather community input into planning processes in NSW. This evolved into the ‘mapping grass roots adaptation’ project which was technically innovative, and revealed previously unrecognised forms of adaptation; however, the use by residents was limited.

Following the insights from the Bega and Shoalhaven SNA case studies, there was considerable policy interest in understanding the social networks and community engagement pathways in inland locations, and whether these might differ away from the coast. This interest led to the Orange case study which did indeed have very different network properties to the previous case studies. In particular, the case study showed the very different profile of the wine industry compared with other forms of agriculture with regard to its links to research and its approach to managing climate risk. In addition to policy insights gained from the CSP Theme, there was a demand for disseminating greater use of SNA techniques in policy contexts, which represented the premise for the SNA primer. The primer was partly presented as a companion document for interpreting the SNA case studies and partly setting out an agenda for expanding use of SNA analysis in adaptation beyond the Adaptive Communities Node.

Regional Innovation Systems (RIS) theme.

Within this theme, the impacts of natural disasters on the business community provided the impetus for a series of projects (Figure 22). At the time of the ACN inception, the Blue Mountains had experienced a devastating bushfire (Table 6). This resulted in the Blue Mountains becoming the focus of a case study of business adaptation during ACN Phase 1. In ACN Phase 2 there were significant floods in NSW (2016-18, Table 6). In 2016, Lismore, Picton and the Central West experienced devastating flooding; both Lismore and Picton were ‘fast floods’ due to a tropical cyclone-East Coast Low combined with features of coastal geography (narrow coastal plain, short-run rivers). Lismore served as an example of the impacts of flood on a regional centre, and Picton as a ‘metropolitan’ case study. Typically, Central West experienced a slow flood caused by a combination of rain falling mainly upstream in an extensive catchment system. Interviews conducted with the business community formed the basis of these case studies and the findings indicated diverse impacts on a range of businesses, and conflict regarding information on the timing of evacuation and communications from State Emergency Services. These findings prompted the development of an application for funding to the Ministry of Police and Emergency Services’ *Community Resilience Innovation Program* (CRIP) to examine improvements in communications through community social networks, thereby forming a link to the SNA research conducted under the community-policy-science nexus theme.

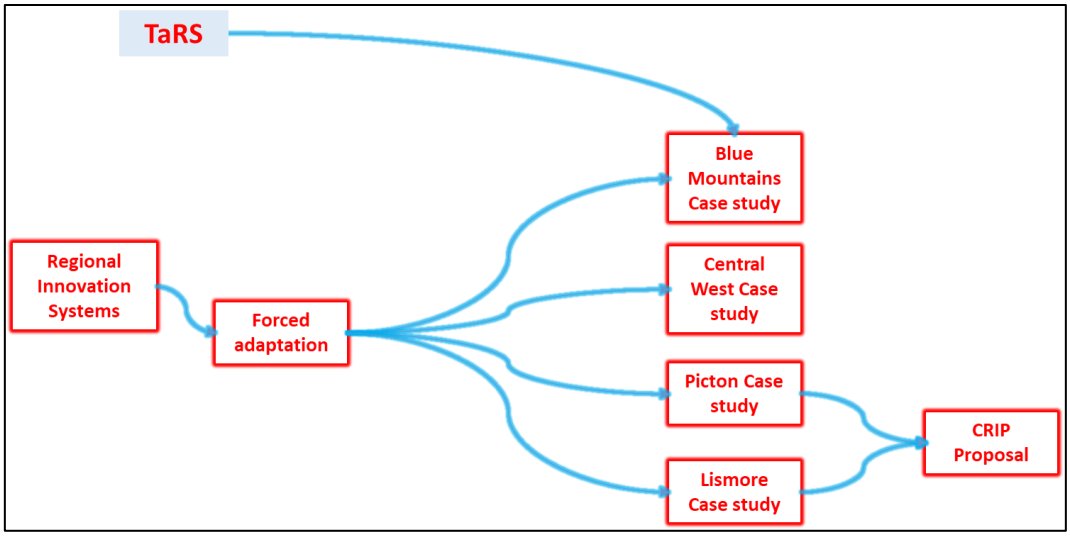

Figure 22: RIS to CRIP a key project pathway through the Regional Innovation Systems theme.

Discussion

ENTREQ

The ENTREQ process (Tong et al 2012) was highly valuable in terms of systematically comparing all the projects conducted under the Node. It helped ACN staff identify key phases in the evolution of the Node and documented the rich diversity of Node projects. At the same time, ENTREQ did not deliver the kind of synthesis outcome which we were expecting it to. Upon reflection it may have been overly optimistic to expect this framework which comes from a different research context (medicine) to provide a 'silver bullet' for synthesis across an extraordinarily diverse set of projects. What the ENTREQ framework did do was guide the research team to rigorously compare projects and to identify constellations of factors (climate events, policy windows, staff movements etc.) which played important roles in progressing the demand-driven model.

Other Nodes in the Adaptation Research Hub have collected extensive quantitative data sets that will be made available for further research through the SEED Portal (A Shared Resource for Environmental Data https://www.seed.nsw.gov.au/) at the Hub's completion. A potential application of the ACN's ENTREQ data is as a contribution to OEH's SEED data sets to ensure broader learning is accessible and guides future adaptation research efforts.

Charting progress towards demand driven research

From the outset, the Adaptive Communities Node developed a program that was demand-driven and focused on the interface between research, government policy and operations. In conducting the meta-analysis underpinning this synthesis, key insights were revealed into the ways in which the Node progressed towards this goal. Highly contextualised demand driven responses were underpinned by an expanded program drawing on other forms of research. We applied a multi-dimensional research typology developed by McNie et al (2016) as a heuristic device to situate the research of the Node according to spectra of criteria that cover three activities: knowledge production, learning and engagement, and organisational and institutional processes (Figure 23).

In the very early days, research in the Node emphasised a process of 'taking stock' of adaptation general trends and bringing together the state of epistemic knowledge about adaptation science worldwide, with a view towards providing the context for subsequent projects. These have been represented in this synthesis as 'foundation' projects exemplified by technical briefs and 'state of the knowledge' outputs (Figure 23). Crucially, these outputs were intended as initial steps to underpin demand driven research, and even at this stage there was significant policy input into the selection of background materials to ensure salience throughout the evolution of the Node.

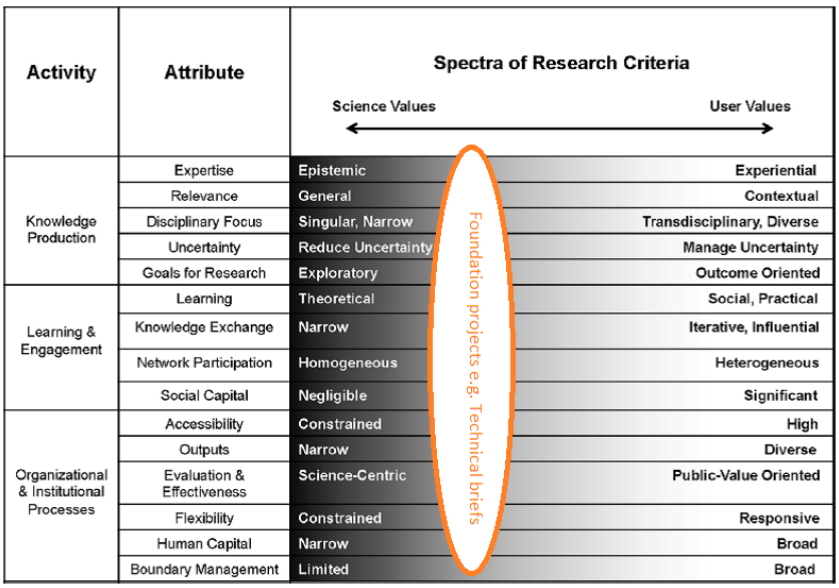

Figure 23: Foundation projects and outputs

Drawing on these outputs and emerging policy needs of NSW Government, a more exploratory group of projects and outputs was developed to address these needs, trialling new approaches to adaptation such as social network analysis. Iterative by nature and focused on managing uncertainty, these projects progressed towards the middle range of the typology as expressed in Figure 24.

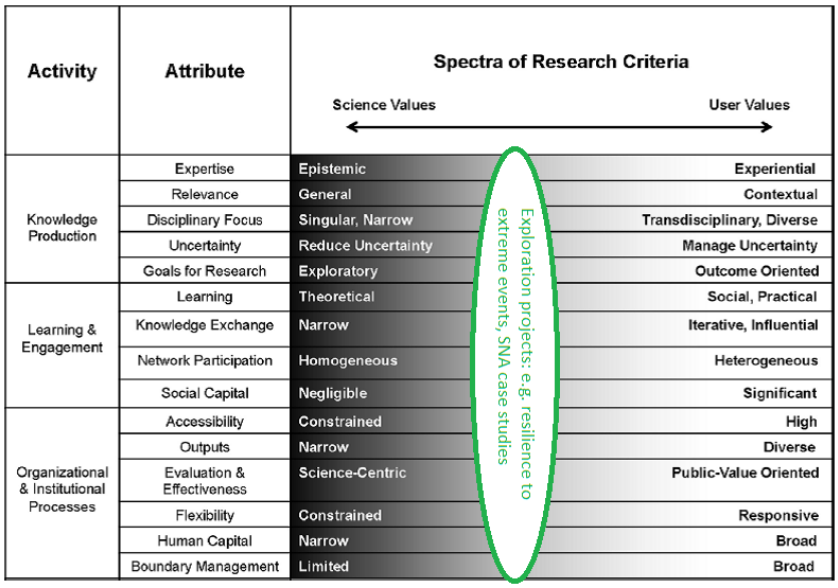

Figure 24: Exploration projects and outputs

The emphasis on flexibility, accessibility and practicality meant that some of the projects during the exploration phase involved trialling new ideas and taking some risks. For example, in seeking to represent the extent and range of unrecognised adaptation responses in communities (Smit and Pilifosova 2003; Eriksen et al 2011), the 'grass roots adaptation' project attempted to document, for the first time, self-initiated autonomous adaptation at the micro scale across the State. This project was technically innovative but had limited uptake and ultimately was not particularly useful. Over time, as the ACN consolidated its development of demand-driven adaptation research, projects were increasingly

contextualised, practical and responsive, moving to the right of the typology, such as the Climate Adapted People Shelter project (Figure 25).

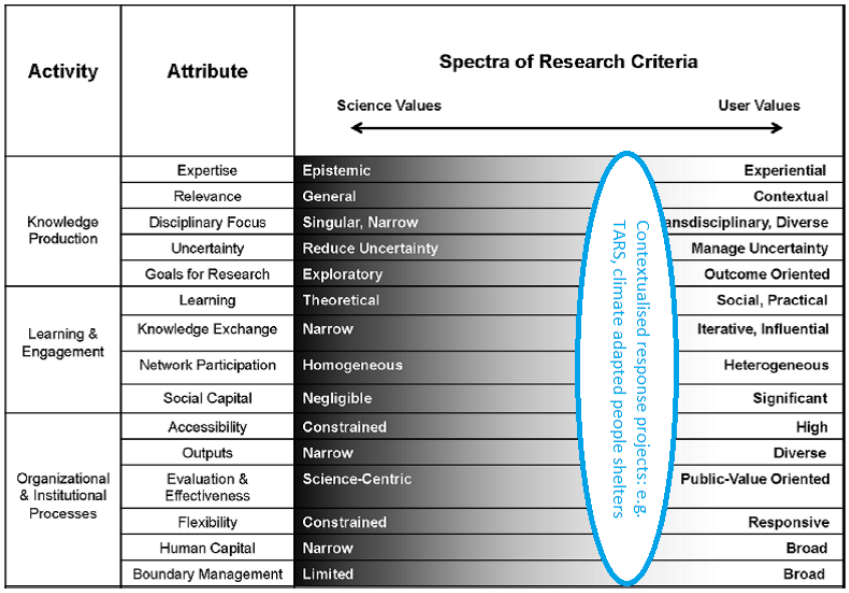

Figure 25: Contextualised, responsive projects emphasising practical orientation and experiential learning.

Conclusions

The adaptive, demand-driven model crystallised within this synthesis represents key challenges and advantages over more traditional approaches to the research-policy interface. Through active implementation of the framework established by McNie (2007), we believe that the ACN represents a unique example of deliberate efforts to improve the alignment of knowledge supply and demand in applied social research. In particular, we sought to reveal tacit 'local' knowledge of stakeholders because the data and modelling systems needed to support capacity building for local-scale adaptation are rarely available and often need to be constructed locally (Campbell et al 2001). We developed strong collaborative linkages with NSW and local government staff involved in operational dimensions of climate adaptation through joint management of research to ensure projects were co-designed and knowledge co-produced to improve salience, credibility and legitimacy of research outputs (Cash et al. 2003) and that social learning for capacity building was prioritised. In addition, the content and design of research outputs were guided by government stakeholders to ensure they effectively translated research findings into a language accessible to decision makers, which often took precedence over more traditional academic outputs such as journal publications.

From a policy perspective, it is not easy to justify the commitment of precious resources to a program of work which is not well specified and relatively unpredictable. Part of managing this issue for the Adaptive Communities Node was earning and retaining the trust of others in the policy environment (Lemos et al 2012). If these hurdles are surmountable within the policy domain, then the ultimate outputs of the research are much more applicable to real-world policy contexts. In this regard, Easterbrook's (2012) model of the transformation of data to wisdom is relevant (Figure 26). Wherever possible, the Node sought to 'value-add' data outputs, such as the regional climate projections from the NSW and ACT Regional Climate Modelling (NARCliM), to deepen engagement processes

with stakeholders, thereby accelerating the transformation process. In the final synthesis workshop (an opportunity which offered significant input into this report), one of the key observations of policy professionals was that they did put the research into practice. Ultimately, this will be a key criterion on which the performance of the ACN should be evaluated.

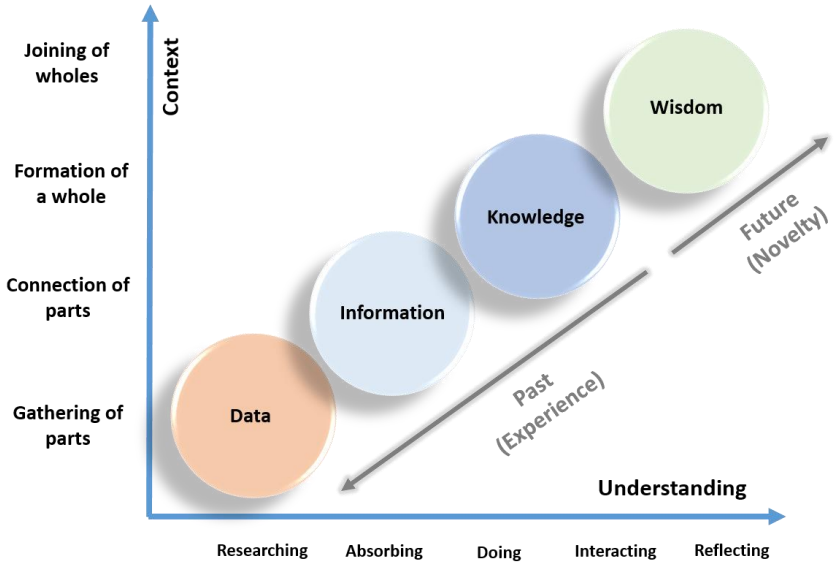

Figure 26: Model of transformation of data to wisdom (Easterbrook 2012).

From a research perspective, there are a parallel set of challenges. The demand driven approach may not result in the spoils and rewards of research that are particularly relevant to traditional early career researchers (Felt et al. 2013). The pathway to increasing publication metrics is opaque; however, the opportunity for impact is significant. As much as anything, the Node was an amazing social network of its own, beginning with pre-existing social networks among and between researchers and policy makers, which expanded during the life of the Node. Moreover, the Node produced innovative methods that will likely continue to underpin future research endeavours far beyond climate adaptation in NSW. Above all, the overarching benefit to participating researchers was that the outcomes of their work were translated into real world, practical and achievable applications, which was the rationale and driver for those researchers becoming involved in the Node in the first place: demand-driven, applied adaptations providing effective, positive and beneficial outcomes for people in our diverse communities.

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Appendix A: Workshop Agenda

Demand-Driven Research | Adaptive Communities Node Synthesis

Date:	Wednesday, 25 July 2018	**Time:**	12:00 – 5:00pm
Venue:	Project 107 107 Redfern St, Redfern NSW 2016 *Enter via stairwell on the left*	**Transport:**	Buses: 305, 308, 309, 310 Train: Redfern Station
Attendees:	Brent Jacobs (UTS:ISF) Tom Measham (CSIRO) Rebecca Cunningham (UTS:ISF) Suzanne Dunford (NSW OEH) Chris Lee (Climate KIC) Carmel Hamilton (Penrith City Council) Denise Anderson (LGA NSW) Storm O'Toole (NSW OEH) Liesl Laker (NSW OEH)		
Apologies:	Samantha Sharpe (UTS:ISF) Chris Cvitanovic (CSIRO) Peter Brown (CSIRO) Bill Dixon (LLS)		

11:45am – 12:05pm	Lunch served upon entry
12:05pm – 12:30pm	**Welcome, outline meeting objectives and update** **Node Lead** – Brent Jacobs **Facilitators –** Tom Measham and Bec Cunningham
12:30 – 02:00pm	**Activity 1: How did research and policy co-evolve** **Objective –** construct a timeline of events in four domains of 1) Policy/Government demand (workshop participants) 2) Climate events (workshop participants) 3) Node research 4) Adaptation theory (Node researchers)
2:00pm – 3:00pm	**Activity 2: Narratives within and beyond the node** **Objective –** gather information for 'case studies' of at least three lines of research. Draw out narratives around the projects. What were the circumstances that have allowed this line of research (and projects in that line) to take place?
3:00pm – 3:20pm	**Coffee Break and Filming in the Garden** Caffeinating & Filming - Liam McCann (UTS:ISF) will be inviting all participants to be interviewed part of a short film documenting the Adaptive Community Node activities - people will be summoned at interviews during the afternoon.
3:20pm – 4:00pm	**Activity 3: Learning outcomes** **Objective –** Looking back over the narratives in activity 2, what did we learn about adaptation and adaptation research that should be documented?
4:00pm – 4:45pm	**Activity 4: Did the Node Model Work?** **Objective –** asking candid questions for the demand-driven Node model work from various stakeholders' perspectives. What were the pros and cons? What could we have done differently/better?
4:45pm – 5:00pm	**Pack up and FINISH**