



CA18

climate adaptation 2018  
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8-10 may 2018, melbourne

Incorporating Practical Responses to Climate Change 2018



# Conference Abstracts

# Day One:

## Tuesday 8 May 2018

### 1. Communication and engagement – the key to good adaptation

#### Using communication and engagement to motivate adaptation action in the built environment; lessons from an Australian in Oxford.

**Tanya Wilkins<sup>1</sup>**

*1. UKCIP, University of Oxford, Oxford, UK*

Communicating climate change continues to evolve as a discipline within the broader field of environmental communications. Current research reveals the specific complexities in this area including the polarity and toxicity of the phrase 'climate change' itself, and that effective communication in this area is better when drawing on shared values like health, responsibility, security.

UKCIP based out of the Environmental Change Institute has delivered the Adaptation and Resilience in the Context of Change knowledge exchange network since 2009, specifically focused on the built environment and infrastructure sectors. In raising motivation for adaptation action, the network has looked at novel ways to communicate and engage policymakers and practitioners with the adaptation actions coming out of the research community. This has included research features at trade shows, design challenges to bring together interdisciplinary teams, and most recently in the development of a murder/mystery dinner party game!

Recently returned from two years in Oxford, this Australian is keen to share her experiences!

#### Identifying and incorporating community coastal values in coastal hazard risk management and adaptation planning: A case study of the south west of Western Australia.

**Craig Perry<sup>1,2</sup>**

*1. Peron Naturaliste Partnership, Mandurah, WA, Australia*

*2. Curtin University, Perth, WA, Australia*

This research is a community focused coastal climate change study; it will show how community coastal values can be identified and incorporated into coastal hazard risk management and adaptation planning in Western Australia. Several coastal cities and towns in the south west of Western Australia have been identified as being at significant risk from the impacts of climate change (Damara WA, 2012). Coastal hazard risk management and adaptation planning are often undertaken from an engineering perspective. However, because sustainability deals with social, cultural, economic and environmental aspects of the coast, it is important that technical information supports, and is supported by, clear understanding of how the community interprets and values the coast.

The present study focuses on key coastal sites in the southwest settlements of Rockingham, Bunbury and Busselton. The research aims to identify and gain a better understanding of community coastal values and how these values may be impacted as a result of climate change. The research also aims to explore how social learning can enhance understanding and knowledge uptake of coastal climate change in the community. The research results will then be used to inform the development of a coastal hazard risk management and adaptation planning framework to better plan and manage current and future coastal risks. These processes in turn help support coastal sustainability.

Damara WA. (2012). Coastal Hazard Mapping for Economic Analysis of Climate Change Adaptation in the Peron-Naturaliste Region (169-01).

#### It's not easy being green...or is it?

**Nicole Halsey, Mark Hannan**

The transition from planning to implementation of adaptation measures has long been identified as a challenge. The City of Charles Sturt has met this challenge head on and has been working to increase the tree canopy across the Council area, recognising the multiple benefits it will deliver including climate change adaptation. Improving the tree canopy is particularly important for the Council as recent studies have identified that tree cover across the City (both on public and private land) has declined since 1998, and that the City is one of the lowest performing areas across metropolitan Adelaide in terms of percentage of tree canopy cover.

Through the development of an evidence base such as urban heat island mapping, analysis of the impacts of infill development via aerial photography at different time frames, analysis of Council complaint and other data and the monetary value of street trees, the Council has identified a range of actions from strategic to operational that will facilitate the increase of tree canopy on both private and public land.

Key to this process has been the engagement with Council staff across the organisation as well as with the elected member body to obtain commitment to the overall vision to improve Council's tree canopy.

This presentation will provide insight into how Council went about this process, including creative engagement techniques used and lessons learnt that can aid others to build commitment from an organisational and political perspective to take action that aids adaptation to climate change impacts.

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### Access to hazard information to underpin adaptation

**Martyn Hazelwood<sup>1</sup>, Miriam Middelmann-Fernandes<sup>1</sup>, Shane Martin<sup>1</sup>**

*1. Geoscience Australia, Symonston, ACT, Australia*

Access to fundamental data is critical for the development of coherent adaptation strategies to improve community resilience. However, currently consumers are not able to access information to understand or mitigate their risk. The Natural Disaster Insurance Review (NDIR), initiated following the devastating floods across Eastern Australian in 2010-11, recommended that steps be taken to improve consumer awareness of the natural disaster risks they may face, in order to make informed adaptation decisions.

One of the Australian Government's responses to the NDIR was the development of the Australian Flood Risk Information Portal (portal), completed in 2017. The portal enables flood information, currently held by different sources, to be accessible from a single online location. The portal provides access to authoritative flood hazard studies with flood maps, flood management plans, and incorporates tools that enable users to search, display and retrieve information for their location.

The data management tools and standards within the portal enable data custodians (mainly local councils) to standardise their data and upload it to the portal via a web-based data entry tool, or to make compliant data accessible to the public via a web service.

This presentation will highlight some of the challenges associated with making hazard information resources available to the general public, and approaches developed to overcome these challenges. Expanding this approach as part of a national disaster mitigation framework is necessary to improve community understanding of their disaster risk and serve as a basis for the development of evidence-based adaptation plans thereby increasing community resilience.

### Finding the right path: stakeholder engagement tools for adaptation planning

**Andrew Warren<sup>1</sup>, Marjolijn Haasnoot<sup>1,2</sup>, Willem van Deursen<sup>3</sup>, Judy Lawrence<sup>4</sup>**

*1. Deltares, Delft, Netherlands*

*2. Faculty of Technology, Policy and Management, Delft University of Technology, Delft, Netherlands*

*3. Carthago Consultancy, Rotterdam, Netherlands*

*4. New Zealand Climate Change Research Institute, Victoria University of Wellington, Wellington, New Zealand*

Decisions on climate adaptation measures and other investments are taken over time, in response to changing conditions and events. Decisions must be made early enough to prepare for the future, while simultaneously ensuring that any investments made are 'future-proofed'. The Dynamic Adaptive Policy Pathways (DAPP) approach offers a novel methodology towards dealing with these challenges, but stakeholders can find 'pathways thinking' challenging to comprehend and integrate into conventional planning processes. Deltares has developed two tools to assist in this regard: the Sustainable Delta serious game and Pathways Generator.

Serious games are receiving increasing attention as effective tools for stakeholder engagement and learning. They provide a fun and engaging environment within which to share and translate scientific knowledge and information; and facilitate improved comprehension and retention. Sustainable Delta was developed to introduce stakeholders to the importance of long-term planning and anticipating and preparing for an uncertain future, as well as to teach the value of the DAPP approach in addressing these needs.

Similarly, the Pathways Generator is a touchscreen application specifically developed to support stakeholders to explore adaptation pathways. Adaptation pathways maps can be interactively and collaboratively produced and edited, using information derived from either expert judgement or prior modelling studies.

This presentation outlines core features of both tools, as well as indicates the appropriate moments at which to apply them during adaptive planning processes. We also describe key lessons derived from each of their developments and applying them in practice.

### Supporting Indigenous Rangers Manage the Impacts of Climate Change on Cultural Heritage Sites

**Bethune Carmichael<sup>1</sup>, Greg Wilson<sup>2</sup>, Deanne Bird<sup>3</sup>, Bob Webb<sup>1</sup>**

*1. Australian National University, Canberra, ACT, Australia*

*2. Djelk Rangers, Maningrida, NT, Australia*

*3. University of Iceland, Iceland*

A growing global awareness of climate change threats to cultural heritage sites (cultural sites) has seen the recent emergence of multiple management methodologies. However, none of these are amenable to use by local, non-specialist groups using participatory planning processes, such as Indigenous ranger groups. This research aimed to develop a Cultural Site Adaptation Guide (the Guide), a decision support tool to assist non-specialists undertaking participatory, climate change adaptation planning for cultural sites. A preliminary version of the Guide was created by synthesising elements from generic, bottom-up climate change adaptation planning tools on the one hand, and a risk analysis methodology that combined and built on archaeological approaches pioneered in the United Kingdom and France on the other. The first three steps of the five-step Guide are steps for Scoping, Risk analysis, and Options analysis. The research engaged two Indigenous ranger groups in Australia's Northern Territory with strong perceptions of climate change impacts on cultural sites and a strong view that managing these impacts is a priority need. The preliminary Guide was tested and further refined by the Indigenous rangers, using a Participatory Action Research methodology. The research found that practical and rigorous approaches can be taken to climate change adaptation of cultural sites by non-

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specialists, even where resources are likely to be severely constrained.

### Communicating climate risk in the Department of Health and Human Services: framing and engagement (Speed talk)

**Daniel Voronoff<sup>1</sup>**

*1. Department of Health and Human Services, Melbourne, VIC, Australia*

Preparation of an Adaptation Action Plan is a statutory duty for certain Victorian Government departments under the Climate Change Act 2017, the first of which is required by 2021. The Department of Health and Human Services is participating in a program piloting the development and implementation of an Adaptation Action Plan for the health and human services system. The presentation will outline the approach to climate risk communication and engagement in the Department of Health and Human Services, as part of its preparation of the pilot Adaptation Action Plan. The presentation will describe the role of communications in the overall engagement process. It will detail the framing elements, such as problem statement and call to action. The talk will outline the structure and content of climate risk communications, briefly discussing the need for an approach both tailored to the needs of specialised roles and responsibilities, and the requirement to address interdependencies, shared risks and common actions.

## 2. International aspects of adaptation

### Paris compatible climate action planning for cities: Global best practice and implications for Australian cities and councils

**Stella Whittaker<sup>1</sup>, David Hotffman<sup>1</sup>**

*1. Ramboll, Sydney, NSW, Australia*

As part of an effort to lead the way on a response to climate change, C40 has conducted extensive research and undertaken a process to evaluate member cities' progress in achieving targets in accordance with the COP21 Paris agreement talks. This work is based on C40's Deadline 2020 report (2016) and the C40 Mission Possible program, presents a detailed pathway of what C40 cities' need to do to play their part in converting the COP21 Paris Agreement from aspiration into reality. It represents:

"The first and significant route map for achieving the Paris Agreement, outlining the pace, scale and prioritization of action needed by C40 member cities over the next 5 years and beyond. Deadline 2020 is committed to keeping the global average temperature below 2 degrees above pre-industrial levels, whilst aiming at limiting the temperature increase to 1.5 degrees above pre-industrial levels." (Deadline 2020)

Building on the Deadline 2020, and through an iterative process with member cities and outside consultants as well as scientific study, C40 has developed a Climate Action Planning Framework (CAPF), which outlines the essential components of a Climate Action Plan. The CAP is one that will satisfy the goals of the Paris Climate Agreement (2015). In this paper, Ramboll will outline work being undertaken with C40 to finalise and pilot the CAPF. The CAPF tool provides support and guidance, measures progress against agreed and proven scientific standards, and helps to define the current state of a city's climate action. The Framework gives an overview of actions and measures which are essential to achieving a robust and transformative climate change response and effort within a city. Three Pillar of action in (1) Commitment and Collaboration; (2) Challenges and Opportunity, and (3) Acceleration and Delivery, and over 30 categories of activity are included in this comprehensive and ground breaking Framework for action. Lessons learnt from piloting the framework will be addressed in this paper. Best practice in the pilot cities will be used to illustrate the robustness of the framework. Implications for Australian cities will be discussed.

### Coastal Engineering Solutions for Remote Pacific Island Communities

**Stuart H Bettington<sup>1</sup>, Robyn C Bussey<sup>2</sup>, William Blank<sup>3</sup>**

*1. AECOM, Fortitude Valley, QUEENSLAND, Australia*

*2. AECOM New Zealand Ltd, Christchurch, New Zealand*

*3. Hall Pacific, Sunshine Coast, Queensland, Australia*

Tuvalu's islands are highly vulnerable to inundation and coastal erosion; issues that are worsening with climate change. These threats were highlighted when large swells associated with Tropical Cyclone Pam in March 2015 pushed high water and waves over the islands, leading to extensive damage, coastal erosion, and destruction of crops. The Government of Tuvalu (GoT), recently undertook coastal works on two islands to improve resilience to climate change induced erosion and flooding. GoT engaged Hall Pacific, a dredging and civil contractor, supported by AECOM, to develop affordable solutions that included seawalls and beach nourishment with groynes on Funafuti and Nukufetau.

Being coral atolls, the islands lack rock or other construction materials commonly used for coastal armouring. As a result armour has historically been imported or won by mining the reef to obtain coral boulders. The only environmentally sustainable construction material that can be exploited on these islands is sand from deeper waters. Recognising the impact of climate change and budget limitations, large geobags were identified as a suitable quasi-permanent solution. These can provide protection while longer term climate change adaptation strategies are

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developed and implemented. The use of this method allowed works to be planned and completed within six months. This approach has the potential to deliver affordably resilient and attractive protection in areas lacking the resources for more conventional coastal engineering solutions. This paper compares cost, and performance of these recent examples with more conventional armour solutions and discusses the application of these technologies on threatened remote islands.

### Frontline Cities and Islands - an ICLEI & Glispa initiative advancing adaptation and resilience through partnership

**Steve Gawler<sup>1</sup>**

1. ICLEI Local Governments for Sustainability, Melbourne, VIC, Australia

ICLEI and the Global Island Partnership (GLISPA) are working together to promote sustainable island and urban development through sub-national and city leadership on a range of issues important to islands including amongst others: resilience and systems planning, climate change and clean energy, healthy oceans and near-shore coastal fisheries management, resilient infrastructure and innovative finance, ecosystems services for resilience and post disaster recovery and sustainable tourism. This Front-Line Cities and Islands initiative was launched at COP23 with endorsement of the Government of Fiji as COP Presidency. Front-Line is based on partnering island cities with global north cities from the ICLEI and GLISPA networks, features rapid resilience assessments and accelerated action with international support to build more sustainable island cities.

### Using climate and disaster risk information to build resilience: Evidence from Oxfam's resilient development portfolio (Speed talk)

**Charlotte L Sterrett<sup>1</sup>, Edward Boydell<sup>2</sup>, Julie Webb<sup>2,3</sup>**

1. Oxfam Australia, Carlton, VIC, Australia

2. Independent consultant, Canberra, ACT, Australia

3. Independent consultant, Melbourne, VIC, Australia

Climate and disaster risk information are an important tool for resilient development. Evidence from Oxfam's programs demonstrates that combining such information with participatory analysis and planning can create effective early warning systems, and inform forward-looking planning at household and community level. Through its programs, Oxfam has built links with government agencies and local NGOs to ensure that this information is locally relevant, and accessible to women and people with disabilities. However, more needs to be done by Oxfam and others to further ensure equitable access to climate and disaster risk information, and to build on programming success to more effectively prepare for slow-onset hazards.

This Evidence Brief, Climate Information and Forward-looking Decision Making in Resilient Development, synthesises evidence of how Oxfam is working to integrate climate and disaster risk information into its programs. It also considers the contribution of Oxfam's work with stakeholders at different levels to promoting the use of information for forward-looking decision-making.

### Latent Knowledge on Green Infrastructure as a Source of Community Resilience against Climate Change, a Case Study in Dhaka's Slum, Bangladesh (Speed talk)

**Razia Sultana<sup>1</sup>**

1. ., Gwynneville, NSW, Australia

The aim of the research is to examine urban green infrastructure (UGI) as a strategy for climate change adaptation for slum dwellers in Dhaka, Bangladesh. In Bangladesh and elsewhere in the Global South urban slum dwellers are often wells of knowledge on sustainable practices through their prior backgrounds in rural areas. Due to poverty and frequent natural hazards many rural people take shelter in informal settlements in cities. One of the prime challenges of urban slum dwellers is to harness this knowledge considering their changed circumstances. Several issues such as land insecurity, space constraints, incomes, crime, and other social issues have created strains on slum dwellers' lives and livelihoods. One important aspect that can enhance slum dwellers' resilience capacity is harvesting latent knowledge in new environments. This contribution draws upon semi-structured in-depth interviews with slum dwellers in Kurail slum, Dhaka. From the narratives of slum dwellers in Kurail slum I explore how latent knowledge on UGI can serve a source of community resilience for them in precarious urban settings. The research project will further explore the opportunities and constraints of mobilizing UGI in Dhaka, Bangladesh.

### Adaptation to Climate Change in Nawairuku Village, Ra Province, Fiji (Speed talk)

**Renee Currenti<sup>1</sup>**

1. ., Sippy Downs, QLD, Australia

This research examines vulnerability to climate change in the context of multiple stressors through a case study of Nawairuku village located in Ra Province, Viti Levu, Fiji. Climate change adaptation research in Pacific Islands has largely focused on biophysical changes such as sea-level rise with people living in urban or near-urban areas in the coastal zone. Less is known about how lives and livelihoods are affected and what adaptation options are feasible for people living in interior villages. This knowledge gap has left the voices of a large percentage of Pacific

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Islanders out of global climate change narratives. This research employs a vulnerability framework to identify how people are experiencing changing climatic conditions together with other environmental and social stressors already affecting livelihoods. The participatory approach includes semi-structured interviews with community members (n=30) and focus groups. Key areas of concern to people in Nawairuku are increased frequency and intensity of extreme weather events, such as cyclones and floods, economic stressors, and shifting cultural norms. Current adaptations are mainly reactive and short-term. Future climate changes will be experienced in new social and environmental contexts and adaptation efforts must be designed in reflection of these.

### Building resilience through civil society, government and private sector partnerships: Evidence from Oxfam's resilient development portfolio (Speed talk)

**Charlotte Sterrett<sup>1</sup>, Edward Boydell<sup>2</sup>, Julie Webb<sup>3</sup>**

1. Oxfam Australia, Carlton, VIC, Australia
2. Independent consultant, Canberra, ACT, Australia
3. Independent consultant, Melbourne, VIC, Australia

Partnerships lie at the core of how Oxfam understands the world and the role they play in working for change. Oxfam is working in partnership with governments, civil society and the private sector to build the resilience of poor women and men in the Asia-Pacific. Investment in these partnerships is delivering outcomes, ensuring locally-relevant and innovative approaches to building resilience. Partnerships are most effective when they are grounded in a shared understanding resilience, and future programs should invest more in strengthening long-term capacity of local partners to advocate for change at national level.

The Oxfam International Framework for Resilient Development recognises the need for effective multi-stakeholder relationships to work toward resilient development. These include relationships between women and men, communities, civil society, the private sector and different levels and sectors of government. These partnerships and relationships contribute toward just, locally appropriate action to that increases capacity of women and men in communities.

## 3. Adaptation policy and governance

### Urban Climate governance: Adaptive capacity of local governance, a case study of Kathmandu

**Jharana Bhattarai<sup>1</sup>, Joe Hurley<sup>1</sup>, Susie Moloney<sup>1</sup>**

1. Global, Urban and Social Studies, RMIT University, Melbourne, VIC, Australia

This paper explores the importance of urban climate governance in improving climate change adaptation outcomes in cities, and secondly, it examines the critical role of governance arrangements in building the adaptive capacity of local actors focusing particularly on the context of developing countries. This paper presents research on the case study of Kathmandu, Nepal and the role of multilevel governance in driving local action on climate change adaptation. An analysis of the many actors actively involved in the development and delivery of service systems in the city is vital to understand climate change adaptation efforts. Findings from the research show how various actors including developers, industrialists, NGOs and INGOs, energy providers, transportation and civil society activists, etc. all shape climate change adaptation outcomes and that their various roles in the city and their ability and willingness to initiate adaptation planning can contribute to promoting local climate governance. The paper identifies some of the key challenges, particularly for city authorities, in ensuring that these diverse actors are working towards shared and agreed goals.

### Coastal adaptation - towards a statutory reconciliation of private rights and public interests

**Andrew Beatty<sup>1</sup>, Samantha Marshall<sup>1</sup>, Ballanda Sack<sup>1</sup>**

1. Beatty Legal Pty Limited, Sydney, NSW, Australia

Australia's beaches are a significant public asset attracting visitors from around the world and, unlike many other countries, our culture values unimpeded and free access to our coast. Along our populated East coast, however, major storm events and climate change impacts threaten to exacerbate the processes of coastline recession, and increasingly, the public beach buffer between the ocean and the boundaries of valuable private real estate is narrowing. In the face of these impacts, tension between the protection of private property and maintaining public access to, and affording free use of, our beaches is increasingly being played out in our Courts. Hard-engineered protective works, which tend to be preferred by private landowners, can often be put into place without a coordinated approach to either down-drift erosion management or properly securing public access and use of the beach. A rigid, line-drawn-in-the-sand approach to protecting private assets fails to account for the reality of ambulatory coastal zone boundaries, and the need for flexible, future-focused legal frameworks. This paper examines how the statutory implementation of an Australian- adapted Public Trust Doctrine and other mechanisms within a Torrens Title system might help reduce "adaptation by litigation."

### Attributes of good governance for effective regional adaptation

**Suzanne Dunford<sup>1</sup>**

*1. Institute for Sustainable Futures, University of Technology, Sydney, Sydney, NSW, Australia*

Economic, social and technological drivers are changing regional communities. Climate change presents a disruptive, threat multiplier to known transitional pressures which will require robust and flexible decision making processes to ensure regional responses are informed, collaborative and successful. There is an urgent need to understand Governance of adaptation or existing vulnerabilities will be exacerbated, and opportunities will be wasted.

Using lenses of social ecological systems, resilience, transformation and subsidiarity, this paper will explore those attributes of governance that support communities to adapt, anticipate and manage transitions at a regional scale, and that seek to strengthen the role of local communities in action to reduce their vulnerability to climate impacts.

### Overcoming challenges for adaptation across borders - insights from a case study of the ACT

**Jo Mummery<sup>1</sup>, Brian Weir<sup>1</sup>**

*1. University of Canberra, Bruce, ACT, Australia*

The relative small scale of the ACT, its links and interdependencies with adjacent regions for core societal functions and resource management, and its vulnerability in a changing climate, are useful characteristics from which to explore cross-border governance for climate change adaptation. Climate change impacts do not align with jurisdictional boundaries, and there is a growing literature on the importance of cross-border collaboration and measures for effective adaptation. However, governance for adaptation across boundaries can be challenging, as significant differences in adaptive capacity, priorities, regulatory frameworks and planning horizons may exist. This research draws on a review of the scholarly literature on climate change impacts and cross-scale adaptation, document analysis of plans and strategies from local, state and territory governments in the region, and interviews with stakeholders and decision-makers, to explore the challenges and factors that enable cross-border collaboration for adaptation in the ACT and adjacent local government areas. Key findings of the research point to (i) the significance of trigger events in driving collaboration; (ii) the importance of assessing capacity differences across borders in tailoring measures to reduce vulnerability; (iii) the need to address data and policy calibration inconsistencies for effective implementation; and (iv) the value of cross-border including regional institutional mechanisms. This research contributes to the literature on overcoming barriers to adaptation and where policy reform is needed to enable mainstreaming.

### Monitoring, Evaluation, Reporting and Improvement Framework for Climate Change Adaptation in Victoria

**Jessica Barnes<sup>1</sup>, Clare Brownridge<sup>1</sup>, Allan Klindworth<sup>2</sup>, Euan Lockie<sup>3</sup>**

*1. Department of Environment, Land, Water and Planning, East Melbourne, VICTORIA, Australia*

*2. AECOM Australia Pty Ltd, Melbourne, Victoria, Australia*

*3. Australian Continuous Improvement Group, Melbourne, Victoria, Australia*

In 2017, the Victorian Government released Victoria's Climate Change Adaptation Plan 2017-2020 (the Adaptation Plan), which included a commitment to develop a best-practice monitoring and evaluation framework to monitor the implementation and effectiveness of actions in the Adaptation Plan.

The Victorian Department of Environment, Land, Water and Planning, in partnership with a consortium that included AECOM, the Australian Continuous Improvement Group, and representatives from RMIT and NCCARF, has developed a Monitoring, Evaluation, Reporting and Improvement (MERI) Framework for Climate Change Adaptation in Victoria. The MERI Framework outlines a whole-of-government approach to objectively analyse how successfully Victoria is adapting to the risks and impacts of climate change. This includes the implementation and effectiveness of actions in the Adaptation Plan and how the state is adapting overall, beyond the actions outlined in the Adaptation Plan.

There has been much discussion and research on the topic of MERI for climate adaptation; however few practical examples of frameworks exist, particularly at the regional (state-level) scale.

The leading- practice approach outlined in the MERI Framework is based on the most recent literature on monitoring and evaluating climate change adaptation, significant engagement with stakeholders across government, and has been designed to consider issues of scale and complexity.

This presentation will outline the content of the MERI Framework and share lessons learnt from its development.

### Monitoring and Evaluation of climate change adaptation by local government: The state of play in Australia

Helen F Scott<sup>1</sup>

1. Centre for Urban Research, RMIT University, Melbourne, VICTORIA, Australia

Governments at varying levels have invested funds in climate modelling, impact, risk and vulnerability assessments, and proactive planning for future climate conditions. Local governments have been very active in this space, as climate change adaptation is recognised to be particularly context specific. In Australia, many local governments have developed either stand-alone climate change adaptation plans, or incorporated significant adaptation goals and actions in other organisational strategies. However, are these strategies and actions contributing to 'successful' adaptation – a somewhat slippery concept? Monitoring and evaluation can contribute to our knowledge of whether actions are effective, and for whom, in which context. A recent survey of Australian local governments, however, suggests that very few plans are being actively monitored, and evaluations are often informal internal reviews, rather than robust evaluations. There are many barriers and challenges to monitoring and evaluating climate change adaptation. However, decades of evaluation theory and practice, combined with new practical insights, can inform and guide local government practitioners so that we can determine if efforts are truly contributing to 'successful adaptation'. This presentation will provide the findings of a national survey of local governments' adaptation initiatives and their monitoring and evaluation efforts, as well as provide useful guidance for monitoring and evaluating climate change adaptation.

### Key themes on undertaking collaborative research to inform government policy for the benefit of regional transitions

Tayanah O'Donnell<sup>1</sup>

1. University of Canberra, Bruce, ACT, Australia

As societies begin to transition as a result of climate change, closer scrutiny of the ways in which government policy shapes social outcomes is required. Drawing on three years of postdoctoral research focussed on the role of government, regulatory boundaries, and climate adaptation, this paper explores key themes relevant to the relationship between government policy and regional transition. This paper will also discuss research which found that government requires a robust approach to building an evidence base in supporting policy, that governments looked to academics in providing this evidence, and that government policy-makers needed quality research delivered according to policy timetables.

## 4. Decision-making options for risk management: pathways approaches

### How are Adaptation Pathways actually applied in climate change adaptation planning? A review

Estelle Gaillard<sup>1</sup>, Karyn Bosomworth<sup>1</sup>

1. Climate Change & Resilience Research Program, RMIT, Melbourne, VIC, Australia

Adaptation Pathways are receiving increased theoretical and practical interest as an approach to planning and decision making under conditions of uncertainty. Yet, despite this growing interest, details regarding its practical application in a range of policy problems remain scant. This presents a challenge to those seeking to undertake a pathways-informed approach to climate adaptation planning. With the aim to contribute to filling in this gap, we conducted a literature review focused on assessing what evidence exists on Adaptation Pathways in practice in Australia and internationally. The lessons learned from these empirical case studies will be presented. The focus will be on how a pathways approach was used (different approaches and methods used in applying the concept; planning processes and steps), by whom, in what context, and what worked and did not work (challenges, successes and limitations). This presentation will provide insights gained from the review about practical challenges of developing and implementing an Adaptation Pathways approach and opportunities.

### Applying Resilience, Adaptation and Transformation pathways lens for effective design, implementation and assessment of sustainable development interventions

Yiheiyis Maru<sup>1</sup>, Deborah O'Connell<sup>2</sup>, Nicky Grigg<sup>1</sup>

1. Land and Water, CSIRO, Canberra, ACT, Australia

2. Land and Water, CSIRO, Canberra, ACT, Australia

The sustainable development goals (SDGs) provide nations with a framework and opportunity to work together to address social-ecological issues at global, national and local levels. However, designing and implementation of interventions to achieve the SDGs require understanding and addressing the root causes of current states social-ecological systems. There are only limited systems thinking based and practical design and implementation approaches.

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In an attempt to address this gap and in response to a request from Global Environmental Facility (GEF). We developed Resilience, Adaptation pathways and Transformation Approach (RAPT Approach), which has 7 flexible components.

RAPT approach has been piloted in Ethiopia to assist with the design of a national level food security project for co-funding from GEF and the Ethiopian government and a local community project through funds from Stockholm Resilience Centre.

Based on interviews with local, national and international stakeholders, impact assessment of the pilots show that at: the national level - a shift among stakeholders to a systems understanding of food security and thresholds, feedback loops and cross scale interactions that need attention in the design of interventions. Among other things, this led to an expansion of the conventional natural resource management interventions to include options such as renewable energy provision to reduce use of manure and trees for fuel.

At the local level – a significant collective learning was achieved among participants about systemic problems and opportunities to improve their social-ecological system including ways to build the resilience of part of a functioning rain-fed agriculture, adjustment of parts to small scale irrigated horticulture and orderly and dignified exit of youth from farming to employment in emerging light industries in the vicinities of the village.

## **Bogies and Volcanic Plains: some lessons from using 'Adaptation Pathways' for climate change planning in Natural Resource Management (NRM)**

**Karyn Bosomworth<sup>1</sup>, Helen Scott<sup>1</sup>, Chris Pitfield<sup>2</sup>, Jenny Wilson<sup>3</sup>, Fiona Johnson<sup>4</sup>, Geoff Brown<sup>5</sup>, Kate Brunt<sup>3</sup>**

1. RMIT University, Melbourne, VIC, Australia
2. Corangamite Catchment Management Authority (CMA), Victoria, Australia
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4. Fiona Johnson Consulting, Goulburn Valley, Vic, Australia
5. RustyBrown Consulting, Aireys Inlet, VIC, Australia

Theoretically, 'Adaptation Pathways' (AP) planning helps practitioners develop an array of options that are robust across a wide range of possible futures, consider multiple perspectives, and provide flexibility in dealing with the inevitability of change. Yet while it has proven conceptually useful, there are a number of challenges and remaining factors for testing and application in NRM. These include questions of whether pathways concepts improve current NRM planning, and how might pathways approaches be applied in different NRM contexts to develop and implement practical adaptation plans?

This presentation engages with these questions and seeks to contribute to understandings of how the AP concept can help planning for climate change in NRM. Lessons from application of AP concepts in two trials with the Goulburn Broken Catchment Management Authority (CMA) and the Corangamite CMA are discussed. The focus landscapes were in the Strathbogie Ranges in the Goulburn-Broken Catchment, and the Western District Lakes/Volcanic Plains in Corangamite. Both trials drew on the Adaptation Pathways Planning Playbook (Bosomworth et al 2015), and additional academic literature, and group facilitation methods. Guided by the 'real world' requirements of the CMAs and their stakeholders, the participatory action-research (PAR) approach enabled continuous learning through constant participant feedback and facilitator reflections throughout both trials. This presentation will provide an overview of the approaches used and key lessons gained, which the authors hope may be useful for others seeking to undertake a pathways-informed approach to adaptation planning.

1. Bosomworth, K., Harwood, A., Leith, P. and Wallis, P (2015) Adaptation Pathways: a playbook for developing robust options for climate change adaptation in Natural Resource Management. Southern Slopes Climate Change Adaptation Research Partnership (SCARP): RMIT University, University of Tasmania, and Monash University. ISBN 978-1-86295-792-3

## **How to adapt and when: Three perspectives on emerging challenges in the use of adaptation pathways for coastal hazard management**

**Mark Siebentritt<sup>1</sup>, Christine Arrowsmith<sup>2</sup>, Maisie Auld<sup>3</sup>**

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3. Edge, Sydney

Adaptation pathways are becoming an increasingly popular element in the development of adaption plans and strategies. This is especially the case along the coast where the timing of planned retreat through to defence structures lends itself to a pathways approach. While visual "pathways maps" are becoming more common in coastal hazard strategies, there still remain few formal adaptation pathways approaches and there is a need to explore how best to apply this approach from a technical versus public participation perspective. Using case studies, this presentation will explore emerging challenges in adopting a pathways approach from three perspectives: economic analysis, coastal engineering and stakeholder engagement.

# Day One:

## Tuesday 8 May 2018

### Real-life testing of adaptive pathways and risk assessment tools in a coastal hazard and sea level rise context

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The practice of adaptation requires robust decision making tools for application where there are resource and time constraints, and deep uncertainty over long timeframes. A real-life 2120 Coastal Hazards Strategy development process presented itself, in which researchers could be embedded as knowledge brokers. We applied Dynamic Adaptive Pathways (DAPP) planning alongside Multi-Criteria Analysis (MCA) within a governance framework and community panel process set up by three councils in Hawkes Bay New Zealand. This hybrid approach enabled a time component to be added to MCA thus addressing uncertainties and widening the space for long term options to be analysed, including managed retreat and doing nothing. By advising on the methodologies, observing and evaluating the process, we gained unparalleled insights to the efficacy of the methods and the process. Lessons included the difficulty of participants focusing on the long term and thus the importance of; the role of facilitator and knowledge from the researchers; the need to have a manageable number of options for consideration; valuing differing perspectives; having the right people in the room; participant dominance and gaming behaviours and how this was addressed through direct intervention by researchers when inconsistencies or bias crept into the assessment processes. The lessons have value for professional advisors and decision makers as well as building trust with communities.

### The politics of pathways: lessons learned from developing countries?

Russell M Wise<sup>1</sup>, James R.A. Butler<sup>2</sup>, Oscar Guevera<sup>3</sup>, Seona Meharg<sup>1</sup>, Deborah O'Connell<sup>1</sup>, Alice Ruhweza<sup>4</sup>, Carina Wyborn<sup>5</sup>, Erin Bohensky<sup>6</sup>, Toni Darbis<sup>7</sup>, Michael Dunlop<sup>1</sup>, Dewi Kirono<sup>7</sup>, A Nicol<sup>8</sup>, Yiheyis Maru<sup>9</sup>, W. Mekonnen<sup>9</sup>, Y Sutaryono<sup>10</sup>, F K. Yifru<sup>11</sup>, Barron Orr<sup>12</sup>

1. CSIRO, Canberra, ACT, Australia

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8. International Water Management Institute, Colombo, Sri Lanka

9. Climate Resilient Green Growth Unit, United Nations Development Programme, Addis Ababa, Ethiopia

10. Faculty of Animal Sciences, University of Mataram, Mataram, Lombok, Indonesia

11. United Nations Development Programme, Addis Ababa, Ethiopia

12. Science, Technology and Implementation Unit, UNCCD, Bonn, Germany

It is now widely accepted the primary future adaptation challenge is to transform maladaptive and unsustainable societal practices towards climate-compatible development (IPCC, 2014). The urgency for systemic change mounts as the stresses and shocks caused by climate change become increasingly unprecedented and extreme. Tackling systemic causes of vulnerability and barriers to adaptation, however, involves politics, because it challenges the ways natural resources, money and people are managed and distributed, and who benefits. There are few examples of how politics has been considered in the design and implementation of adaptation pathways approaches, particularly where antagonistic political relations are present. These challenges are particularly acute in less developed communities or regions, where multiple institutional arrangements operate simultaneously (e.g., formal and informal markets; deliberative democracy and traditional tribal lore/norms). We developed a political-economy framework and applied it ex post to case studies in Ethiopia, Colombia and Indonesia of practical attempts to mainstream climate change into resource-use planning using adaptation pathways practices. We did so to answer the question: "what are the implications for the design and implementation of transformational adaptation pathways when power and politics are acute?" Our analysis revealed how adaptation efforts can be derailed and curtailed where only partial understanding of the multiple sources and manifestations of politics are considered in the design and implementation of the pathways approach. We identify key pointers for adaptation pathways approaches to better and pre-emptively consider the political dimensions and processes in their design and implementation.

### Advantages and pitfalls of using risk management as an entry point to adaptation pathways

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One of the greatest challenges of getting climate adaptation to be part of business as usual is that it's a new consideration that people need to fit into their already busy work lives. A common solution has been to frame climate considerations as risk management and thus build climate risk into existing risk practices. However, risk practices still need to be modified to adequately feed into pathways approaches, particularly to deal with uncertainty, decision lifetimes, and sequencing risk treatments. Thus, it is possible that using existing risk practices as an entry point actually inhibits the innovation needed and inadvertently slows the process of mainstreaming adaptation. In 2017, CSIRO began developing a guide to incorporating climate risk into existing risk management practices for large organisations, where a consistent approach might need to meet the needs of a variety of sections or divisions. In 2018, we observed several such sections applying the draft process. We explicitly tested if and how risk management framing provided a useful entry point, or whether it accidentally led to constrained understanding of climate risk and limited innovation. Our results were mixed and reveal how we can better help organisations take their first steps toward considering climate risk in their work without accidentally getting them started on the wrong foot.

## 5. Responding to sea-level rise and adaptive coastal management

### Camping ground, battleground or losing ground for coastal adaptation to climate change

**Anne M Leitch<sup>1</sup>**

*1. Griffith Centre for Social & Cultural Research, Griffith University, Gold Coast, QUEENSLAND, Australia*

Caravan parks and camping grounds on coastal Crown land are well known for the important role they play in terms of social and economic benefits in terms of tourism, lifestyle, affordable housing options and community building. What is often overlooked is the future of caravan parks in a changing climate. Coastal caravan parks can be located in low lying areas that are already vulnerable to flooding, however they also play a role as areas of low intensity development that can provide a buffer zone for coastal adaptation to sea level rise. Recently, caravan parks are undergoing changes which result in their conversion to more permanent structures, either through gentrification of the park itself or a change in land use to apartment development. This paper reports on a case study of a caravan park in Brunswick Heads in northern New South Wales, Australia. Analysis of discourse in the local news media over an eight year period describes key themes such as the changing tenure of the park from local to state government management and the park's evolving infrastructure to include cabins and an altered foreshore. Also discussed are the themes around community engagement—and community conflict—accompanying these changes. This study is significant as it provides an example of coastal change that, if not managed effectively, will reduce potential options to respond to future climate change impacts.

### Coastal Hazards and Climate Change: New Zealand Guidance

**Emma Lemire, Dan Zwart, Rob Bell, Judy Lawrence, Scott Stephens, Sylvia Allan, Paula Blackett**

The New Zealand Government provides information and non-statutory guidance to help local government identify and quantify opportunities and risks that climate change poses for their functions, responsibilities and infrastructure. The *Coastal Hazards and Climate Change* guidance is one of three climate change adaptation manuals. The new edition released in December 2017 contains substantial new content on implementing a risk-based approach, adaptive planning and community engagement.

The biggest addition is that the updated guidance recommends a new “pathways” approach to adaptive planning that is dynamic and flexible. It is designed to be used when there is uncertainty about future physical conditions affecting the coastal environment. This uncertainty is unavoidable in matters involving future climate change, especially on longer time frames. Key updates in the guidance focus on methods for hazard, risk and vulnerability assessments appropriate to the level of uncertainty and type and scale of development. The update does not prescribe a specific value for sea level rise to use in decision making, but recommends a risk-based approach, considering a range of scenarios. The planning approach recommended depends on the time frame in question and the type of assets at risk.

Central to the revised guidance is a more collaborative approach to community, iwi/hapū and stakeholder engagement through different stages of the decision cycle. The guidance will be reviewed regularly to maintain validity in the light of relevant new information.

### Managing coastal hazard risk for Broome's historical town centre under projected sea level rise

**Jim W Churchill<sup>1</sup>**

*1. Baird Australia, Subiaco, WESTERN AUSTRALIA, Australia*

The historical town centre of Chinatown is Broome's commercial business hub and is susceptible to storm tide inundation as a result of tropical cyclones that can impact on the Kimberley coastline in the wet season (November to April) bringing extreme water levels and waves. At present the land level around the Chinatown peninsula is sufficient to withstand storm tide levels to approximately a 1 in 100yr event. Under projected sea level rise, the storm tide risk increases rapidly and by 2070 the Chinatown area of the peninsula could potentially be at risk of flooding under the general tide regime.

Chinatown serves commercial, residential and tourist purposes and holds historical significance for the town, and this was a key driver in the decision to safeguard its future that was reached through the Broome Town Site coastal hazard risk management and adaptation plan (CHRMAP). The challenge to manage the identified coastal hazard risk for Chinatown over the next 100 years planning period required a tailored coastal adaptation strategy, providing guidance on a range of measures to accommodate and ultimately protect against the coastal hazard risk as sea level rise is realised. A challenge for the Chinatown area was how to effectively mitigate the coastal risk in future planning periods, through a coastal management and planning approach that recognises the unique setting and character of the location, and which ensures future development is consistent with the existing built form.

# Day One:

## Tuesday 8 May 2018

### Adaptation pathway of McEwens Beach – the journey of a constructed, self-funded seawall

Robyn Birkett<sup>1</sup>, Jodie Sekac<sup>2</sup>

1. Strategic Planning, Mackay Regional Council, Mackay, Qld, Australia
2. Office of the Mayor and CEO, Mackay Regional Council, Mackay, Qld, Australia

The Mackay region has a long history of adverse coastal and flooding events dating back to the 1860's. The community of McEwens Beach, approximately 12 km south of Mackay, for instance, has experienced significant erosion with the McEwens Beach coastline receding 95 m over the last 50 years.

Although Australia has a large exposed coastline, there is no coordinated strategy at State or Federal level to address coastal and flooding risks. The responsibility for dealing with coastal and flood impacts has traditionally rested with poorly resourced local government authorities.

A desire to find an acceptable solution to coastal hazards at McEwens Beach without relying on coercive statutory powers led to a collaborative approach between Mackay Regional Council and coastal residents. The solution involved the construction of an engineered seawall, predominantly at the residents' expense, on erosion prone freehold land owned by Council. The Council freehold land will ultimately be subdivided and transferred to the coastal residents as the effective 'custodians' of the seawall.

This paper will explore the adaptation journey of McEwens Beach and delve into the detail of the approval process including the legal, planning and engineering issues associated with the seawall and the importance of communication and collaboration with affected communities. Council is in the early stages of a Coastal and Inland Flood Hazard Adaptation Strategy and is using the adaptation journey of McEwens Beach to assist with the strategy.

### QCoast<sub>2100</sub> - Delivering Queensland-wide adaptation planning for coastal hazards & sea level rise

Subathra Ramachandram<sup>1</sup>, Sel Sultmann<sup>2</sup>

1. Local Government Association of Queensland, Newstead, QUEENSLAND, Australia
2. Environment Policy & Planning, Department of Environment & Science, Queensland Government, Brisbane, Queensland, Australia

This presentation aims to provide an overview of the Queensland Coastal Hazard Adaptation Program (QCoast<sub>2100</sub>), particularly on how it is structured to provide funding and technical assistance to enable councils to progress the preparation of plans and strategies to address climate change related coastal hazard risks over the long-term.

QCoast<sub>2100</sub> is a \$12M partnership between the Queensland Government and the LGAQ and is designed to encourage participation from all coastal councils, ranging from the small indigenous to the large south east Queensland councils. Key Program components are listed below:

- **Continuous Program Engagement** with coastal councils to promote Program awareness and provide relevant information and assistance.
- **Grant funding** that is not competitive, and determined taking into account councils' capability and resources. Councils are expected to contribute a minimal amount of project fee, with a significant contribution from the Program.
- **Minimum Standards & Guidelines** are provided to ensure consistent and systematic development of Coastal Hazard Adaptation Strategies (CHAS) by councils.
- **Expert Panel** comprising specialist from key disciplines of a CHAS is accessible to all councils for technical advice.
- **Knowledge Sharing Forums** are held regularly to share lessons learnt between stakeholders and to bring together practitioners within the adaptation space.

Since the Program launch in June 2016, 39 councils have been engaged and 23 councils have been approved for funding to progress with their CHAS. Another key outcome is the improved collaboration and knowledge exchange between neighbouring councils and between local and state government stakeholders.

# Day One:

## Tuesday 8 May 2018

### Adapting priority coastal recreational infrastructure for climate change

**Galen Lewis<sup>1</sup>, Eduardo Pombo Lavin<sup>1</sup>, Edward Couriel<sup>1</sup>, Geoff Withycombe<sup>2</sup>**

1. Manly Hydraulics Laboratory, Manly Vale, NSW, Australia

2. Sydney Coastal Councils Group, Sydney

NSW Governments' Manly Hydraulics Laboratory (MHL) and Engineers Australia through its National Committee on Coastal and Ocean Engineering (NCCOE) were commissioned by Sydney Coastal Council Group (SCCG) to prepare an assessment methodology and decision framework for priority recreational coastal infrastructure assets regarding coastal hazards.

Huge investment has been made along the NSW coastline into public infrastructure that is highly vulnerable to the impacts of climate change. This includes recreational infrastructure, such as wharves, jetties, beaches, promenades, parks, pools, pathways and boat ramps. This project has created an assessment method and decision framework for priority recreational coastal infrastructure assets that has been trialled and refined using a number of case study sites. We are now promoting the methodology and tools to be used more widely and encourage councils across NSW to utilise it as part of their normal planning and budgeting processes.

The case studies tested comprise public recreational infrastructure assets in NSW to assess the value, affordability and sustainability of the selected public recreational infrastructure and the amenity values they provide. The tool has been used to help define maintenance/renewal costs for Council's IPRF (Integrated Planning and Reporting Framework) and to establish future action triggers based on discounted future costs exceeding expected future benefits.

This project provides coastal councils and managers with a process tool to help make rational and strategic decisions in responding to the effects of climate change, and to maximise public value for money by building resilience through explicit triggers and well-defined funding models.

### A Scenario Wherein The Nation of Kiribati Partly Or Wholly Transmigrates As An Adaptation To Sea Level Rise (Speed talk)

**Jonathan Dobson<sup>1</sup>**

1. Integrated Environments P/L, Whyalla, SA, Australia

Kiribati, being composed of atolls, is vulnerable to sea level rise. Subsequent dispersal of this people group to any countries which will take them "lest they drown", would be an early case of environmental genocide, as in all likelihood, their nation, people, and language would be severely diminished, if not extinguished.

One adaptive mechanism for the people of this nation may be being partly modelled in Northern Australia. The Lease of one coastal cattle station has been changed to allow the development of an enormous prawn farm. It is expected to create 3,800 jobs at Australian wage rates. If the Lease of another similar area was made available to people from Kiribati wanting to live in an enclave of their own people, customs and language, that could provide self-funding means to avoid a last minute, chaotic, evacuation.

Unlike funding for mitigation, adaptation must be done where the costs of not adapting are the highest. There will be debate about what this means, but we cannot have endless debate, that will condemn species, peoples and nations to catastrophe.

The potential loss of Kiribati society is an unnecessary sequelae to the unnecessary climate changes we are experiencing. This radical adaptation might be successful, and provide a model for the transmigration of much larger populations which will be involved in subsequent sea level crises.

Even consideration of such radical adaptation, by the people of Australia and Kiribati, would help develop the tools required for the conceptualisation, negotiation and planning of future responses.

# Day Two:

## Wednesday 9 May 2

### 6. Climate ready natural resources management and the resilience of ecosystems

#### Climate change adaptation efforts for species may be antagonistic to natural evolutionary responses

**Alistair Hobday<sup>1</sup>, Juan Deigo Gaitan-Espitia<sup>1</sup>**

*1. CSIRO Marine and Atmospheric Research, Hobart, TAS, Australia*

Impacts of climate change are apparent in natural systems around the world and many species are and will continue to struggle to persist in their current location as their preferred environment changes. In many places, scientists, managers and policy makers are developing a range of intervention strategies that seek to boost population persistence in the face of these changes. These strategies are focused on two aspects that theoretically enhance species persistence – population connectivity and population size – and have been successful approaches for species conservation in the past. However, while these past successes are based on an “equilibrium” view of the environment. In contrast, climate change represents a relatively fast non-equilibrium (directional) selection pressure, producing conditions outside the historically experienced range. Novel genotypes might need to evolve, and so interventions that facilitate large, connected populations may in fact interfere with the direction of selection pressure and slow down evolutionary responses to climate change. Thus, some intervention efforts may be antagonistic to species persistence. We argue that successful interventions will require consideration of effects at genetic, individual, population and community levels. We provide advice and a conceptual framework to guide thinking about the risks with species interventions, and show that in some cases enhancing population size and increasing connectivity may not be the most appropriate options for species threatened by climate change, and may even reduce the success of their natural evolutionary responses.

#### Impacts and adaptation strategies of climate change in the Kimberley: an ecosystem based study

**Hector Lozano-Montes<sup>1</sup>, Fabio Boschetti<sup>1</sup>, Brad Stelfox<sup>2</sup>, Catherine Bulman<sup>1</sup>, Joanna Strzelecki<sup>1</sup>, Michael Hughes<sup>3</sup>**

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*3. Environmental and Conservation Sciences, School of Veterinary and Life Sciences, Murdoch University, Perth, WA, Australia*

We integrated a large amount of data, knowledge and state-of-the-art understanding of the bio-physical, ecological and social processes affecting the Kimberley marine environment drawing in new information generated by several research projects of the Kimberley Marine Research Program within WAMSI (Western Australia Marine Science Institution). This information was used to parameterise two computer models (ALCES and Ecopath with Ecosim [EWE]) to simulate land, coastal and marine processes. We developed “climate change” scenarios (based on RCP 8.5 climate model projections) and “Development” scenarios (human population, tourism, agriculture). Computer simulations were used to test the Kimberley system’s responses to these scenarios under a number of management strategies including current and proposed marine parks under different options of zoning and multiple uses. The analysis of the impacts of these scenarios and management strategies sheds light on a range of future states the Kimberley marine environment may experience during the 2015 to 2050 period. Careful analysis of model behaviour shows that the lower part of the food web is a key component in the functioning of the Kimberley marine system. Benthic primary production associated with seagrass and macroalgal assemblages provide food resources and shelter to diverse communities of invertebrates and finfishes. Our results can provide managers with an indication of the expected direction and magnitude of a species’ response to a specific scenario and thus the extent to which a management intervention targeted at a specific group is likely to succeed.

#### The Biodiversity Node: tools for NSW decision-makers to facilitate species’ resilience to climate change

**Linda Beaumont<sup>1</sup>, Victoria Graham<sup>1</sup>, Rachael Gallagher<sup>1</sup>, Michelle Leishman<sup>1</sup>, John Baumgartner<sup>1</sup>, Manuel Esperon-Rodriguez<sup>1,2</sup>, Nola Hancock<sup>1</sup>, Suzanne Dunford<sup>3</sup>, Lesley Hughes<sup>1</sup>**

*1. Department of Biology, Macquarie University, North Ryde, NSW*

*2. Hawkesbury Institute of the Environment, Western Sydney University, Sydney, NSW*

*3. NSW Office of Environment and Heritage, Government of New South Wales, NSW*

Climate change presents a major threat to biodiversity: land managers and policy-makers are faced with enormous challenges to manage the adaptation of natural systems and minimise species extinctions. The Biodiversity Node of the NSW Adaptation Research Hub (hosted by Macquarie University) has developed a suite of online tools that empower stake-holders to assess climate risks and reduce the vulnerability of species and ecosystems to climate change. This talk will showcase key tools, including:

1. Climate Refugia: an interactive website with maps of potential refugia from climate change for > 300 of NSW’s threatened species. Users can view projections of suitable habitat, visualise agreement across multiple climate scenarios, and download reports summarising impacts for threatened species within administrative regions.

# Day Two:

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2. NSW Niche Finder: basic metrics of species' ecological ranges are routinely used to assess vulnerability to environmental change. Until now, these data were lacking for NSW's flora. This web-tool enables users to explore baseline maps of ecological ranges and access climate niche metrics of NSW plants.
3. Climate-ready revegetation: practical advice for natural resource managers tasked with revegetation, and guidelines on using the latest climate tools to support the long-term persistence of plantings.
4. Weed futures: a decision support tool where users can access risk assessments for > 600 weed species, and download maps illustrating regions most vulnerable to future weed invasions.
5. These tools, co-designed by academic researchers, government scientists and stakeholders, provide an effective basis for conservation and land management under climate change, and will help maximise species and ecosystem resilience.

### Living Shoreline Response to Building Coastal Resilience

**Ralph M Roob<sup>2,1</sup>, Stephen E Swearer<sup>1</sup>, Rebecca L Morris<sup>1</sup>, David M Kennedy<sup>3</sup>, Teresa M Konlechner<sup>3</sup>**

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2. City of Greater Geelong, Geelong, VICTORIA, Australia

3. National Centre for Coasts and Climate, School of Geography, University of Melbourne, Melbourne, Victoria, Australia

Coastal land and associated communities are increasingly threatened by erosion and inundation hazards, due to the impacts of changing climate and increased pressure from growing population. To mitigate this threat, construction of hard engineering structures such as rock seawalls have been common over the last two centuries. As these structures sit within and above the intertidal zone, community attitudes have grown increasingly negative, some believing them to be unsightly, obstruct access and alter ecological and physical processes.

This has prompted increasing research into building coastal resilience through implementing living shoreline responses that work with natural processes, while exploring new innovative techniques. This project aims to implement a living shoreline approach to coastal defence, which has a positive impact on the coast by delivering its primary objective in attenuating wave energy, stabilising the beach and encouraging coastal progradation as well as realising co-benefits such as habitat creation and restoration. An artificial offshore breakwater seeded with mussels will be established by the City of Greater Geelong this Summer along a section of sandy-beach near Portarlington on the Bellarine Peninsula. The breakwater has a modular design composed of rock and shell filled mesh gabions that are constructed on land, quickly installed and modified if required.

The City of Greater Geelong has partnered with the University of Melbourne through the National Centre for Coasts and Climate to develop and implement an elaborate and detailed monitoring and evaluation program that aims to deliver learnings that can be applied to other sections of the coast.

### Mangrove Farming As a Trial Pre-Adaptation to Sealevel Rise (Speed talk)

**Jonathan Dobson<sup>1</sup>**

1. Integrated Environments P/L, Whyalla, SA, Australia

Coastal adaptation is required as sea levels rise, and oceans heat and acidify. In many coastal zones natural adaptive migration of mangroves inland is prevented by manmade infrastructure, Eg. farms and roads.

Flood irrigation, with windmill pumped sea water, of diked, salt pan areas inland from existing mangroves, would allow "pre-adaptation" of suitable sites. These areas would eventually be colonised by mangroves following inundation anyway. Sale of carbon credits, generated from the mangroves replacing salt pans, could offset establishment and maintenance costs.

Coastal adaptations will be competing for land, funds, and social backing and therefore we need to develop trials and models to enable conceptualisation and thence prioritisation of adaptive needs and opportunities. Not every need will be matched by an effective, efficient opportunity to adapt, some species will go extinct, some coasts will be inundated, but early responses may prove more cost effective than later panic.

Unlike funding for mitigation, which can be done where the marginal cost of CO<sub>2</sub> emission avoidance is lowest; adaptation must be done where the costs of not adapting are the highest. Local marine ecosystem collapses may be prevented by the systematic development of mangrove farms.

Such "pre-adaptation" may serve to educate the public about future changes, be partly self-funding, and be more effective than letting unaided ecosystem adaptation proceed. Mangrove farms could accelerate poleward species migration and would also provide many of the ancillary benefits, such as fish, crustacean, etc. nurseries, to wider marine ecosystems that natural mangroves currently provide.

# Day Two:

## Wednesday 9 May 2

### Impacts of groundwater extraction on ecophysiology of Australian trees (Speed talk)

**John Gallego Carboneras<sup>1</sup>**

*1. ., ACT, Australia*

Groundwater extraction has increased seven-fold in the last century leading to further overexploitation situations in aquifers. It is well documented that a continued absence of groundwater involves significant changes in the function of ecosystems that had previous access to it. However, many of these studies have estimated these variations across a natural gradient in depth-to-groundwater (DGW). The aim of this study is to determine the possible changes in the function of ecosystems within an induced gradient in DGW and identify the safe limit for groundwater extraction that avoids negative impacts. A cone of depression was formed in three different bore-field locations within the Hunter-Central Rivers area (NSW, Australia). Thirty six trees of three predominant species are being studied at different DGW sites, radiating out from an extraction bore in close, intermediate and far distances. Measurements in stem diameter, transpiration and aboveground biomass as well as analysis of foliar  $\delta^{13}C$  and  $\delta^2H - \delta^{18}O$  are carried out before and after the impact of groundwater extraction (BACI method). Temperature and precipitation pulses are driving water fluxes in ecosystems before groundwater extraction. High amounts of precipitation (20–40 mm) are positively related to increments of stem diameter ( $0.04 \pm 0.01$  mm), soil moisture ( $0.126 \pm 5.10 \cdot 10^{-2}$  m<sup>3</sup>/m<sup>3</sup>) and lower demand for water. Increments in the average daily temperature (15–20°C) are related to lower stem increment ( $0.01 \pm 0.01$  mm). Little variation of Ci/Ca ratio and water-use efficiency (WUE) are observed across the different topographic levels (0–7 m DGW).

### Climate ready natural resource management and the resilience of ecosystems – Prioritising management actions for the Gippsland Lakes (Speed talk)

**Sacha Jellinek<sup>1</sup>, Elisa Raulings<sup>1</sup>, Alistair Phillips<sup>1</sup>, Kay Morris<sup>1</sup>, Tim Thomson<sup>1</sup>, Tracey Regan<sup>1</sup>**

*1. Greening Australia, Melbourne, VIC, Australia*

Under a changing climate, it is essential that habitat restoration planning to enhance ecological systems take full account of modelled climate futures in Australia. In this presentation (and poster) we provide an example of resilience planning at the landscape-scale. This project focusses on the Gippsland Lakes landscape in eastern Victoria, which includes internationally recognised Ramsar wetlands. This diverse landscape consists of over 2,000 wetlands of varying salinities (fresh to hypersaline) and water regimes, and it is predicted that these wetlands will become increasingly saline over time, or disappear under hotter, dryer conditions. To determine how target bird and frog species will be influenced by Climate Change to 2050, we modelled how connectivity would affect these species, and how different management actions could ensure their persistence over time.

This approach offers a quantitative and reproducible approach to strategic natural resource management for organisations. It shows how maps and decision support tools can be used by practitioners to support efficient and effective management of wetlands and other landscapes.

## 7. Living better with extremes: predictions and preparedness

### A historical perspective on Australian temperature extremes

**Joelle Gergis<sup>1,2</sup>, Linden Ashcroft<sup>3</sup>, Penny Whetton<sup>1</sup>**

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*2. ARC Centre of Excellence for Climate Extremes, School of Earth Sciences, University of Melbourne, Melbourne, VIC, Australia*

*3. Australian Bureau of Meteorology, Melbourne, VIC, Australia*

Recent consolidation of pre-20th century instrumental, documentary, and palaeoclimate data for southeastern Australia has presented the first opportunity to provide a detailed examination of historical climate variability and extremes. Our region's strong regional warming trend in the 20th century has caused more warm extremes and fewer cool extremes, as recorded by changes in the frequency, duration and magnitude of heatwaves, snow and frost events. Research into pre-20th century temperature variations from newly consolidated early instrumental data and the readily accessible availability of online historical resources offers new opportunities to examine past societal and environmental impacts such as agricultural losses, heat related deaths and transport disruption experienced in local regions, highlighting areas of historical vulnerability to temperature extremes.

We use a newly consolidated early instrumental dataset and a range of historical sources for Adelaide in the South Australia – Australia's driest state – to investigate changes in the characteristics of temperature extremes back to 1838. Our dataset is derived from colonial newspapers, meteorological diaries and government records that contain daily weather observations. We identify notable snowfall events occurred during the winters of 1846, 1879, 1895, 1901, 1905, 1908, 1909 and 1910. Historical heatwaves were observed during the summers of 1839, 1895, 1897, 1908 and 1939. Finally, we highlight the potential of using historical records for identifying past analogues for future climate change planning, and discuss aspects of past societal impacts and vulnerability that are relevant for climate change adaptation.

# Day Two:

## Wednesday 9 May 2

### Emergency Simulations, Disaster Preparedness and the Arts: Evaluating the *Refuge* Project

Lachlan MacDowall<sup>1</sup>, Suzanne Fraser<sup>1</sup>

1. University of Melbourne, Parkville, VIC, Australia

*Refuge* is an ongoing arts-led project based in North Melbourne that links artists and curators with key figures in Emergency Management Victoria, Red Cross Australia, local community organisations, and the Victorian government, with the aim of generating new and critical ways of thinking about climate and crisis. Each year, between 2016 and 2020, a new emergency scenario is imagined in a 24-hour relief centre simulation at Arts House in North Melbourne, incorporating interactive art works, staged emergency facilities and educational information for the public to experience. In 2017, the enacted scenario was an extended heatwave. As an experiential, experimental knowledge exchange and long-form action-research project, *Refuge* asks how and what artists and arts organisations can contribute to preparedness, adaptation and recovery from catastrophes and disasters.

This paper will present the findings from the current evaluation of *Refuge* undertaken by the Research Unit in Public Cultures at the University of Melbourne concerning the benefits of arts knowledges in contemporary conversations on climate change, catastrophe and preparedness. A key strand in this evaluation is how the arts can help to activate community engagement in times of crisis. The continuing research also aims to open new dialogues on how Indigenous knowledges can provide cultural safety and enhance wellbeing in relief centre contexts, as well as how accessibility and equity can be foregrounded in an emergency. With the escalating threats from climate catastrophes in a contemporary global context, exploratory projects such as *Refuge* are vital in uncovering effective new models in extending community resilience.

### Heatwaves, highrise and the ageing population: Are we prepared?

Leigh A Wilson<sup>1</sup>, Deborah A Black<sup>1</sup>

1. University of Sydney, Lidcombe, NSW, Australia

**Background:** Heatwaves are known to contribute to increased mortality in populations aged over 65 years.

In 2003 a catastrophic heatwave killed around 14,000 people across Europe. The majority of these were older people living in high rise dwellings. Australian cities are becoming increasingly urbanised with high density living the norm in major cities as a result of increasing land values. As the population ages many older people are living in high rise buildings that rely on electricity or cooling and egress from the building. Overload of the electrical grid causing blackouts has the potential to expose older people in high rise buildings to the effects of extreme heat.

**Aim:** This study aimed to investigate the preparedness of older people living in high rise buildings for periods of extreme heat.

**Methods:** Using an online survey, the knowledge, awareness and understanding of extreme heat in people aged >55years who were living in high rise apartments was investigated. The survey was de-identified and was conducted following the extreme heat of summer 2017-2018.

**Results:** Preliminary results indicate that residents of high rise buildings rely heavily on the electricity for cooling and egress from the building. Most residents did not know whether their building had a backup generator to provide power when electricity grids fail.

**Conclusions:** With the increasingly aged population living in high rise buildings consideration should be given to the provision of backup power generation in the event of power failure to ensure the devastating effects of the heatwave in Europe are not repeated.

### Are we hot and bothered? Associations between temperature and crime in New South Wales

Heather R Stevens<sup>1</sup>, Paul J Beggs<sup>1</sup>, Petra L Graham<sup>2</sup>, Hsing-Chung Chang<sup>1</sup>

1. Environmental Sciences, Macquarie University, New South Wales, Australia

2. Statistics, Macquarie University, New South Wales, Australia

There is a common assumption that hot weather makes us irritable; if this is the case a warming world could become a 'hotbed' of aggressive crime. Some international studies have made connections between temperature and crime, however very little has been done within the Australian climate. This study investigated the seasonality of crime, as well as associations with monthly and daily temperatures. The study modelled the common offences of assault, theft and fraud against meteorological and socioeconomic data over an 11-year period in New South Wales (NSW). Assault was also investigated spatially to model how the crime/temperature association differed across NSW.

Results suggested that assault and theft counts were significantly higher in summer than winter, and that for every 10°C increase in temperature, average daily assaults significantly increased by 18.6%, and thefts by 2.6%. Fraud, an example of a non-aggressive crime, did not vary seasonally or with temperature. Spatial modelling revealed that 96% of local government areas in NSW had a higher summer assault rate than winter. Theories suggest that temperature influences crime rates through changing our routines, our physiology and even our culture. The results of this study are discussed in light of these theories and within an Australian context.

The findings of this study enable better predictions of criminal behaviour and are of interest to those within the public health, justice and social services sectors. However, importantly they also raise questions about how climate change may impact crime rates, and thus the cohesion and safety of our society.

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### Assessment of Climate Change Hazard Impacts on Victorian Coastal Assets

**Harmen Romeijn<sup>1</sup>, Lawrance Ferns<sup>2</sup>, Stephen Farrell<sup>1</sup>**

*1. Spatial Vision, Melbourne, Victoria, Australia*

*2. Department of Environment, Land, Water and Planning, Melbourne, Victoria, Australia*

Monitoring and assessing natural hazards along the Victorian coastline has typically been undertaken in the form of local coastal studies. When considering where to invest in increased monitoring along the coast to better plan for climate change impacts, a full state-wide assessment that is typically referred to as a second pass assessment, is required.

Spatial analysis and risk modelling plays a vital role in the supporting this process. This process also underpins an assessment of which assets are at greatest risk from increased coastal erosion and inundation, and informs planning to address this risk. To assist in this, an innovative and flexible spatial framework has been developed and implemented to assess likely impacts of climate change on coastal assets based on erosion and inundation.

The approach incorporates multiple streams of coastal data, where relevant datasets are assessed and further analysed for various processes that are known to contribute to coastal hazards. Data is integrated back into modules consisting of 50m segments, to which attributes and indexed scores are assigned. A coastal asset evaluation can be generated by assigning a profile to identified assets, either on or near to, the coast, to categorise coastal erosion vulnerability impacts and inundation for different levels of sea level rise and storm events.

Outcomes of this can be used to prioritise regions of greatest impact and support asset risk modelling. The work has been undertaken in partnership with the Department for Environment, Land, Water and Planning, to inform prioritisation of the Victorian Coastal Monitoring Program.

### A review of climate change and extreme events in Australia

**Andrew J Dowdy<sup>1</sup>**

*1. Climate Research, Bureau of Meteorology, Docklands, VIC, Australia*

The influence of climate change on weather and ocean hazards in Australia is reviewed here based on recent research. This includes results from a project on extreme weather projections within the Earth Systems and Climate Change (ESCC) Hub of the National Environmental Science Program (NESP), as well as other literature and information sources. Summaries of findings relating to a number of topics include: Bushfires—more dangerous bushfire conditions particularly in southern and eastern Australia; Thunderstorms—potentially large increases for convective rainfall extremes, with larger uncertainties for extreme winds, tornados, hail and lightning; Cyclones—fewer but potentially more intense cyclones in some regions; Extreme Rainfall and Flooding—more intense extreme rain events in many parts of Australia, with larger uncertainty for floods; and Compound Events—important for amplifying impacts, with large uncertainties in changes. It is also noted that natural hazards can intersect with other existing problems, such as socio-economic issues, thereby intensifying the impacts of disasters. Improved preparedness for these hazards will help climate adaptation and disaster risk reduction, with benefits for a wide range of sectors such as emergency management, planning, natural resource management, agriculture, finance, insurance, defence, tourism, transport and health.

## 8. Financing adaptation – Liability and risk in climate change adaptation

### The affordability of natural peril insurance

**Tim Andrews<sup>1</sup>, Andrew Xu**

*1. Institute of Actuaries of Australia, Sydney, NSW, Australia*

The paper will match indicative insurance premiums being charged by residential building insurers for natural perils for each address in Australia with socio-economic data about the profile of people living in those dwellings.

We will assess the ability of the residents of those homes to afford the natural peril insurance premiums, according to how many weeks of average weekly earnings would need to be spent to pay the premium. Whilst the analysis will be undertaken at a granular level, by individual home, the results will be presented in segments (region, socio-economic group and others).

### The case for a national adaptation fund to reduce ongoing climate risks? Can we change the discourse? A New Zealand perspective

**Judy Lawrence, Jonathan Boston**

New Zealand faces unprecedented and new challenges arising from the impacts of climate change. Impacts compound existing natural hazards and create new hazards which cascade across the economy as they increase in frequency, intensity and duration, and in some cases, accelerate beyond the capacity of people and our institutions to adapt. This suggests anticipatory adaptive measures are required to enable timely and

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orderly transitions. The level of transformation required within our systems, services and communities could be at a scale beyond affordability limits at local levels of governance and thus will require new national adaptation funding measures that can reduce ongoing risk exposure. Current funding measures are designed for past climate conditions and focus on post hoc responses to climate 'events', rather than being forward focused on reducing the scale and scope of impacts likely over the next 100 years and beyond. We examined the adequacy of existing funding measures in NZ and elsewhere, including superannuation and sovereign wealth funds. We found a plethora of ad hoc funding measures which has embedded mal-adaptive decisions, entrenched exposure to hazard risk. The understanding gained has enabled us to elaborate design principles and allocative criteria that will need to be satisfied for equitable and efficient implementation of any new adaptation funding mechanisms. The factors enabling this cycle of risk entrenchment to be broken using new funding mechanisms, include addressing policy commitment, moral hazard, transparency and fiscal sustainability.

## Law and Climate Change

Tayanah O'Donnell

The exploration of the numerous facets of law remains under explored. This is despite the significant inroads into the ways society and laws can and must respond to the challenges and opportunities that climate change presents. This presentation offers insights on the role of law in climate change with reference to recent developments in three discrete areas of law: land use planning, public interest considerations, and corporate disclosure obligations. The presentation will then open for broader discussion on philosophical and political questions that the 'role of law' in and for climate change raises.

## From point value to sustainability investment logic- infrastructure appraisal and the challenges of climate change

Angela Reidy<sup>1</sup>, Arun Kumar<sup>2</sup>, Stephen Kajewski<sup>2</sup>, Fiona Lamari<sup>2</sup>

1. Inxure Consulting, Melbourne, VIC, Australia
2. Queensland University of Technology, Brisbane

Strategic decision making at the front end of infrastructure projects, centred on the findings of a business case, is critical to the delivery of sustainability commitments by infrastructure providers. These commitments contribute to collective efforts responding to the UN Sustainable Development Goals. In current practice, decisions on major investments are typically contained within a narrow frame of analysis using the comparison of costs with benefits or value, and where a point value is often used as part of a pass/fail rule. This framing of economic analysis does not support sustainability and may preclude innovative project solutions and opportunities to address emerging challenges such as climate change, typified in areas such as integrated water cycle management.

Based on empirical research, this paper presents a sustainability investment logic that considers outcomes in terms of benefits that are measurable indicators, and outputs in terms of values that may be both qualitative and quantitative. Benefits assessment for infrastructure investments should align with broader policy directions and include considerations of benefits for the wider community, beyond the boundaries of the infrastructure provider. This paper challenges the premise that better analysis should be based on assigning monetary value to a broader array of economic, environmental and social items. Within the model that is proposed, participation by stakeholders, including end-users, informs the identification of values and benefits, and is integral to the considerations of trade-offs between competing values dimensions.

## A flood of claims: Incorporating climate change into peril models for insurers

Kate Simmonds<sup>1</sup>, Andy Casely<sup>1</sup>, Michael Barkhausen<sup>1</sup>

1. Willis Re, Sydney, NSW, Australia

Willis Re has developed a suite of natural hazard models, including bushfire, cyclone and flood, to advise insurers on the risk that these perils pose to their property portfolios. However, these models currently assume a static climate. In order to continue helping insurers adequately quantify these risks, we are endeavouring to incorporate the effects of climate change within our models. This is especially important in Australia where these effects, alongside population growth and urban development, mean that the costs of natural hazards are likely to continue to rise.

One particular concern for our models is potential changes in the distribution of extremes. For example, our flood hazard model provides peak water depths for design floods at 20, 50, 100 and 10,000 year average return intervals (ARI) at address resolution. This enables our clients to appropriately underwrite each property that they insure. However, if the distribution of flooding or rainfall changes, flood events may occur more frequently or with different geographic characteristics. Inaccurate estimates of flood risk undermine insurers' capacities to pay claims, keep premiums affordable and provide insurance in high-risk areas in the future.

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## 9. Decision-making options for risk management

### Fit-for-purpose: a phased approach to pathways application

**Andrew Warren<sup>1</sup>, Marjolijn Haasnoot<sup>1,2</sup>, Laurens Bouwer<sup>1</sup>**

1. Deltares, Delft, Netherlands

2. Faculty of Technology, Policy and Management, Delft University of Technology, Delft, Netherlands

In response to uncertain future climate change and socio-economic developments, planners are advised to develop adaptive plans that achieve objectives under a wide range of futures and can be adapted in response to how the future unfolds. One way to develop adaptive plans is to explore and evaluate Dynamic Adaptive Policy Pathways. It is often assumed that in order to undertake pathways analyses complex, sophisticated, in-depth modelling studies are mandatory. This can have the consequence of discouraging policy makers from undertaking these analyses at all, particularly in resource-constrained and data-scarce contexts.

In this presentation, we emphasise an iterative and phased fit-for-purpose approach towards pathways analysis implementation. Under this approach, an initial analysis of the problem is undertaken together with stakeholders using a combination of readily available information and expert judgement. During the second phase, simple models can then be used to refine the analysis. The final phase comprises targeted in-depth modelling studies as required. Phasing policy analyses in this manner minimises risks of over-investment in costly and potentially unnecessary modelling studies, while nevertheless opening up the discussion and decision space for a consideration of transformative measures. We illustrate this process using the case study of flood mitigation pathways recently developed for Miami, Florida.

### The governance of learning to do differently: enabling adaptation by evolving decision contexts

**Michael Dunlop<sup>1</sup>, Paul Ryan<sup>2</sup>, Russell Gorddard<sup>1</sup>, Russell Wise<sup>1</sup>, Lorrae Van Kerkhoff<sup>3</sup>, Claudia Munera<sup>3</sup>, Rachel Williams<sup>1</sup>**

1. CSIRO, Canberra, ACT, Australia

2. Australian Resilience Centre, Beechworth, Victoria, Australia

3. Fenner School, Australian National University, Canberra

Adaptation analyses often overlook the societal factors that determine what options might actually be available to managers, or indeed the factors society may use to judge the legitimacy or efficacy of different options in the future. In responding to transformational climate change society will need to manage many familiar issues in different ways, from biodiversity conservation to disaster management. We explore the idea that the governance of learning to do *differently* is very different from the governance of learning to do *better*, the latter characterised by continuous improvement, adaptive management, productivity, benefit-cost, and so on. The extent to which managers can experiment with and adopt different options is shaped by the societal decision context within which they conceive, choose and implement options. 'Values, rules and knowledge' has proven to be a powerful framing for analysing decision contexts. It helps identify the factors that enable or constrain decisions. And critically, it helps identify where in society these factors originate, and so whom might need to learn and change to create contexts for decision makers that enables future adaptation options.

We present experiences from case studies from Australia and overseas where adaptation has been framed as the process of driving the evolution of the societal decision context to create the environment for new adaptation options. These involve identifying processes that managers can implement now to stimulate on-going learning in others to evolve their preferences, drive reform of formal and informal rules and generate relevant knowledge to support future adaptation.

### Co-creating adaptation pathways for primary industries in Hawke's Bay, New Zealand

**Nick Cradock-Henry<sup>1</sup>, Paula Blackett<sup>2</sup>, Franca Angela Buelow<sup>1</sup>, Madeline Hall<sup>3</sup>, Paul Johnstone<sup>4</sup>, Edmar Teixeira<sup>5</sup>, Anita Wreford<sup>6</sup>**

1. Manaaki Whenua Landcare Research, Lincoln, CANTERBURY, New Zealand

2. National Institute for Water and Atmosphere (NIWA), Hamilton, New Zealand

3. Hawke's Bay Regional Council, Napier, New Zealand

4. Plant & Food Research, Havelock North, New Zealand

5. Plant & Food Research, Lincoln, New Zealand

6. Agribusiness and Economics Research Unit, Lincoln University, Lincoln, New Zealand

Primary industries are of particular importance to New Zealand (NZ) worth 7% to annual GDP. Agricultural producers are likely to be adversely affected by changes in mean temperatures, more frequent extremes, and an increase in climate variability, with implications for established management practices. Hawke's Bay is a premier food- and wine-producing region, however changing land use, competition for freshwater, and climate change, present primary industries with a significant challenge. We present and discuss the application of adaptation pathways planning in the region, and the ways in which we are working with local government and other stakeholders to support strategic planning. The aim is to identify factors for successful co-creation and collaboration. Insights into the ways in which decision making capability and capacity is being enhanced – in communities, industry and local government – are identified and discussed. Results to date highlight how the co-creation process is building local capability and capacity for dealing with complex problems. Participation by community groups, industry representatives and local government enables and empowers stakeholders to consider a range of possible futures. Framing adaptation in a broader context, also allows for consideration of non-climatic drivers of stress, and change, such as improvements to infrastructure, economic diversity and social well-being. Findings provide new insight into the potential for participatory and collaborative action research to support

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decision-making. Bringing together land managers, local government and researchers, modeled quantitative social, economic and ecological data are being integrated with community values and objectives to help navigate uncertain and complex climate futures.

### Managing coastal flood risk: vulnerability assessment and long-term adaptation planning

**Timothy Ramm<sup>1</sup>, Christopher White<sup>2</sup>, Christopher Watson<sup>1</sup>**

1. *University of Tasmania, Hobart, Australia*

2. *University of Strathclyde, Glasgow, Scotland*

Projecting the extent of sea level rise, changes to coastal flood frequencies and resultant community impacts becomes increasingly uncertain across multi-decadal timeframes. Robust decision making (RDM) and dynamic adaptation policy pathways (DAPP) are two promising decision support techniques that can guide long-term adaptation planning in such situations. We present lessons learnt from two cases studies in south-eastern Australia that draw upon the strengths of RDM and DAPP in their assessment of coastal flood vulnerability and in the evaluation of adaptation responses. Both studies implement their analysis with open source programming and spatial data to lower the entry barrier for resource constrained decision-makers. We find that RDM is useful in uncovering tipping points to describe key vulnerabilities in the community, which can help focus data collection, risk monitoring activities and illustrate broadly how aspects of uncontrolled land use and development can intensify flood impacts. The identified tipping points can then be embedded into DAPP, which offers a framework to formulate long-term adaptation pathways. While challenges remain with the modelling and detection of environmental change, both case studies demonstrate how a better understanding of tipping points can improve adaptation planning and the long-term management of coastal flood risk. We conclude by discussing the barriers and enabling factors that local government might face if they were to replicate the methodology in other vulnerable coastal locations.

### Developing workflows to support consideration of climate risks in decision-making by non-(climate)-experts

**Mark Stafford Smith<sup>1</sup>, Russ Wise<sup>1</sup>, Paul Paul Box**

1. *CSIRO, Canberra, ACT, Australia*

Adaptation mainstreaming still struggles in policy decision-making. As Webb et al documented, decision-makers often do not know what information they should be using. Available data portals and analytical platforms are not enough, as they still require expert input. Meanwhile business practices use standardised accounts, projects and travel workflows. The Climate Risk Information and Services Platform project developed a set of standard typologies of projects and related climate risks for similar repetitive workflows in policy business case assessments. We engaged with government investors in major infrastructure projects to determine whether users could be enabled to access the right climate risk information at the right time in their assessments. For a defined set of asset types (e.g. roads, railways, irrigation storages), we created a typology of climate risks to each type, linked to relevant datasets, and guidance for their application. Risks affect construction costs (e.g. lifetime resilience of different building standards), running costs both chronically (e.g. heating/cooling costs) and acutely (e.g. flood or storm damage, business interruption), and benefits flows (e.g. effects of transition risks on transport demand). User testing showed that amended workflows can be boundary objects for proponents and assessors to develop BCAs that are robust to climate risks. Looking forward, some policy decisions will always need bespoke analyses of climate risk. However, for repetitive project assessments in programs diverse as infrastructure, NRM and health, enabling decision-makers (expert in their own domain but not in climate) to access authoritative, tailored climate risk information aims to accelerate appropriate mainstreaming.

### DAPP goes Philippines: Practical Guideline on Integrating Uncertainty into Adaptation Investment Decisions

**Andrew Warren, Maaïke van Aalst, Femke Schasfoort, Marjolijn Haasnoot**

The Dynamic Adaptive Policy Pathways approach (DAPP) assists decision makers to plan for and implement robust and flexible short- and long-term investments options under uncertain changing circumstances. DAPP has been developed and applied in high-income contexts, where effective institutions and government planning processes exist and where data is available and abundant. However, limited applications have taken place in middle- and low-income countries with less governance stability and data availability but which are nevertheless facing imminent climate change impacts.

We recently applied DAPP in the Philippines, a country known for its rapid economic development but also for several devastating climatic events over past decades. Its government planning is both fragmented and short-term focussed, while resources and capacity are lacking for elaborated long-term planning. DAPP was applied to identify robust investment portfolios for selected sites facing key climate risks: Tacloban (storm surges and typhoons); Laguna de Bay (flood risk and watershed degradation); and Cebu (water shortage). Methodological guidelines were also developed to enable local practitioners to undertake future pathways and economic analyses of investment decisions under uncertainty.

Consequently, DAPP has been elaborated with a framework to select relevant levels of analysis and related economic methods based on data availability, capacity, available resources, beneficiaries and objectives. This provides local decision makers with practical guidance to identify which level of pathways exploration and economic analysis is feasible and/or required, ranging from fast and simple analyses to more comprehensive assessments which demand greater resources and data.

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### Robust adaptation decision-making under uncertainty: An application of real options analysis to decision-making in the water sector (Speed talk)

Anita Wreford<sup>1</sup>, Daniel Collins<sup>2</sup>, Alan Renwick<sup>1</sup>, Ruth Dittrich<sup>3</sup>

1. Lincoln University, Lincoln, CANTERBURY, New Zealand

2. NIWA, Christchurch, New Zealand

3. University of Portland, Portland, Oregon, USA

Planning for climate change adaptation is challenging due to the inherent uncertainty associated with future climate changes. Despite this uncertainty, adaptation decisions may need to be made now, to effectively reduce future vulnerability to climate change. We apply an economic approach that places a value on flexibility, Real Options Analysis (ROA) to a water storage investment decision. Our study site is in a region of New Zealand (NZ), where water availability for irrigation, industry and domestic use is currently under considerable pressure, and is likely to increase further under climate change.

Scenarios of future water availability (and from this, reservoir size) are projected based on regionally downscaled climate change projections for six CMIP5 GCMs and four RCPs. The ROA involves the development of a decision tree with different decision points (2018 and 2040), so that the size of the reservoir in 2018 will be sufficient to provide water availability until 2040, and have the capability to be extended if necessary at the next time period. The net present values of each of the 24 branches is estimated, so that the most economically efficient decisions can be made.

The findings will allow the identification of the most efficient size of reservoir in the current time period, and the ability to extend that if necessary in future time periods, meaning an avoidance of over or under-investment in adaptation.

## 10. Building resilience of communities and community services

### Resident Experiences of Shock Climate Events – Lessons for Resilience

David Schlosberg<sup>1</sup>, Luke Craven<sup>1</sup>, Hannah Della Bosca<sup>1</sup>

1. University of Sydney, Sydney, NSW, Australia

Urban Resilience incorporates preparedness and recovery from increasing stresses and shock events. In cities, these events have complex impacts that interact with and affect one another, crossing multiple geographic, community and administrative boundaries. This paper reports on a project that examines the complexity of resident experiences during and after shock events across urban metropolitan Sydney, including flooding, bushfires, and heatwaves. Based on an engagement process that includes focus groups and an event mapping exercise, the paper addresses the broad impacts of events on the basic needs and processes of everyday life, as well as enablers and barriers to resilience. The goal is to use the lived experience of vulnerability to climate stresses and shocks, and a capabilities approach to justice to understand both the specific injustice of vulnerability and the ways it can be addressed. This method will enable policymakers to understand the multifaceted ways in which citizens experience vulnerability, and design responses for resilience policy that are issue-specific, efficient, effective, and just.

### Building Community Resilience through Industry and Academic Partnership

Jon Harwood<sup>1</sup>

1. Suncorp, Barangaroo, NSW, Australia

Suncorp's work with James Cook University has led to a better understanding of the cyclone vulnerabilities in homes and what can be done to address them. Since the launch of the Suncorp Cyclone Resilience Benefit in 2016, Suncorp has reduced the premiums of more than 35,000 customers who have reported roof upgrades, covered windows, stronger doors and property maintenance at their homes.

The program was supported by the introduction of a low-cost loan to help customers in cyclone-prone areas of Queensland make their homes more resilient.

Jon Harwood, Consumer Portfolio Manager at Suncorp will discuss:

- Suncorp's journey in helping the community increase its resilience to severe tropical cyclones and storms;
- Suncorp's partnership with James Cook University, work at Townsville's Cyclone Testing Station, and the development of the Cyclone Resilience Benefit;
- Research methods and findings that informed the program; and
- An overview of the next phase of international research with James Cook University and Florida University, including the largely unexplored behavioural science aspects of natural disaster mitigation and climate adaptation.

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### Embedding resilience to climate change and disaster risks within community sector organisations: A Victorian case study

Luke Sarsons, Daniel Voronoff

Community sector organisations (CSOs) are highly vulnerable to climate change and disasters. At least 25% of organisations may no longer operate, and 50% be out of action for up to a week following serious disaster damage. The challenges confronting CSOs are multiple and interconnected, raising the question: how do they embed climate resilience whilst responding to existing business challenges? This presentation explores CSO experiences in planning for climate change across Victoria. The Community Sector Climate Resilience Program was funded by Victorian Department of Health and Human Services and the Commonwealth Government and supported 65 organisations to understand their current resilience levels and plan for climate change impacts. Organisational resilience was determined across four dimensions; culture, resources, capability and place using our resilience monitoring tool. This assessment informed the project's engagement activities, enabling the targeting of support directly towards areas of greatest organisational need.

The most important project finding centres on anchoring climate strategies in practical policies such as business continuity and health and wellbeing, to assist embedding climate risk management, and reducing process duplication. Organisations reported the program's flexibility enabled support to be utilised in ways that best fit their needs, although further support is needed for long-term change. The program also experienced challenges engaging the sector including limited staff resources to support delivery and difficulties recruiting organisations. Finally, we identified that a new approach to local climate leadership might be achieved through supporting clustered organisations, such as neighbourhood houses, regional councils, and health service providers to build collective resilience.

### Islands of resilience - building community resilience in the Torres Strait

John J Rainbird, Hilda Mosby

Island communities in the Torres Strait have a number of key vulnerabilities which increase their sensitivity to climate change impacts. Focusing initially on water security and working with the community of Masig and key partners, TSRA is piloting a framework to enhance community resilience through building adaptability. Water is a critical and limited resource for most Torres Strait islands and climate change will exacerbate water security issues. The initiative draws on a mixture of conceptual frames from resilience of socio-ecological systems and social learning coupled with pragmatic tools to map out the island water system and to establish practical pathways that deliver improvements in water security as well as building community adaptability. The heart of the initiative is working with community to understand how they view their situation and facilitating the emergence of community led solutions whilst working in tandem with the local council and other partners to develop holistic solutions. The initiative is a priority activity identified in the Torres Strait Regional Adaptation and Resilience Plan.

### Cooling Communities

Kathryn A Skidmore<sup>1</sup>, Mike Collins<sup>1</sup>

<sup>1</sup> Moreland City Council, Coburg, VIC, Australia

The *Cooling Communities* project builds upon the Moreland City Council Urban Heat Island Effect (UHIE) Action Plan, which revealed that much of Moreland experiences excessive summertime heat, often over 50 degrees. The Plan further revealed that many persons are particularly vulnerable to heat stress, including social housing residents.

*Cooling Communities* aimed to improve the resilience of residents within non-government social housing. Partnering with the Moreland Energy Foundation, two local social housing providers, Aboriginal Housing Victoria and Housing Choices Australia, the project created a set of recommendations which outline how to improve UHIE resilience in social housing. The recommendations are applicable for Federal, State and Local Government as well as social housing providers and residents.

- The project installed various capital works upgrades in homes and emphasised behaviour changes aspects, whilst also exploring key relationships, roles and responsibilities. It also had a strong human element, working with providers and residents in the context of broader social issues and priorities. The project findings provide a pathway for implementation that is transferable across various regions. Key areas explored and findings included:
- How to identify persons vulnerable to excessive temperatures who are not easily known to government or service providers.
- Co-designing interventions that are effective for specific residents' needs.
- Exploring the role of not-for-profit social housing providers and the wider community in providing safe thermal comfort levels in face of rising urban temperatures.
- Making policy recommendations for Federal, State and Local Government in improving residential heat resilience.

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### Adapting to climate change in the Tiwi Islands

Mavis Kerinaiu<sup>1</sup>

1. Mantiyupwi Land Owning Group, ., VIC, Australia

The Tiwi Islands are inhabited by the Tiwi people, as they have been since before European settlement in Australia. Tiwi people have adapted to environmental changes in the past, and their culture and livelihoods are indivisible from their country. Climate change poses new risks to Tiwi people, and the Tiwi Land Council (TLC) has taken the lead in planning for climate change. This paper reports on these initial activities, highlighting the impacts of concern, priority targets for adaptation, and the challenges in advancing adaptation in the Tiwi Islands. Key risks include: damage from floods and storms to critical infrastructure such as roads and bridges, health centres and townships; diminished revenue from forestry activities through changing fire and temperature regimes; and to impacts on fisheries through coral bleaching and changes in mangrove habitats. Townships and their infrastructure are a priority area for adaptation and strategic plans for land use and investment are required. Other priority activities include: factoring climate change risks into disaster management plans, development of systems for monitoring relevant changes, and constructive engagement of the broader Tiwi community. The key challenge in advancing adaptation is the distribution of responsibilities for these activities across several authorities, including the Tiwi Shire Council, the Commonwealth Office of Township Leasing, the Northern Territory Power and Water Corporation, Police, and Territory and Commonwealth health services. Sustaining Tiwi rights and values through a changing climate requires that these responsible authorities work together with Tiwi communities.

## 11. Agriculture: adapting for increased climate variability

### Mind the gaps: assessing the evidence, and impact of adaptation research for New Zealand primary industries.

Nick Craddock-Henry<sup>1</sup>, Paula Blackett<sup>2</sup>, Franca Angela Buelow<sup>1</sup>, Stephen Flood<sup>3</sup>, Anita Wreford<sup>4</sup>

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4. Agribusiness and Economics Research Unit, Lincoln University, Lincoln, New Zealand

The future of primary industries will depend on their ability to adapt. Although advances have been made in understanding climate change impacts and implications, determining what exactly is known, not known and needs to be known about adaptation presents policy- and decision-makers with significant challenges. Combining systematic review methods with a robust evaluation framework to synthesise the available scientific evidence on adaptation, we summarise and assess the state knowledge for New Zealand primary industries, and evaluate the impact of adaptation research. The aim is to characterise the 'adaptation deficit': where is adaptation occurring, by whom, to what stressors, by what means and with what effect? Results of the review reveal significant gaps in our understanding, particularly for decision-making and adaptation planning at strategic levels. Biophysical sciences dominate with limited examples of recent environmental and applied social science. Action research does demonstrate impact in building adaptive capacity of primary sector decision-makers. However without national guidance or policy, adaptation research and practice in New Zealand may continue to be implemented piecemeal through sector- or industry-specific research; subsumed under other concerns (such as biosecurity); or overlooked by a greater emphasis on mitigation. Results of the study contributes to an emerging literature tracking on the ground adaptation processes and outcomes, and helps inform future research and policy agendas for addressing key knowledge gaps. Conclusions provide an up-to-date assessment of the state of adaptation science and its outcomes; help identify enablers and barriers to adaptive capacity; and consider the value for money of previous research.

### Leaving the farm: exploring the drivers of farm exit over time in the Murray-Darling Basin

Sarah Wheeler<sup>1</sup>

1. University of Adelaide, Adelaide, SA, Australia

The decline of farm numbers has always been an issue that rural communities care deeply about, because it is often associated with falling rural services and economic decline. While climate conditions and water access can play important roles in farm exit, they are not always well understood, especially when ignored from other long-term issues that impact on farm numbers in rural areas. This study put together a unique regional-level panel data set from 1991-2011 of farm, community and environmental influences at the Statistical Local Area level in the Murray-Darling Basin to explore the drivers of farm exit over time using spatial econometric analysis. Preliminary early results suggest that, along with other standard known economic influences on farm exit (namely commodity prices, urbanisation, increasing farm economies of scale), increases in temperature in local areas over time decreases farm numbers. The climate change impact was more significant than the irrigated water diverted by local areas, emphasising that current Murray-Darling Basin water reform needs to carefully consider long-term drivers of farm exit and be focused on what is the best way to help farmers adapt to a hotter (and less water secure) future.

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### The Adaptation Action Plan for Agriculture Pilot

**Jane Fisher<sup>1</sup>**

*1. Department of Economic Development, Jobs, Transport and Resources, Victorian Government, Southbank, Victoria, Australia*

Under the Climate Change Act 2017 nominated Ministers must prepare Adaptation Action Plans (AAPs) for key systems that are vulnerable to climate change impacts every five years, commencing in 2020. AAPs will include an assessment of climate change-related vulnerability and risks to the system; an outline of roles and responsibilities for adaptation in the system; a list of actions to be implemented under the AAP; and a monitoring and evaluation plan to assess the effectiveness of the AAP (DELWP 2017 Climate Change Adaptation Plan). The DELWP 2017 Climate Change Adaptation Plan nominated the primary production system as one of three pilots for testing and developing AAP's. The other two are health and human services system and the water system.

A pilot AAP for the primary production system is being developed. Pilot AAPs were also endorsed for health and human services, and water cycle systems. The primary production system includes growing and cultivation of horticultural and other crops, controlled breeding, raising or farming of animals and infrastructure, and the workforce and communities supporting these activities.

This paper will describe the framework being used to review investment in climate adaptation by various actors in the primary production system, conclusions from the review and potential approaches to managing the gaps.

### Agricultural Land Suitability Analysis of Metropolitan Peri-Urban areas now and into the future – Case study of City of Whittlesea, Melbourne, Australia (Speed talk)

**Ana Spataru, Robert Faggian, Victor Sposito, Annemaree Docking**

Pressures from urban development in metropolitan peri-urban areas has led to decline in agricultural activity. Methodologies that address the impacts of climate change on agriculture are better at creating adaptive capacity for local communities. Land Suitability Analysis (LSA) methodology has been used to investigate the bio-physical and climatic crop growth requirements, defining three main criteria: soil, landscape and climate. The analysis creates a spatial composite map that displays areas of various suitability ranked from 0 to 10. The timeframe includes baseline, and 2030, 2050, and 2070 based on higher emission scenario projections, and include irrigated and non-irrigated models. This paper presents the versatility LSA maps of ten commodities: Phalaris Perennial Ryegrass, Lucerne, Brassicas, Citrus, Plums, Cherry, Raspberry, Cut Flowers, and Blue Gum. The case study area was City of Whittlesea, a Council in northern Metropolitan Melbourne. The results indicate that agricultural land is highly suitable and versatile when irrigation is provided. The purpose of the analysis is to inform decision-makers and create the opportunity to discuss future agricultural development initiatives, which account for climate change as an enabler of agricultural activity. In conjunction with this approach, overarching strategies to ensure climate change adaptation are equally important. Towards the end, we discuss opportunities for new modes of agricultural activity as suggested by Multifunctional Agriculture.

### Adaptation Conversations: Creating a climate for change through ag advocacy (Speed talk)

**Verity V Morgan-Schmidt<sup>1</sup>, Corey C Watts<sup>1</sup>**

*1. Farmers for Climate Action, Cooroy, QLD, Australia*

Farmers for Climate Action is committed to putting those on the front-line of climate change, front and centre in creating climate solutions. We're advancing a completely new model of ag-advocacy and taking a community organising approach; recruiting farmers to organise other farmers and connecting pockets of climate literacy, action and adaptation across the country.

We recognise that the best way to meet with challenging and uncertain times, including climate change, extreme weather events, droughts and natural disasters is with strong and resilient farmers underpinning regional communities.

Our overarching framework is guided by recognition of farmers and primary producers as land custodians of 50% of Australia's land mass. We recognise the innovation and resilience of Australian farmers, with many already leading the way in climate adaptation.

With four key pillars of emissions reduction, energy transition, carbon sequestration and climate smart agriculture Farmers for Climate Action is driving a wave of change across the agricultural sector; encouraging farmers and graziers to become increasingly proactive with climate adaptation and strengthening rural resilience. We're building climate literacy via our Climate Smart Agriculture Fellowship and meeting farmers wherever they are on their climate change journey.

Farmers for Climate Action is a movement whose time has come. Underpinned by a strong evidence based approach, we are tackling headfirst the challenges of engagement and adaptation across Australia. Join our presentation to learn more about how Farmers for Climate Action is encouraging change across the sector.

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### You Reap What You Sow? (Dis-)Incentives for Adaptation to Climate Change (Speed talk)

**Franca Angela Buelow<sup>1</sup>**

*1. Manaaki Whenua Landcare Research, Lincoln, CANTERBURY, New Zealand*

Climate-friendly behaviour change is commonly incentivized financially. The latest example is the most recent European Union's Common Agricultural Policy reform, which redesigned its subsidy scheme to include 'Greening Measures' to its Direct Payment scheme (EC 2014). However, recent research has shown that financial incentives do not seem to promote sufficient behaviour change in farmers to meet current and future climate change challenges (Arbuckle, Morton, Hobbs 2015; Burke & Emerick 2016). This study applies Protection Motivation Theory (PMT) to a survey experiment to better understand a) how individuals decide to adapt and b) which incentives promote behavior change intentions. It contributes to an empirical understanding of the measurable and alterable psychological conditions of individual-level behavior change and provides causal explanations for their relevance. Four different incentives are analysed with regard to their potential to promote individual adaptive change intentions. Contrary to the assumption of profit maximizing individuals, economic incentives trigger less overall change intentions. Economic rewards act on risk perception, but are less likely to trigger coping perception, while other treatments do so. As coping perception is one of two socio-cognitive reactions to climate change (Grothmann & Patt 2005), it seems that current incentive structures fail to act on half the factors leading to adaptation intentions. These effects dependent on subgroups, farm structures, and climate experience. This suggests that a) subsidies alone do not suffice to promote adaptation, and b) there is no 'one-size-fits-all'-incentive for behaviour change, but a set of linked options to trigger change intentions.

## 12. People perceptions and knowledge to change behaviour

### Navigating conflict and identity to achieve successful adaptation outcomes: Perspectives from social psychology

**Rebecca M Colvin<sup>1</sup>**

*1. Australian National University, Acton, ACT, Australia*

Social conflict about the need and methods for adaptation can undermine the efficacy of decisions made, and can erode public support and engagement. Successfully navigating such conflict requires understanding the stakeholders involved – their identities, values, and beliefs – and how different stakeholders interact with each other and decision-makers. Theoretical perspectives on conflict from social psychology can inform science and equip practice to achieve better adaptation outcomes.

Where an adaptation initiative divides society across lines such as 'environmentalists' and 'farmers', stakeholders are categorising into social identities which come pre-packaged with associated beliefs, agendas, behaviours, and norms for engagement with other stakeholders and decision-makers. When identity-powered conflict emerges, hostility toward, cynicism of, and stereotypes about other stakeholder groups characterise the intergroup relations. Individual group members are stereotyped and dehumanised by opposition group members, meaning that causing harm can be more easily rationalised.

Such a situation can result in stakeholders pursuing courses of action which are harmful to other stakeholders whom they consider to be in an 'out group'. These effects encourage polarisation through directing group leaders to adopt extreme stances, skewing negotiations toward intractability. This can cause action to slow or stagnate, undermining the potential for implementation of effective adaptation initiatives.

Relationship building between conflictual stakeholders and collaborative approaches to adaptation present opportunities informed by social psychology for deescalating conflict and building environments which are conducive to successful adaptation.

### Adapting to a changing natural environment using the Great Barrier Reef as a case study

**Nadine A Marshall**

In 2013, some 9,000 residents, tourists, tourism operators and commercial fishers accepted to be part of a social and economic survey that helped researchers to understand their relationship with the Great Barrier Reef. This survey was repeated again in 2017 with 4,000 people from the same stakeholder groups. Here, we present the major social and economic changes that have occurred during the four years under study during which two severe back-to-back coral bleaching events occurred, and significant coral reef degradation. Our research predominately looked for signs of 'eco-depression', and other socio-economic impacts, as well as for signs of adaptation to the new regime (such as around wellbeing, levels of environmental satisfaction, stewardship and place attachment). We show how people valued the Reef in 2013 (most highly for its biodiversity and aesthetic values), and then again in 2017 (most highly for its economic values), and discuss changes in terms of both environmental changes as well as changes in social and economic drivers. We discuss these results as insights into how people adapt, and refer to the phenomenon of 'shifting baselines'. The ability to 'shift' our relationship with natural resources suggests that we are adaptable, but we argue that, as we approach critical ecological thresholds, adapting to local conditions may not always be desirable. Given our dependence on natural resources, resisting change events, such as environmental degradation, may be harder than adapting to degradation, and against our natural inclination, but critical for our long term survival.

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### Creating resilience to risk in the ACT

**Timothy JF Sides<sup>1</sup>, Catherine Keirnan<sup>1</sup>**

*1. ACT Government, Dickson, ACT, Australia*

As climate change induces longer droughts, more intense heatwaves, catastrophic bushfire weather days and extreme storms increasing flash flooding, there will be a heightened risk to communities, property and the environment across Australia, the Australian Capital Territory is no exception.

The ACT Climate Change Adaptation Strategy defines short-term actions to reduce the vulnerability of the ACT's communities. By identifying risks to Government buildings, utilities, other infrastructure and delivery of essential services we are managing risks that will ensure the ACT is resilient to the impacts of climate change. Taking a sectoral pathway approach the ACT's "Climate Buddy" works closely with all agencies to identify both residual and emerging risks to assets and services using a traditional risk matrix which identifies the likelihood and consequence of hazards to determine a risk rating.

The hazards (e.g. bushfire, heatwave, severe storm, energy supply emergency and flooding) are self-assessed by agencies, including a risk control effectiveness statement in accordance with the ACT Insurance Authority Risk Matrix. The ACT's innovation of a dedicated "Climate Buddy" to collaborate directly with the key staff across all agencies is successfully:

- increasing awareness and knowledge of projected climate change impacts and consequent risks
- delivering incremental, systems and transformational adaptation actions
- prioritising resources and upgrade of assets and services to increase resilience
- developing a risk dashboard to capture risks and enable information sharing
- reducing vulnerability of communities and assets.

By integrating adaptation and mitigation actions the ACT is empowering resilience to create a sustainable and carbon neutral city.

### Climate aware decision making – getting the right information to the right people at the right time

**Kathleen Beyer<sup>1</sup>, Matthew Riley**

*1. NSW Office of Environment & Heritage, Licombe, NSW, Australia*

It is becoming increasingly important to ensure that decision-makers have access to the best available climate information and that they have the capability and support to use it effectively. The body of literature on the challenges involved with delivering climate services and on approaches to meet those challenges is growing. However, much of the research in this area is provided from the perspective of service providers with fewer examples coming from the receivers of climate services (clients/customers). The NSW Office of Environment and Heritage (OEH) manages around 10% of the NSW landscape and is responsible for managing biodiversity, environmental water, air quality, natural heritage and managing risks from natural hazards. OEH also provides data, information and advice to other NSW Government agencies, local government and communities on climate change risks, impacts and adaptation options. As a provider of and client for climate services, it is paramount that we have a good understanding of our users (internal and external) and their needs. Users require up to date information that is targeted and fit-for-purpose. The NSW Government also requires a consistent approach to climate risk assessments. Our regional climate projections support consistency across state agencies and knowledge brokers ensure that we build the capacity of decision-makers to use climate information more effectively. Here we present our insights into providing climate services and describe the approach we have applied to better understand the type, characteristics and specific needs of users. Our aim is to get the right information to the right people at the right time.

### Climate Resilient Tonga: A case study in capacity building through practical professional development

**Fabian Sack<sup>1</sup>, Langitoto S Helu<sup>2</sup>, Judy Turnbull<sup>1</sup>**

*1. Sustainably Pty Ltd, Dulwich Hill, NSW, Australia*

*2. Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications, Government of the Kingdom of Tonga, Nuku'alofa, Tonga*

Tonga is extremely vulnerable to the adverse effects of climate change and disaster risks because of its geographical, geological and socio-economic features. The Government of Tonga has recognised the need to mainstream climate resilience. Through a grant from the Asian Development Bank the Government commissioned the delivery of innovative training on climate change adaptation and disaster risk reduction for Government staff.

The practical training, accredited by TAFE NSW, was delivered in Tonga over two intensives by a team of Australian expert trainers and an in-country training coordinator. The team encompassed experts from the private, government and university sectors. A comprehensive professional development program covered international institutions, climate projections for the South Pacific, frameworks for climate change

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adaptation & resilience, communications and engagement strategies, approaches to national environmental accounting and emergency management and disaster preparedness. The participants also conducted action-learning projects designed to deliver value to the Tongan Government.

The participants, many with post-graduate qualifications, were drawn from across the Government, representing both frontline and central budget agencies from executive to recent recruits. Evaluation showed that participants found the course effective, clear, relevant and high quality. Participants reported a substantial increase in their knowledge and rise in confidence in applying their skills. The participants have since established a 'community of practice' that will continue to foster capacity across the Government.

The impact of this program demonstrates how well-structured, formal vocational education can consolidate the existing skills of climate change adaptation practitioners and build the resilience of a small island developing state.

### How do smallholder farmers perceive climate variability in Nigeria?

**Adefunke F. O Ayinde<sup>1</sup>, Peter A. Johnston<sup>2</sup>, Olanrewaju O. Olujimi<sup>1</sup>, Purnamita Dasgupta<sup>3</sup>**

1. Federal University of Agriculture, Abeokuta (FUNAAB), P. M. B. 2240, Ogun State, Nigeria, West Africa., Obantoko/Odeda Local Government, OGUN, Nigeria

2. Climate System Analysis Group, Department of Environmental and Geographical Sciences,, University of Cape Town, Cape Town, Western Province, South Africa

3. Environmental and Resource Economics Unit, Institute of Economic Growth,, University of Delhi Enclave,, Delhi, India

This research attempted to understand the perception of respondents to climate variability and also identified adaptation decisions and strategies adopted by them. The survey was carried out on 400 respondents selected through multi-stage sampling procedure starting with two locations; rain-forest zone and derived savannah zones from Ogun and Kwara States respectively. Climatic data spanning 1965 to 2015, were used to corroborate recorded perception of farmers. Some (23.31%) smallholder farmers perceived climate variability as an act of God while 11.28% perceived it as wrath of God and the majority (65.41%) perceived it as the unpredictability of weather elements (especially rainfall and temperature). Some of the adaptation strategies adopted were changing livelihoods; crop processing (58.9%), vegetable production (63.2%); trading (62.2%), asset income (46.2%) and artisanship (58.4%), family members out-migrating to seek higher, steady sources of income and also to study (60.8%), use of weather forecast (55.4%), ridging across the slope (55.9%) and call for adaptable crop varieties (focus group discussion). Also 49.9% and 38.8% of respondents agreed respectively that women and youth were consulted when households take a decision on migration, women had the right to process and keep farm produce for household survival (41.4%) as well as freedom to expand their non-farm economic activities (53.6%). Conclusively, smallholder farmers were aware of climate variability and were able to use adaptation measures to minimise its attendant effects on their farming activities. The study recommended that soft loans should be provided to the farming communities to assist farmers to develop more adaptive capabilities to climate variability.

### Communicating Risk and Building Resilience in the Face of Climate Change

**Rob Gravestocks, Amanda Newbery**

The frequency and intensity of climate change related extreme weather events in Australia are increasing, with the length, extent, severity and impact of current extreme weather events unprecedented in recorded meteorological history. Climate change modelling also identifies this trend will continue, meaning more frequent, larger and longer lasting extreme weather events. In Australia these include heatwaves and sea level rise.

Heatwaves are expected to cause an increase in the number of heat-related illnesses and deaths in Australia, particularly within more 'at risk' sectors of the community including the elderly, the very young, people with a disability, CALD communities, low income households, and those with existing illnesses.

Sea levels on the east coast of Australia are currently predicted to rise by 1m by the end of this century.

Articulous has worked with local government organisations in both Queensland and New South Wales to engage with their local communities to communicate climate change related risk and build resilience with the following goals:

- Raise awareness within the community (particularly 'at risk' groups) of the very real risks that extreme weather event related conditions pose to health, safety and property
- Facilitate behaviour change that practically builds both individual and community level preparedness for climate change related extreme weather events and in doing so reduces their impact on health, safety and property

Articulous Communications is a Brisbane based engagement and communications consultancy and we work across Australia and New Zealand. We specialise in cutting edge and challenging engagement projects.

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### 14. Tools, knowledge and communication: building support for action

#### Which climate projections should I use? The importance of providing guidance material for users in an era of abundant data

**John Clarke<sup>1</sup>, Michael Grose<sup>1</sup>, Marcus Thatcher<sup>1</sup>, Craig Heady<sup>1</sup>, Vanessa Hernaman<sup>1</sup>, Claire Trenham<sup>1</sup>, Tony Rafter<sup>1</sup>, Brenda Lin<sup>2</sup>, Clare Brownridge<sup>3</sup>, Alice Bleby<sup>3</sup>, Tim Erwin<sup>4</sup>**

1. CSIRO Oceans & Atmosphere Flagship, Aspendale, VIC, Australia
2. Climate Risks and Resilience Group, CSIRO Land and Water, Aspendale, VIC, Australia
3. Climate Policy, Dept. of Environment, Land, Water and Planning, Melbourne, VIC, Australia
4. Scientific Applications, CSIRO High Performance Computing, Clayton, VIC, Australia

Climate models are the primary sources of quantitative data for informing detailed impact assessment studies. In Australia however, we're sometimes blessed (or are we cursed?) with multiple sources of projections data – from dynamical and statistical modelling approaches at a range of scales and complexities; and occasionally giving apparently inconsistent results. Consultation with users of projections undertaken by the CSIRO Climate Science Centre and others clearly shows that many people are overwhelmed by choice. Rather than facilitating on-ground actions, this plethora of data is a 'road block' for many people. As a consequence, there is strong demand for clear, easy to follow guidance on 1) how the various projections differ from each other, 2) why they differ, 3) their strengths and weaknesses, and 4) how to know which ones to use.

Here we describe the approach being taken in a current project to develop high-resolution projections for Victoria. In addition to providing tailored datasets and scientific reports, the project is delivering a total projections package that describes the context of the various projections available and gives clear guidance on how to choose the projections that best suit the needs of users.

#### Collaborative Climate Change Adaptation: XDi-informing insights through immersive virtual reality

**Rebecca Cunningham<sup>1</sup>, Karl Mallon<sup>2</sup>**

1. University of Technology Sydney, Sydney, NSW, Australia
2. Climate Risk, Sydney, New South Wales, Australia

Climate change is worsening extreme weather events and their impact on critical infrastructure. This project presents new tools to allow emergency managers and asset engineers to access hazard and vulnerability data within the context of real assets, all using virtual reality (VR). The aim is for a step change in the interface between decision makers and data.

XDi Sydney is a collaborative partnership led by the NSW Office of Environment & Heritage with Transport for NSW, Sydney Water, City of Sydney and Climate Risk, bringing climate science together with infrastructure engineering expertise and financial analysis. XDi Sydney alongside UTS:ISF and Ctl-ALT have created an immersive interactive method to engage with the massive NARCLIM dataset using VR; allowing for deeper insights into collaborative adaptation across infrastructure domains.

#### Rapid climate adaptation plans for Council projects – the Adaptation Guidance Tool

**Duncan Blackburn<sup>1</sup>**

1. Arup, East Melbourne, VICTORIA, Australia

Arup has developed an Excel based tool (the Adaptation Guidance Tool) to help Council staff rapidly complete adaptation plans for new Council projects. The tool is designed to be used within existing Council project proposal processes, and to therefore help embed adaptation thinking into everyday activities. The tool has been set up to be intuitive, easy to use and useful. An overview of the flow of the tool is below:

- The user enters the key project details.
- The user is presented with relevant climate projections, asked to think about the objectives of their project and how these objectives may be impacted based on the presented climate projections.
- The user is presented with a tailored set of pre-defined adaptation actions (depending on the project type initially selected), with the ability to enter additional adaptation actions. The top five actions are then ranked, and further rated against a number of action criteria.
- The final page pulls together a summary of key information collected throughout the completion of the tool. The user is also asked to complete 'next steps' and 'barriers' for the top ranked actions.

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The tool was originally developed for the City of Yarra, and has subsequently been modified for several additional Councils in the Barwon South West region in Victoria. The tool provides value in that it puts climate change risks and adaptation considerations in the forefront of the minds of Council staff when proposing new projects, leading to more resilient communities.

### City Resilience Assessment Melbourne: Enabling cities to measure their capacity to survive and thrive shocks and stresses

**Rob Turk<sup>1</sup>, Maree Grenfell<sup>2</sup>, Julia Gluchowska<sup>1</sup>**

1. Arup, East Melbourne, VIC, Australia

2. Resilient Melbourne Delivery Office, Melbourne, Victoria, Australia

Cities are simultaneously the key contributors to climate change and the most vulnerable to its effects. The challenge in the ability to understand, adapt and transform in the face of climate change lies in the ability of a city to comprehensively understand its interdependencies and vulnerabilities, and how it responds to sudden shocks and chronic stresses. How does a city tangibly and practically identify and measure these factors? How do we develop resilience strategies and plans to prioritise investments in the face of constant change?

In response to this need, Arup and the Rockefeller Foundation, developed the City Resilience Index. The tool provides cities with a comprehensive, accessible, globally applicable and replicable basis for assessing and measuring resilience at a city scale. The tool comprises of 52 resilience indicators, assessed through 156 questions using qualitative and quantitative data.

The Resilient Melbourne Delivery Office is nearing completion of the index for metropolitan Melbourne. Once complete it will represent the first comprehensive resilience assessment of a city in Australia. A key challenge for Melbourne has been providing a resilience diagnosis across its 32 constituent local government areas that form the metropolitan area. A community of practice was established, comprising of government and relevant agency officials, to ensure city-wide ownership and engagement, as well as to provide a robust data validation process. Findings will highlight the interdependent nature of social, environmental and economic vulnerabilities and risks enabling integrated and collaborative adaptation planning.

### Popularising Resilient Building

**Tom Davies, Karl Sullivan**

There is a direct correlation between global mean temperature increase and the number of "Global Loss Events" in insurance terms. Global loss events include geophysical, meteorological, hydrological and climatological events. All but the geophysical events have increased steadily in line with global mean temperature. The insurance industry globally has responded with initiatives to drive a more resilient built environment to limit financial loss and sustain the industry that provides us a method to treat residual risk. The Resilience Program is The Insurance Council of Australia's (ICA's) program of initiatives and tools designed to communicate, inform and incentivise the market to make choices that will deliver a resilient built environment.

Over the course of seven years, the ICA has developed the program with a set of tools available to be used by local governments, home owners/buyers, architects and designers amongst others to plan, design and deliver more resilient buildings. This presentation gives the ICA's perspective on climate change and presents the developed set of tools, including: the ICA DataGlobe; The Building Resilience Rating Tool (v17.2); and the new the Build It portal designed to provide resilience knowledge about products and materials. The Resilience Program is premised on continual and sustained effort to develop knowledge, communicate to the market and ultimately incentivise action through an economic incentive (reduced insurance premiums for resilient buildings). The Resilience Program has been building support for seven years and recognises that resilience is a relatively new concept that requires nurturing into a climate changed future.

### Adaptation to coastal climate hazards: a framework to evaluate and guide local government's urban planning

**Oscar T Metcalfe<sup>1</sup>, Frank Jotzo<sup>1</sup>, Andrew Macintosh<sup>2</sup>**

1. Crawford School of Public Policy, Australian National University, Canberra, Australian Capital Territory, Australia

2. College of Law, Australian National University, Canberra, Australian Capital Territory, Australia

Local governments are planning for coastal adaptation, using different approaches and evolving their planning frameworks over time. Systematic evaluation of local planning for adaptation is crucial to ensure maximum effectiveness but is often lacking in practice. An emerging strand of research seeks to systematically evaluate different approaches, with a view to help guide local planning to be non-maladaptive. This study presents a new multi-criteria framework that synthesises two approaches in the earlier literature on adaptation to SLR induced coastal climate hazards. It evaluates planning documentation of Redland and Lake Macquarie City Councils, two coastal local governments with predominantly urbanised populations on Australia's East coast. Plan quality and capability for non-maladaptive planning is assessed by applying existing multi-criteria analytical frameworks. The results indicate improvements in planning but cannot identify how to improve adaptation planning. A synthetic multi-criteria is developed and applied to Redland City Council. This allows to distinguish which planning elements contributed to non-maladaptive planning and to identify areas for development. The framework is applicable as a non-prescriptive checklist to evaluate and support adaptation to sea-level rise and other climate change impacts in different local contexts. To this extent, it

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may be used to systemically compare and share knowledge across jurisdictions in lieu of a nationally standardised approach, with potential to reduce reliance on external expertise. The paper concludes by highlighting barriers to non-maladaptive planning by local governments with recommendations for improvements.

### Tracking progress on climate change: developing a tool for monitoring and evaluation for local governments

**Susie Moloney<sup>1</sup>, Helen Scott<sup>1</sup>, Fran MacDonald<sup>2</sup>**

1. RMIT University, Melbourne, VICTORIA, Australia

2. Western Alliance for Greenhouse Action, Melbourne, Victoria, Australia

In the post Paris climate policy context, there is an imperative to effectively monitor and evaluate progress across a range of scales in responding to climate change. In particular the focus on how well we are tracking adaptation progress has been identified as a key challenge (Christiansen, L. et al 2016; Ford et al 2015). While this is particularly important for comparing progress across nations in terms of assessing current actions and future needs, this challenge also applies to regional and sub-regional scales where the impacts of climate change are most prevalent. Attention turns to the capacity of local actors, particularly local governments, and their capacity to track progress and improve on climate change adaptation (CCA) planning and action. While many Australian local governments have begun implementing actions, few have identified ways to systematically monitor, evaluate and report (ME&R) on these actions to ensure they are achieving their stated objectives, contributing to successful CCA and avoiding maladaptation. This paper presents a case study of a regional local government climate change alliance in western Melbourne who over three years designed and developed a ME&R framework ('How Well Are We Adapting?') designed as a learning and communication tool for internal and external use. We present the project process, framework and indicators and discuss the challenges and issues involved in developing a 'fit-for-purpose' approach to ME&R for local governments.

1. Christiansen, L. Schaer C. Larsen C. Naswa P. (2016) Monitoring and Evaluation for Climate Change Adaptation, A Summary of the key challenges and emerging practice, UNEP DTU Partnership Working Papers series; Climate Resilient Development Programme, Working Paper 1 [www.UNEPDTU.org](http://www.UNEPDTU.org)
2. Ford J.D., Berrang-Ford L., Biesbroek R., Araos M., Austin S. E., and Lesnikowski, A. (2015) 'Commentary: Adaptation Tracking for a post-2015 climate agreement', *Nature Climate Change*, Vol 5, Nov. 2015.
3. Western Alliance for Greenhouse Action (2017) How Well Are Adapting? Online ME&R tool see <http://adapt.waga.com.au/>

### A tool for incorporating climate change projections of changes in flood event rainfall in eWater Source models (Speed talk)

**Phillip Jordan<sup>1</sup>**

1. Hydrology and Risk Consulting Pty Ltd, Blackburn, VICTORIA, Australia

The eWater Source modelling framework has developed into Australia's national platform for hydrological modelling and water resources management. The Source framework includes rainfall runoff modelling capability to generate flows from gauged and ungauged catchments. All time series data inputs to Source, such as time series of rainfall and potential evapotranspiration, are accommodated via the "Data Sources" and "Input Sets" capabilities within Source.

This paper discusses the development of plugin code to Source, which will take the rainfall data in the base case Input Set and produce a modified copy of the base case Input Set to simulate a climate change projection. The Source model can then be re-run, utilising the rainfall and potential evapotranspiration inputs from the modified Input Set, to simulate projected inflows under climate change. The plugin adopts a relatively simple daily quantile-quantile rescaling approach in order to demonstrate the plugin concept, although more sophisticated algorithms could be incorporated.

GR4H rainfall runoff models were set up in Source to simulate hourly flows from catchments, with a focus on flood events. The application of the plugin will be demonstrated for these example catchments.

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### 15. Climate change and human health

#### Developing a State Adaptation Plan for the Health and Wellbeing sector in Queensland

David Rissik<sup>1</sup>, Fahim Tonmoy<sup>2</sup>, Sue Cooke<sup>3</sup>, Fiona Armstrong<sup>3</sup>, Jyoti Rajan<sup>4</sup>

1. BMTGlobal, Brisbane, QLD, Australia

2. NCCARF, Parklands Drive, Southport, QLD, Australia

3. Climate Change and Health Alliance, Brisbane

4. Queensland Department of Environment and Science, Brisbane

Climate change is contributing to changes in weather patterns, more intense and frequent extreme events such as heat, floods and storms, affecting water, air, food quality and quantity, and impacting ecosystems, livelihoods and infrastructure. All which have an impact on human health, happiness and wellbeing, creating challenges for the health, aged and childcare sectors. These immediate and longer-term impacts require the establishment of policies and plans to build the capacity of the sector to prepare for and better manage these risks.

With Queensland Government funding, we developed a stakeholder driven plan to support the Queensland health sector to be innovative and resilient in managing the climate change risks. The plan establishes key directions for ongoing action by the sector and its members and is aligned with the Queensland Climate Adaptation Strategy.

We present the process we followed to produce the plan, and to ensure ownership by the sector, building on previous work led by CAHA at a national level. We will outline our consultation process, including an on-line survey, workshops and face-to-face meetings. We discuss synergies with other sector plans subordinate to the Queensland Climate Adaptation Strategy. The plan aims to move adaptation forward helping to inspire health, aged care, and childcare boards to act on climate change, identifying the way forward to act on the risks and challenges, and considering how to set the sector up for success in a climate affected future.

We highlight some of the lessons learned during the process, and next steps for implementing outcomes.

#### The impact of sustained hot weather on risk of acute work-related injury in Melbourne, Australia

Judith A McInnes<sup>1</sup>, Ewan M MacFarlane<sup>1</sup>, Malcolm R Sim<sup>1</sup>, Peter Smith<sup>1,2</sup>

1. Monash University, Melbourne, Vic, Australia

2. Institute for Work & Health, Toronto, Canada

**Introduction:** The aim of this study was to quantify the impact of consecutive days of hot weather on risk of work-related injury in Melbourne, Australia.

**Methods:** A case crossover study design was utilised to examine the association between 2 and 3 consecutive days and 2 and 3 consecutive nights of hot weather and risk of work-related injury, using definitions of hot weather ranging from the 60<sup>th</sup> - 95<sup>th</sup> percentiles of daily temperatures for Melbourne, 2002-2012. Workers' compensation data were used to identify cases of injury.

**Results:** Overall, 2 and 3 consecutive days of hot weather was associated with an increased risk of injury. This effect became apparent at 27.6 °C (70<sup>th</sup> percentile). Exposure to three days of hot weather and the highest temperatures was associated with the strongest effect, with a 15% increased risk of injury (OR 1.15, 95% CI 1.01-1.30) for workers exposed to temperatures  $\geq 33.3^{\circ}\text{C}$  (90<sup>th</sup> percentile) for 3 consecutive days, compared to those who were not. At a threshold of 35.5 °C (95<sup>th</sup> percentile), there was no association between temperature and injury for either 2 or 3 consecutive days of heat. No association was observed for hot nights.

**Conclusions:** Significant associations between consecutive days of hot weather and risk of work-related injury were apparent at relatively mild temperatures. These findings suggest warnings to minimise injury risk to workers from hot weather should be given and prevention protocols initiated when consecutive days of temperatures lower than extreme temperatures are forecast and before extreme temperatures are reached.

# Day Two:

## Wednesday 9 May 2

### Climate change and malaria risk in East Africa: Using structural analysis to rank influencing variables and identify suitable adaptation pathways

**Esther Onyango<sup>1</sup>, Oz Sahin<sup>1</sup>, Brendan Mackey<sup>1</sup>**

*1. Griffith University, Brisbane, QLD, Australia*

Approximately 3.3 billion, or half of the world's population, are at risk from malaria and this number is projected to rise under climate change scenarios. While climate change does influence the global distribution of malaria, the spatial extent within regions will be determined by local land use factors and by other non-climatic factors. The latter include biological, social, demographic and cultural factors, along with human behaviour, drug resistance and public health interventions. At a local level, these factors can influence malaria transmission independently or by modifying the effects of climate change therefore, quantifying and understanding the impact of climate change needs consideration of the interactions between these other factors, climate change and malaria transmission. Using East Africa region as a case study, this paper suggests a participatory process of identification and ranking of key variables influencing malaria transmission known as structural analysis. In this process, we used systems thinking, literature review and expert consultations to identify a candidate set of influencing variables, describe the relationships between them and further, rank these identified variables in the order of their influence on the system. From our results we determined that El Niño, average rainfall, malaria vector control, quality of information and agriculture were the five most influential variables of the system. Ranking of variables in order of influence is important in the context of decision-making as it identifies the most effective adaptation pathways for risk reduction.

### Heat's influence on everyday behaviour in outdoor public space and implications for health-supportive cities

**Louise McKenzie<sup>1</sup>**

*1. The University of New South Wales, Sydney, NSW, Australia*

Healthy city initiatives recognise that public space is vital to promoting physical activity, social interaction, and connection with nature. In a warming climate, however, few studies explore the influence of hot weather and heatwaves on everyday public space use and the implications for creating health-supportive cities.

Most studies investigating heat-health impacts focus on mortality reflecting only extremes. Yet, heat also impacts on morbidity and people's ability to be active outdoors. As those most vulnerable to heat include the elderly and those suffering chronic ill-health, increasing levels of chronic disease and ageing populations will increase the health impacts of heat. Few studies have been conducted and little guidance exists for those researching in this domain. For professionals designing and planning public spaces for hot urban environments, practical knowledge is also scant.

This paper presents a cross-disciplinary research design for exploring the influence of heat on everyday behaviour in real-life outdoor public spaces. Founded on landscape architectural practice and theory, methods draw from built environment, ethnography, public health and urban climatology disciplines. The case study metropolitan park and neighbourhood, located in Western Sydney, are examined through contextual analyses, fieldwork (meteorological measurements, behavioural mapping and infrared photography), and conduction of a focus group. Results provide essential practitioner knowledge for heat-related behavioural shifts, comfort choice and microclimatic design, and priorities to assist older people and disadvantaged communities adapt to warming climates. This paper is part of a doctoral study undertaken at the Faculty of the Built Environment UNSW, completed in 2017.

### Hume Heatwave Help - simple home retrofits for vulnerable residents

**Michelle Bennett<sup>1</sup>**

*1. Hume City Council, Broadmeadows, VIC, Australia*

Research suggests that in Melbourne, cheap home retrofits can reduce the risks of severe health impacts in low income households by 25% (NCCARF/ CSIRO, 2013). Hume Heatwave Help is a simple and practical response to improve the heat wave resilience of vulnerable residents. With funding from the Victorian Government, Hume City Council delivered the inaugural Hume Heatwave Help project in 2014 to just over 100 Home Care Clients, targeting those considered most vulnerable to heatwaves.

An in-home assessment was conducted which included a consent form, provision of a heatwave kit and an assessment/discussion re which retrofit products could be provided and installed. The retrofits included draught sealing, external blinds, light globe upgrades and provision of quality fans as a low cost, efficient cooling option. Ceiling insulation was also checked and supplied for 11 homes with no or inadequate insulation.

A pre-retrofit and a post-summer survey was conducted with participants: 93% were either 'very satisfied' or 'satisfied' with the project; 64% felt that they were better able to manage during heatwaves. The project resulted in other benefits including improved home comfort in winter, an increase in awareness of safe behaviours and support, and contributed to the management of energy bills. There are also tangible but unquantifiable health, well-being and satisfaction benefits for participants.

The project has continued to be delivered by Hume City Council since the initial year of funding. Learnings from the project and the opportunities and barriers for home retrofits will be discussed.

# Day Three:

## Tuesday 8 May 2018

## 16. Drought and water management

### Remembering the future; using the Millennium drought for adaptation planning in South Australian agriculture

**Peter T Hayman<sup>1</sup>, Dane S Thomas<sup>1</sup>**

*1. SARDI, Adelaide, SA, Australia*

Droughts have been described as creeping catastrophes and the Millennium drought (2002-2009) had major, but different impacts on dryland grain production, irrigated wine grapes and the emerging industry of irrigated almonds. This drought was referred to as the first irrigated drought. Prior to this drought, perennial horticulture in South Australia on high security water was seen as drought-proof. These three industries have different histories and a range of non-climate factors that buffered or exacerbated the impact of the drought. For example the wine grape industry was affected by high exchange rates, a world over supply of grapes and the Global Financial Crisis.

The timing of the Millennium drought coincided with increased awareness and media attention to climate change both internationally and nationally. In this paper we analyse the Millennium Drought through agro-climate indices (growing degree days, heatwaves, frost, growing season rainfall) and the cropping system model APSIM. The purpose of this analysis is to understand how the drought compared to the historical record and how it compares with future projections.

We complement the climate analysis with a summary of key findings from a series of focus groups and in-depth interviews on participants' lived experience of the drought. These discussions drew out what was learnt about vulnerability, adaptation and resilience. We address some of the strengths and drawbacks of using a temporal analogue such as a drought as a basis for adapting irrigated and rainfed agriculture to future climates.

### Sub-alpine irrigated agriculture: adaptation insights for the Upper Murray River basin, Australia

**Edward Cornwell, Victor Sposito, Robert Faggian**

Cropping is nowadays changing because of unfolding global warming, compromising our ability to maintain sustainable development in rural areas. In spite of recent agricultural suitability findings across Australia, it has not been broadly addressed for mountain-valley systems. For these particular environments, Irrigation Potential is mainly shaped by natural water storage (snowpack) and human-induced transformations over the land cover type (cropping). In this research, key outcomes are obtained from hydrological modelling over the Upper Murray River basin (Australian Alps) in relation to the available streamflow for Pastures and Winter Wheat irrigation requirements. Considerable changes are estimated to occur during 2085-2100 in total streamflow (-60%, RCP8.5) and irrigation (average +35%, RCP2.6) with uncertainties reaching  $\pm 35\%$  and  $\pm 25\%$  respectively. Also, Pasture and Winter Wheat full-extended irrigation are affected by different mechanisms, both requiring full water storage capacity by 2050 (deficit around -13%) and extra water sources by 2100 (deficit around -158%). Water availability and requirement distribution along the elevation gradient is evaluated in order to suggest transformational and incremental adaptation measures. The latter is relevant due to the importance of this headwater basin for the rural development in the region and the Murray-Darling basin.

### Experience at the local scale in the Aconcagua Valley for evaluating adaptation to drought in a changing climate

**Paulina Aldunce<sup>1</sup>**

*1. University of Chile, Santiago, REGIÓN METROPOLITANA, Chile*

Since 2010, a severe drought has affected central Chile, resulting in losses that prompt the need to evaluate and improve adaptation responses. The evaluation process requires the engagement of multiple actors in order to collect knowledge of their experiences and to inform future design and implementation of adaptation responses. A case study was conducted in four counties of the Aconcagua Valley, Chile, to evaluate the usefulness of existing drought response measures, and to identify strengths and weaknesses, and relevant actors' recommendations for overcoming them. We applied the Index for the Usefulness of Adaptation Practices (IUPA), a multi-criteria tool that systematically identifies the perceived usefulness of measures. The most salient strengths of the evaluated measures were: replicability, pertinence, and efficacy; representing key factors that could facilitate the implementation of drought responses in similar contexts. The most salient weaknesses were: lack of integration with other policy domains and projects, low environmental protection, diminished autonomy in decision-making, and inequity. Proposed recommendations to overcome these weaknesses have real potential for implementation because they emerged from local actors. Results present empirical evidence of the utility of participatory approaches for a context-specific evaluation of measures, contributing to enhance adaptation to climate variability and change.

# Day Three:

## Tuesday 8 May 2018

### Adapting to Changing Climate, Environments and Regulations: Hetao Basin, Yellow River, Inner Mongolia

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Hetao Basin, Yellow River, Inner Mongolia encompasses one of China's three largest irrigation areas. Annual temperatures have increased over 60 years. Precipitation around the Basin and pan evaporation within show mixed trends. Irrigation extractions average 4.7 km<sup>3</sup>/year with 60% losses from canals. Upstream diversions and growing downstream demands resulted in a mandated 15% reduction in water supply to Hetao. Almost 3 million tonnes/year of salt have accumulated in groundwater and soils of the Basin, mostly from evaporated irrigation. Deposition of salt varies spatially but has increased average salinity of groundwater by 0.43 kg/m<sup>3</sup> per decade over 30 years. Over 30% of irrigation is used to flush salt from top soils. If unchecked, salinity will limit food production in the Basin within 100 years and may require increased flushing volumes. Farmers in the Basin face significant adaptation challenges: increasing temperatures and salinity; decreasing water supplies; imperatives to maintain plant production; limited incentives; and no economies of scale. The 19<sup>th</sup> Peoples' Congress, in October 2017, outlined new policies with potential to improve adaptation. These included: rural revival through land reforms and development of economies of scale; inter-regional coordinated development; and institutional reforms of property rights allowing market forces a greater role in production. Some evidence of adaptation is seen already in agglomeration of farms, permitting introduction of water saving technology and improved irrigation and drainage infrastructure, conjunctive surface and groundwater use, changing cropping patterns, irrigation schedules and crop-types. Full implications of these new policies remain to be appreciated, but seem far-reaching.

### Testing three different hydrological models under non-stationary climate conditions – two case studies from southeast Australia

Proloy Deb, Anthony Kiem

Robust hydrological models are essential for informing sustainable water resources management. However, there is a shortage of studies investigating the reliability of different hydrological models in catchments where climate-related non-stationarity exists. Therefore, this study compares three different hydrological models (i.e. IHACRES (lumped model), HEC-HMS (semi-distributed) and SWATgrid (fully distributed)) for their suitability to simulate flows under different climate conditions. The hydrological model testing was conducted in two case study catchments in southeast Australia, one with an area of 122.16 km<sup>2</sup> and the other 1061.10 km<sup>2</sup>. The three hydrological models were automatically calibrated for an average epoch (normal rainfall) and validated for the dry epoch (below normal rainfall) and vice versa for both study catchments. For the smaller catchment, all three models perform satisfactorily for the calibration periods (NSE > 0.65, PBIAS ≤ |25|), but only SWATgrid performs satisfactorily for both validation periods. For the larger catchment, IHACRES and HEC-HMS do not perform satisfactorily in the calibration or validation periods and SWATgrid only performs satisfactorily for the calibration periods (NSE = 0.96, PBIAS = -11.80% for calibration in the average epoch and NSE = 0.84, PBIAS = 18.80% for validation in the dry epoch). These results highlight that both IHACRES and HEC-HMS are not suitable for runoff simulation under climate-related non-stationarity and that the ability of SWATgrid to realistically simulate climate-related non-stationarity is limited to smaller catchments.

### Practices in Climate Adaptation to Extreme Droughts in the Mekong Delta

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In recent years, extreme droughts appeared to happen more frequently in the Mekong basin. The 2010 drought in China and the 2016 drought in the Lower Mekong basin's countries caused widespread damage to the regional economy and disruption to livelihood of millions of people. Understanding the climate 'new normal' and its impacts, and promoting appropriate adaptation strategies and practices to enhance the local resilience are urgently needed. This is the objective of current collaborative R&D between CSIRO Australia, Chinese Academy of Sciences, and Can Tho University Vietnam, allowing an integrated and legitimate approach for a whole basin consideration.

As part of the project, an exploring study in the Vietnamese Mekong Delta was conducted through group discussion with local governments and farmers to understand the impact of and their response to the drought in 2016. The study was undertaken in three coastal communities that were most affected by salinity intrusion and water scarcity during the drought, focusing on effectiveness of local governance systems. It was found that there were strong needs to improve early-warning information systems, and to improve the flows of information within various governmental agencies and farmers for timely responses. The drought however provided a positive impetus to the locals, initiating various innovative transformations in agriculture and aquaculture production, and a long-term thinking in land and water resource management in a regional context. Innovative and locally-suitable information technologies were therefore identified as a key solution option for improvement of the governance systems and adoption of the adaptation practices.

# Day Three:

## Tuesday 8 May 2018

### Assessing groundwater responses to climate change in the context of water supply catchment management (Speed talk)

**Tony Cauchi, Sarah Gaskill, Timothy R Anderson<sup>1</sup>**

*1. GHD, Melbourne, VIC, Australia*

#### INTRODUCTION

Changes in future climate within Melbourne Water's protected water catchments have the potential to affect the water balance of surface water and groundwater systems, primarily through altering the dynamics of rainfall, runoff and evapotranspiration in a surface water system, as well as recharge and evapotranspiration in a groundwater system.

These altered conditions have the potential to impact water use of the forests for decades, resulting in potential changes to catchment yield, water quality and water security. This case study highlights risks, indicators and monitoring approaches that may be useful in assessing changes to water resources, specifically groundwater, in a water supply catchment setting.

This project aims to improve the understanding of existing water balances, based on two conceptually different subcatchment areas, so that potential future changes resulting from bushfires and climate change can be identified.

#### METHODOLOGY

The first task was to develop conceptual models to identify data gaps and highlight key catchment issues to groundwater, reliant ecosystems, water availability and quality. The identified risks relate to the impacts of climate change and bushfire on the harvesting capacity, water quality and environmental health of the catchment. Groundwater and surface water monitoring networks were developed to improve the understanding of the role that groundwater plays on the harvesting capacity and health of the system, and to understand the impact of identified risks. Long term data monitoring would assist in supporting future technical studies and improve the understanding of environmental stressors, particularly those that may be driven by climatic changes.

## 17. Climate inspired innovation & entrepreneurship: from challenge to opportunity

### Forced innovation: Small business preparedness and response to natural disasters

**Samantha A Sharpe<sup>1</sup>, Candice Delaney<sup>1</sup>**

*1. University of Technology Sydney, Broadway, NSW, Australia*

The impact of natural disasters and extreme climate events, such as bushfires, floods and droughts, can be devastating and disruptive to economic activity. For small and medium sized businesses, the results can include business closures, loss of skilled employees and decline and delay in investment in business assets and innovative activities. Much of the empirical research on business recovery post natural disasters has focused on how businesses return to business-as-usual and the costs and timing of this process. However, the innovation capacity and processes of firms, both individually and collectively, as a business community are critical precursors for preparedness and a key ingredient in recovering from natural disasters, and developing future resilience.

This paper details two case studies of business preparedness, impacts and response to natural disasters (bush fires and floods). The case studies highlight the activities of businesses and business organisations, before and after the natural disaster events, and reflects on how individual businesses and the business community changed in response to the event, and the role of innovation and innovations processes in these responses.

Business and economic resilience planning for natural disasters are not done with the same emphasis as community, or infrastructure recovery, even though the business community is pivotal to post disaster recovery. The paper concludes with recommendations for planning for business and economic recovery in natural disaster-prone areas. This type of planning will be of increasing importance into the future as climate change increases the severity and frequency of extreme weather events and natural disasters.

# Day Three:

## Tuesday 8 May 2018

### Transferring advanced soil data analytic techniques to real-world applications to increase the adaptive capacity of farmers in a changing climate

Senani Karunaratne, Fahim Tonmoy, Melaka Gunasekara, David Rissik, Joseph Canning

The emergence of big data, cloud computing and unmanned aerial vehicles (UAV) brings immense opportunities to the agricultural sector, supporting climate-smart decision making, and in turn, driving more cost-effective farming practices. Soil scientists are leveraging these developments and building complex statistical and mathematical models to solve current and emerging issues in agriculture such as optimising the use of fertilisers and water. Over the past few decades, these techniques have been widely used in applied soil science disciplines such as pedometrics, digital soil mapping, proximal soil sensing, and have resulted in a continual increase of academic scientific publications. However, the dissemination of these advanced techniques to real-world users such as landowners/growers, agronomist has been limited.

In this paper, we present a pragmatic start-up project which aims to increase the availability of these new advanced techniques for the practical benefit of the real-world users. We use UAV, advanced data analytics techniques and cloud computing to create agricultural decision support products, and deliver them to end users through a web-based dashboard which is easy to use and understand, and does not need any prior GIS or data science knowledge. To enable this, we use an open source R statistical development environment and add-on packages, and RShiny dashboards. Providing access to these products with clear guidance on decision-making to on-ground farmers at a reasonable cost can enable them to optimise their on farm resource utilization which in turn will increase their adaptive capacity to make smart and economic decisions in a changing climate.

### Adaptive Coastal Defence Works

R J Cox<sup>1</sup>, Angus Gordon<sup>2</sup>

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Ideally development should be moved back from the fluctuation zones of beaches and dunes and beyond harms way from both present and future climate and sea level impacts. The political, economic and social reality is however that, where development is sufficiently intense, albeit not wisely located, defence works will be required both now but also into the future as more and more development comes under threat. Planning can seek to ensure future development is adequately set back and adaptable but the reality is that defence works will be required in some locations and these will need to be adaptive. Defence works can include breakwaters, concrete or rock seawalls, sloping revetments, dunes and beach nourishment programs. Most of such works are currently designed for existing conditions with, at best, limited consideration for ensuring the works can be adapted to an uncertain future climate and sea level.

The authors have nearly 50 years each of experience in designing, testing, building and monitoring coastal defence works and have, in more recent times given considerable thought as to the realities and pitfalls of current design practices in regard to coastal works. The paper will identify the types of works most suitable for adaptation and the considerations that must be included in the design of adaptive works. The paper will also discuss how some of the currently favoured types of defence works are unlikely to prove practical to adaptation.

### Business and Industry - Breaking Down the Barriers to Climate Adaptation

Greg Fisk<sup>1</sup>, David Rissik<sup>1</sup>

1. BMT, Spring Hill, QLD, Australia

With substantial resources about climate change such as NCCARF's 'CoastAdapt' being made freely available, there has never been a better time for private sector organisations to investigate and understand the risks they face from climate change and extreme weather events and to start onto a pathway toward adaptation.

Despite this, the social and economic barriers to climate change adaptation within the private sector remain strong; and are indeed growing stronger in some quarters. The emerging requirement for shareholder organisations to disclose information and report on climate risk and adaptation activities to investors as recommended in the 2017 Report by the Task Force on Climate-related Financial Disclosures (TCFD) may serve to weaken some these barriers. With similar demands on reporting on carbon emissions associated with business practices, there is also an intersection between carbon and adaptation disclosure that is useful to consider.

We provide an overview of the key and persistent barriers to private sector organisations taking on climate change adaptation initiatives, the dimensions and implications of the new reporting regime recommended by the TCFD, and some practical advice for organisations taking their tentative first steps into an uncertain climate future.

Insight is provided from experiences of the authors in undertaking adaptation studies including case studies with private sector organisations as part of the development of 'CoastAdapt' by NCCARF in 2017, as well as discussions with a broad range of individuals across industry sectors including agriculture, financial institutions, small business, transport infrastructure and health professionals about climate change adaptation.

# Day Three:

## Tuesday 8 May 2018

### Economics of system transitions in NSW Riverina Murray

Suzanne Dunford<sup>1</sup>, Mladen Kovac<sup>2</sup>, Rogelio Perez<sup>2</sup>, Brent Jacobs<sup>3</sup>, Melinda Hillery<sup>2</sup>

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Climate change in combination with other drivers (economic, technological, demographic etc.) will likely result in unplanned transformation of social-ecological systems resulting in chaotic transitions that lead to unpredictable new system configurations. Nelson et al (2011) argues that economists need to re-examine the economic nature of climate change adaptation as a public policy agenda because persistent market failures systematically work against precautionary adaptation.

This project has examined the regional change models developed through the Western Enabling Regional Adaptation process in NSW to identify transitions constrained by market failure, the opportunities for government intervention to catalyse market transformations and the value to regional economies of interventions to promote early adaptation. The project has focussed on the Riverina-Murray as a case study region because:

- The region's economy is heavily natural resource dependent (dry land agriculture, irrigation, river tourism) and supports NSW's largest inland city;
- The Riverina is projected to suffer significant impacts from future climate change (a drying rainfall regime and increasing temperatures);
- While currently healthy, the Riverina-Murray was severely affected by the Millennium drought, which provides a useful case for comparative analysis of system transformation.

If adaptation policy can identify market failures it will support anticipatory adaptation outcomes, and potentially reduce financial, efficiency and productivity losses.

## 18. Sustainable Development Goals: Adaptation options for sustainability

### State and Benefit: Climate Change Adaptation Reporting in Victoria

Scott Rawlings<sup>1</sup>

1. Commissioner for Environmental Sustainability, Melbourne, VICTORIA, Australia

The Office of the Commissioner for Environmental Sustainability (Victoria) provides independent advice and reports on the state of the natural environment to inform environmental policy and practice in Victoria.

Reporting on climate change impacts and mitigation at different scales is reasonably well established, but developing indicators on reporting on climate change adaptation is still an emerging field. It is further complicated by the diversity of data required, from biophysical (e.g. phenological data) to the socio-economic data required to report on social adaptation to a changing climate.

- The Commissioner's State and Benefit framework was tabled in the Victorian Parliament in December 2015. The Framework authorises the reform of environmental reporting in Victoria and advocates for:
  - digital technologies
  - citizen science
  - environmental-economic accounts
  - alignment of statutory environmental reporting obligations
  - alignment with the reporting requirements of the UN's Sustainable Development Goals, and
  - a shift towards management effectiveness reporting.

The framework also places Victoria in the broader context of international environmental reporting trends and demonstrates that a key strategy of environmental reporting should be negotiating the important shift from what we do know, to what we need to know.

Finally, consideration is given to what a *State of Climate Change Adaptation* report for Victoria would achieve, using the *State of the Bays* report as an example. Released in multiple formats in December 2016, the *State of the Bays* reporting products enabled accessibility for a much broader audience than ever before. Action on the recommendations from this report are underway within government.

# Day Three:

## Tuesday 8 May 2018

### Analysing thresholds in social risk perception to inform adaptation policy: the example of bushfire management

Douglas K Bardsley, Emily Moskwa, Delene Weber, Guy M Robinson, Nicolette Waschl, Annette M Bardsley

Drawing from theoretical arguments on the importance of social thresholds for guiding effective adaptation decision-making, we present a recent study on how residents' perceptions of climate change relate to understandings of bushfire risk and biodiversity conservation, and how those perceptions translate into personal actions and/or support for policy. Three groups emerged from the analysis of responses from homeowners on the peri-urban fringe of Adelaide and Port Lincoln (N = 988, 30% response rate). Group 1 respondents are aware that climate change increases bushfire risk and are updating their plans and actions. Group 2 are aware of the implications of climate change for bushfire risk, but this urban, younger, less-informed, middle-income cohort, are less likely to be changing their plans or preparing their properties. A third group do not recognise that climate change is increasing bushfire risk, yet are already willing to sacrifice local ecological values to mitigate risk. While a risk perception threshold has not been crossed - where the majority would argue for policy that mitigates risk at the expense of local biodiversity - the lack of action by Group 2 suggests that a potential threshold could exist associated with their willingness to rely on management approaches by the Country Fire Service and the South Australian government. Changes in risk perceptions could lead to demands for government interventions that do not consider all of the implications of a decision. Such knowledge of potential surprises to policy, will be valuable for guiding sustainable climate change adaptation in the long term.

1. Bardsley D.K., Moskwa E., Weber D., Robinson G.M., Waschl N. and Bardsley A.M. (In Press) Climate change, bushfire risk and environmental values: examining a potential risk perception threshold in peri-urban South Australia. *Society & Natural Resources*, forthcoming.

### Embedding ecosystem-based approaches to climate change adaptation and disaster risk reduction in law and policy? Stories from the coast and the floodplain

Anita Foerster<sup>1</sup>, Lee Godden<sup>1</sup>

1. University of Melbourne, Carlton, VIC, Australia

This paper explores the value of an ecosystem-based model for climate adaptation and disaster risk reduction law and policy, by canvassing available international examples and comparing Australian approaches to this model. While legal and policy frameworks for adaptation planning and climate disaster management are developing; there is a tendency to prioritise shorter term, infrastructure solutions, rather than taking a longer term and broad view of the complexities and links between human and ecological elements of various systems. An ecosystem-based approach to adaptation and disaster risk reduction recognises that environmental degradation and poor natural resource management can exacerbate the physical and socio-economic impacts of many hazards and decrease the ability of communities to cope in the aftermath. The flipside is that protecting natural systems can mitigate the disruptions accompanying natural hazards and support adaptation and recovery following an event. For example, maintaining vegetation cover in riparian zones and preserving natural floodplains can minimise flood risks substantially. Using the ecosystem model as a standard, the paper assesses the emerging legal and policy frameworks in Australia for addressing two particular climate hazards - coastal erosion and fluvial flooding - and asks what needs to change in the legal and policy context to facilitate a longer term, more holistic, ecosystem-based approach to adaptation going forward. The authors seek to identify transferable lessons for applying this model in other hazard contexts and in other countries.

### Assessment of climate change vulnerability and local adaptation strategies of transhumant communities in the Himalayas

Suman Aryal

Transhumance is a social-ecological systems (SESs) based on seasonal and recurring movement of livestock. Traditional SESs such as transhumance are threatened by different factors globally. In the Himalayas, transhumance systems are constrained by globalisation, agricultural intensification, rangeland privatisation or nationalisation and introduction of national parks and community forestry policies and practices. There are indications that the grazing based livestock production systems including transhumance are most sensitive to climate change. Climate models have also predicted pronounced warming and changes in precipitation pattern in the Himalayas. However, there is no or limited information about the impacts of climate change to the transhumance system and its vulnerability. Therefore, this study assessed the vulnerability of transhumant communities and their local adaptation strategies. A total of 145 transhumant herders were interviewed and 6 focus groups were conducted which were accompanied by participatory observation in three different high altitude areas of Nepal Himalayas. The study revealed that the transhumant communities are vulnerable to climate change but their vulnerability differs across sites for different reasons. A numbers of local strategies of transhumant communities were identified and are grouped within the broad adaptation (mobility, diversification, storage and communal pooling) which are important for better adaptation of transhumant communities to climate change. The findings of the study are useful in designing adaptation policies and practices, and for the enhanced sustainability of traditional SESs.

**Key words:** Adaptation, Climate change, Himalayas, Transhumance, Vulnerability

# Day Three:

## Tuesday 8 May 2018

### 19. Tools, knowledge and communication: building support for action

#### **Marae-opoly: A climate change adaptation game to enable collective decision making regarding the location of indigenous Māori meeting spaces in Aotearoa-New Zealand.**

**Paula Blackett<sup>1</sup>, Jackie Colliar<sup>1</sup>, Tania Hopmans<sup>2</sup>**

*1. NIWA, Hamilton, WAIKATO/NEW ZEALAND, New Zealand*

*2. Maungaharuru-Tangitū Trust, Napier, New Zealand*

The impacts of climate change will affect indigenous Māori land and marae (meeting space and associated buildings), especially if they are situated near the coast or on flood plains. Simply waiting and reacting to an event puts important cultural assets and land at risk. The people of Tangoio Marae, near Napier, had the foresight to discuss the current flood hazard risk that their marae is exposed to, and confront the potential exacerbation of flood risk due to a changing climate. To aid this discussion, we designed a serious game informed by the goals and aspiration of the people for their marae, the local flood risk and the potential future extent and impact of the hazard based on multiple possible futures, estimated financial resources, and the range of adaptation options and their estimated costs. Played in small groups, the paper-based game facilitated the construction and testing of adaptation pathways over a 100-year timeframe. During the game a “rain-maker” generated floods and presented numerous opportunities for groups to reflect on their decisions and adjust their strategy, provided they had the available cash flow. We will overview key elements of the game and evaluate its success as a learning and planning device.

#### **The Learnings Project – What we learnt from the four pilot Local Coastal Hazard Assessments in Victoria.**

**Rebecca Price, Ross Martin, Robert Dimsey**

The assessment of coastal hazards is a first step towards improving our ability to plan, manage and prepare for the impacts of these hazards now and in the future. A coastal hazard assessment will increase our understanding of coastal processes and potential hazards.

Between 2011 and 2016 the Victorian government’s Future Coasts Program delivered four pilot Local Coastal Hazard Assessments (LCHA). The program aimed to increase awareness and build capacity of coastal land managers to assess and understand the relationship between climate change impacts and coastal hazards. It included developing and testing coastal hazard assessment methodologies for representative coastal landform systems and developing datasets to inform improved and more consistent coastal planning and management practices.

The Learnings Project is an evaluation of the learnings from these four pilot Local Coastal Hazard Assessment studies. It included distilling the learnings and evaluating how well the pilots met the project aims. The three components of the pilot studies that were evaluated are:

1. The technical methodologies used;
2. project management and governance approaches; and
3. the engagement strategies and methods used.

We will present on the methods used to evaluate the pilots, and the results of the evaluations. We will also elaborate on how Victoria is using these learnings to better adapt to current and future coastal hazards.

#### **“Critical Friends” of a New Zealand Coastal Hazard Strategy development: The value-add of researchers**

**Judy Lawrence, Stephen Daysh, Emma Ryan, Rob Bell, Paula Blackett, Graeme Hansen, Simon Bendall**

Adaptation to climate change impacts, such as those at the coast, is beset with governance, institutional and behavioural barriers. After decades of coastal engineering, hazard assessments and piecemeal ‘protection’ from coastal erosion, inundation and flooding by three coastal councils in Hawke’s Bay, New Zealand, the councils united in 2014 in a joint and collaborative effort to develop a Coastal Hazards Strategy for Hawke’s Bay. Three key aspects ensured this coastal management initiative would be different to past efforts: 1) a joint governance framework; 2) the inclusion of community throughout the process; and 3) the contribution of researchers acting as ‘critical friends’ of the Strategy.

We focus on the roles played by the research ‘critical friends’ as a process and knowledge broker, content evaluator, and generator of new knowledge, which was guided by new national coastal hazards and climate change guidance. We discuss the value that the researchers added in these roles to the Strategy process and outcomes. Several lessons were learned with wider currency for similar processes as new national coastal guidance rolls out—the importance of problem framing and clarity of objectives; the value of independent knowledge across many fields (coastal hazard and risk assessment, social vulnerability, governance, planning); and the importance of observation and evaluation throughout the Strategy development process.

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### Normalising Adaptation: a Theory of Change

Rachel D Williams<sup>1</sup>, Alistair Hobday<sup>2</sup>, Rachael Alderman<sup>3</sup>

1. CSIRO, Canberra, ACT, Australia

2. CSIRO, Hobart, Tasmania

3. DPIPW, Hobart, Tasmania

Intervention against threats to species is not new. However, conservation responses to climate change are typically monitoring and preserve-and-protect options. We discuss a case study in which we worked with a conservation agency to test the utility of adaptation concepts for them, co-developed and tested adaptation pathways approaches for iconic species populations under climate change and generated insights into how to enable adaptation. Developing a Theory of Change was a central activity in the project. It enabled the notion of adaptation to be extended beyond sequencing species intervention options for enhancing species viability under climate change to identifying options for changing the decision context for iconic species conservation, ie enabling changes in the prevailing knowledge, values and rules.

### Practical challenges to delivery of application ready climate projections for adaptation to extreme events in Queensland

Jozef Syktus, Ramona Dalla Pozza, Ralph Trancoso, David Putland

Queensland has highly variable and changing climate and is frequently impacted by extreme events such as droughts, floods, tropical cyclones and severe storms. As a result Queensland is facing significant challenges in preparing and adapting to a changing climate. The Queensland Climate Adaptation Strategy (<https://www.qld.gov.au/environment/climate/adapting>) provides a framework for ensuring an innovative and resilient Queensland that manages the risks and harnesses the opportunities of a changing climate. The Department of Environment and Science has released regional summaries (<https://www.qld.gov.au/environment/climate/resources>) and Climate Change in Queensland map application (<https://longpaddock.qld.gov.au/climate-adaptation/climate-change-queensland/>) based on the climate change projections used for the most recent IPCC assessment report. Climate change projections are shown for 13 regions of Queensland at 2030, 2050 and 2070 for both lower (RCP4.5) and high (RCP8.5) emissions. More recently, the Department of Environment and Science has completed and released a set of high-resolution climate change projections based on dynamically downscaled modelling of selected CIMIP5 global models (<http://portal.tern.org.au/high-resolution-climateprojection-queensland-20692/20692>). This high-resolution (~10 km) projection data was used to derive regionally specific information about projected changes in heat waves, extreme climate indices such as hot and cold days and nights, rainfall extremes, consecutive warm and dry days and SPI drought index. Application-ready bias-corrected high-resolution data for biophysical modelling was also released (<https://www.longpaddock.qld.gov.au/climateprojections/about.html>). This talk will describe our experience and challenges delivering regionally specific information for climate change impact assessment and case-specific risk assessment. It will also highlight the need for dialogue and engagement between climate scientists and climate adaptation practitioners to enable meaningful and practical decisions to be made using climate change projections.

### Unharmmed – a tool for pro-active climate risk assessment and adaptation planning (Speed talk)

Graeme Riddell<sup>1</sup>

1. The University of Adelaide, Adelaide, SA, Australia

This talk will introduce UNHARMED, a tool designed to assist governments and industries understand and plan for the long-term physical risks of climate change and test different adaptation measures. The tool models how cities and regions grow to meet population and economic needs and how these changes interact with different climate risks such as coastal and riverine flooding, and bushfires. Adaptation measures can then be implemented and assessed across consistent metrics such as cost-benefit-assessment, and number of properties impacted to develop effective adaptation plans.

## 20. Cities and infrastructure: planning for liveability under climate change

### Facilitating Climate Change Adaptation in the Australian Construction Industry – Identification of Information Sources and Needs

Anna Hurlimann<sup>1</sup>, Valerie Francis<sup>1</sup>, Georgia Warren-Myers<sup>1</sup>, Geoff Browne<sup>1</sup>

1. The University of Melbourne, Parkville, VIC, Australia

The construction industry creates a significant proportion of global greenhouse gas emissions (IPCC 2014). Hence it is in a unique position to facilitate both mitigation and adaptation to climate changes through the way in which built form in cities is constructed. Yet, there has been limited research to explore the capacity of the sector to both mitigate and adapt. In particular there is a lack of information available about the sources of information drawn upon by those working in the construction industry, the sources of information most trusted, and information needs. The paper addresses this knowledge gap through a qualitative study of the capacity of the Australian construction sector to adapt to climate change. Twenty one key actors from the Australian construction sector (sustainability managers and construction managers) were interviewed in 2017. Results of the qualitative analysis identify that less than half of the respondents indicated they kept abreast of climate change developments. A diversity of climate change information sources were drawn upon ranging from client or government sources, to material sourced from online content. The CSIRO was most frequently cited as a trusted source of information, despite few respondents indicating this is where they source information. Three types of climate change information useful to participants were identified: 1) information that created certainty about future weather conditions, 2) information that created certainty about legislation, regulations and codes, and 3) information about emerging trends and projects. Results are discussed in detail, including implications for the Australian built environment professions.

### Beyond compliance building standards for resilient and liveable housing stock in a climate changed future

Tom Davies<sup>1</sup>, Maisie Auld<sup>1</sup>, Karl Sullivan<sup>2</sup>

1. Edge Environment - MANLY, NSW, MANLY, NEW SOUTH WALES, Australia

2. Insurance Council of Australia, Sydney

Extreme weather is likely to increase in frequency and severity under future climate scenarios (IPCC, 2014), increasing the risk of damage and financial loss to residential properties. Historic land-use planning decisions and current building controls continue to shape a built environment that is brittle in the face of the changing climate. The Insurance Council of Australia (ICA) engaged Edge to develop a best practice, voluntary construction and design standard for resilient homes. The purpose of the proposed standard is to influence and progress best practice and/or beyond compliance resilient building design and construction for residential development in hazard-prone areas (flood, storm, bushfire and cyclone). The foundation of this work is seven years of development of knowledge and tools to catalyse a market-based response to resilient built environments through resilience mapping, hazard data disclosure and improved planning. Australian planning frameworks and development controls were reviewed with a focus on Councils that have experienced significant natural hazard events, as identified in the ICA's Catastrophe Database. We found substantial discrepancies in the guidance provided for constructing homes in hazard-prone areas. The primary aim of current guidance is to assure health, safety, amenity and sustainability rather than focussing on limiting damage and financial loss, potentially making homes unliveable into the future. The proposed voluntary standard includes resilience as a principle. It is intended to compliment and support existing frameworks and the delivery of a built form that is equally resilient as it is healthy, safe and amenable for liveable cities of the future.

1. IPCC, 2014. Climate Change 2014: Synthesis Report. Intergovernmental Panel on Climate Change, Geneva, Switzerland, 151 pp.

### Achieving Thermal Resilience of Multi-Residential Buildings During Heat-Wave Power Outages through High-Performance Building Envelope Standards

David Ritter

On 8 February 2017, over 90,000 households in Adelaide lost power for 45 minutes in the middle of a major heatwave. More recently during the extreme heat and humidity of the weekend 27th/28th January 2018, nearly 50,000 homes in the south-east suburbs of Melbourne were without power for several hours. It is inevitable that extreme heat wave events and coincident power outages are going to be a more frequent occurrence going forward. So, how can we ensure that those most vulnerable in our communities are protected from overheating in their homes and suffering potential health consequences.

This presentation will share the results and conclusions from a recent piece of modelling analysis work examining the thermal resilience of a multi-residential student housing scheme in Canberra, and the influence of the specification of high performance building envelope standards (in line with Passive House) to provide better shading, insulation and air-tightness in comparison to the current minimum compliance under the Building Code of Australia.

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The study demonstrates that it is not only from the point of view of achieving carbon mitigation that high-performance building envelope standards are recommended they also provide significant thermal resilience and can provide prolonged comfort conditions in the event of an extreme heat stress event or power outage. Such standards also act to reduce the very peak energy demands that are causing the power distribution grid to fail and cause power outage in the first place.

### Including climate change adaptation in transport systems management

**Michael AP Taylor<sup>1</sup>**

*1. University of South Australia, Adelaide, SA, Australia*

Extreme weather events place constraints on transport operations and sometimes require special operations, such as evacuations. Climate change stands to alter the environmental conditions in which transport systems function, and perhaps the frequency and intensity of extreme weather events. While environment and climate conditions have been factored in to the planning, design and operations of transport, in general this has been done using methods that assume static conditions and rely on historical records. If conditions are changing, then the design parameters, choice of materials and operating systems may not be adequate for future conditions. Transport infrastructure assets generally have service design lives of two to several decades, so that environmental changes may well affect the actual in-service performance of those assets. Design conditions such as the assumed '1 in 100 year flood' may be abrogated by changes in climate, and require revision over the lives of some assets and facilities. This paper reviews the international state of knowledge on climate change impacts on the planning, design and serviceability of transportation networks. It describes alternative frameworks for adaptation to climate change in the planning, provision and management of transportation systems. Methods and models for including climate and weather factors in planning and design are discussed, as are those for use in transport asset management systems when including risk and uncertainty. Specific attention is given to road and rail transport.

### Where do we stand? A survey of resilient design measures for building envelope and MEP systems (Speed talk)

**Stewart Monti<sup>1</sup>**

*1. School of Architecture, University of Technology Sydney, Sydney, NSW, Australia*

Resilient design is an emerging field with increasing importance as the world moves beyond climate change mitigation to adaptation. Prescriptive design literature concerned specifically with buildings' adaptability largely neglects building envelope and MEP systems. It is the responsibility of all built environment professionals to address the fundamental gaps. Understanding where the gaps lie is the first step.

Using a framework of resilience design measures determined by the AIRAH Resilience Special Technical Group as the basis, a survey was conducted. A matrix was constructed to collate responses to specific resilience measures and highlight current gaps in knowledge. The project reviewed prescriptive resilience design documents which took 2 forms:

- Building Ratings Systems (LEED; RELi; REDi)
- Government commissioned reports (New York City; Boston)

A handful of resilient design measures are addressed universally (water storage and provision, and backup power) but generally there is rarely reference to the majority of issues related to envelope and MEP systems. Specifically, equipment engineering, installation and operation – 3 keys aspects in ensuring a building adapts rather than fails. Those measures which receive responses also vary significantly in terms of length and breadth.

The implications are two-fold:

1. An immediate illustration of where gaps in knowledge currently exist - allowing future work to be more targeted for greater impact;
2. An analysis of the responses themselves allows an assessment of both the relevancy and effectiveness to local conditions.

### Quantifying potential benefits of airport cooling using stormwater irrigation: a case study at Adelaide Airport (Speed talk)

**Jingming Qian<sup>1</sup>, Nigel Tapper<sup>1</sup>, Greg Ingleton<sup>1</sup>**

*1. Monash University, Clayton, ACT, Australia*

Extreme summertime heat is becoming a major issue for aircraft operations. Some of the heaviest planes may eventually be unable to depart during the hottest part of summer days and extreme heat on the ground affects airport workers. This research project aims to quantify potential benefits of airport cooling using stormwater irrigation for Adelaide Airport and whether this can benefit airport operations and human thermal comfort. The specific contents included: 1) research the potential for irrigation to provide airport cooling during extreme heat summer conditions; 2) quantify the horizontal and vertical extent of that cooling through trial irrigation on an airport buffer area; 3) use simple land-surface climate models to replicate and analyse observed cooling from irrigation; 4) optimize the airport cooling through modelling approaches.

## 21. Water management and governance under increased climate variability and change

### Banking on the National Water Account to Manage Water Resources under Climate Change

Janice Green<sup>1</sup>, Ulrike Bende-Michl<sup>1</sup>, Dene Moliere<sup>2</sup>

1. Bureau of Meteorology, Canberra, ACT, Australia

2. Bureau of Meteorology, Darwin, Northern Territory, Australia

Under the *Water Act 2007*, the Bureau of Meteorology has responsibility for the annual publication of the National Water Account. Applying the rigour and principles of financial accounting to water resources, the National Water Account gives detailed insight into Australia's water situation for the previous financial year for eleven nationally significant water management regions. These eleven regions represent approximately 80 percent of Australia's total water use and more than 75 percent of its population.

The National Water Account presents water information in a consistent manner that is transparent and reliable. This allows information to be compared nationally and across time, providing insights into surface and ground water availability including stores and flows; water rights, use and trading; and water extracted and managed for economic, social, cultural and environmental benefits. Underpinning this information, are the prevailing climatic conditions including the climate drivers; rainfall; and evapotranspiration.

The 2017 National Water Account, covering the 2016-17 year, is currently being prepared. This represents the eighth in the annual series and provides a bank of National Water Accounts that can be used to assess water use and management under different climatic conditions in different parts of Australia. The perspective provided by this assessment can then be used to provide foresight into how best to manage water resources in both urban and rural regions under future climatic conditions. This is demonstrated using and comparing the Perth and Melbourne region accounts.

### Managing Urban Water Demands - The Challenges Presented by Climate Change

Russell Beatty<sup>1</sup>, Phillip Jordan<sup>1</sup>

1. Hydrology and Risk Consulting, Burwood, NSW, Australia

In the last 30 years in Australia there have been tremendous achievements in managing and reducing urban water demands. The introduction of pay for use water pricing and demand management programs implemented by water utilities and customers have reduced water demands in some places to levels not seen for over 40 years, in spite of high levels of population growth during that period. Future climate change will be the next major challenge in the management of urban water demands. Global climate change models predict rising temperatures and evapotranspiration levels, with less certainty for outcomes for precipitation. These climate changes will almost certainly place upward pressure on water demands. The expansion of our major cities with population growth will also increase the urban heat island effect, which will put additional pressure on water resources. This paper presents the modelling results from a number of urban communities around Australia where the impact of climate on water demands is quantified and the results extrapolated to climate change scenarios. Urban water uses are then examined in the context of these climatic drivers and the implications for our future demand management, urban water management and urban design are discussed. The paper outlines an integrated water management approach that aims to reduce demand in climate-driven water uses, substitutes supply sources that are less dependent on climate outcomes and employs improved urban design and water management approaches to reduce urban communities' dependence on water for cooling.

### Climate Adaptation in the Water Sector: Regional Utilities

Julia Stanley, Michael Thomas

*Publish consent withheld*

Geelong and the surrounding region's conventional water supply system is being challenged by an increase in population, rapid urbanisation, and drastic changes in climate and rainfall. Presently, Barwon Water services a base population of 300,000 which is expected to more than double beyond 600,000 by 2065. Accompanying population growth and rapid urbanisation is a projected increase in demand for water; from around 31 billion litres per year to potentially more than 60 billion litres by 2065 (Barwon Water 2016). Problematically, as demand for water increases, supply is coming under increasingly greater strain. Climate change, by way of example, has driven an 11 percent decrease in Apr-Oct rainfall across the south-east of Australia since the early 1970s (BOM 2016). By the end of this century, under a high emissions scenario, winter rainfall is projected to decrease by up to 30 percent (CSIRO 2017). Thus, by 2065, Barwon Water has estimated that under a high emissions scenario, an extra 15 billion litres will be required to match regional demand (roughly the same amount that Barwon Water currently discharges annually from its Black Rock Water Reclamation Plant (WRP)). The projected shortage of water is driving new and innovative supply options; including source diversification, augmented network capacity, new water saving technologies (eg., smart meters (including IoT and RF technologies), advanced leak detection), through to smarter uses of recycled water (eg., IPR and DPR). This presentation covers these advances from the perspective of a regional water utility.

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### Lessons learned from the Melbourne Water System Strategy

David Flower<sup>1</sup>, Bruce Rhodes<sup>1</sup>, Tim Rowan<sup>1</sup>, Elisa Hunter<sup>2</sup>

1. Melbourne Water, Melbourne, VICTORIA, Australia

2. City West Water, Melbourne, Victoria, Australia

Melbourne Water recently completed the Melbourne Water System Strategy (MWSS), a 50 year water resource management strategy. The MWSS addresses significant potential challenges that could emerge by 2065. Recent projections suggest that the current population of more than 4.5 million people in Melbourne and the surrounding region could more than double by 2065. Climate change projections also suggest that streamflows in the rivers surrounding Melbourne could decline by up to 55% by 2065, with implications for water supply system yield and environmental values of waterways.

To respond to these challenges and others, the MWSS outlines an adaptive portfolio approach with four elements: making the most of the water supply system, using water efficiently, using diverse sources of water, and optimising the water grid and market. Strategic recommendations identified in the MWSS were linked to 13 of the 17 United Nations Sustainable Development Goals, demonstrating the broad opportunities that Melbourne Water has to contribute to delivering these goals under its overarching vision of 'Enhancing Life and Liveability'.

To ensure delivery of the MWSS, appropriately adapted to observed conditions, a detailed implementation plan has been put in place. The implementation plan translates the strategic recommendations from the MWSS into over 80 specific, measurable, assignable, realistic, and time-bound business activities that can be monitored and reported on.

This paper will explore the challenges, opportunities, and transferable lessons learnt in developing and implementing the MWSS.

### Systems analysis reveals complex challenges of climate change on linked towns and irrigation districts connected to Murray Darling Basin

Peter J Coombes<sup>1</sup>, Michael E Barry<sup>2</sup>

1. Urban Water Cycle Solutions, Carrington, NEW SOUTH WALES, Australia

2. Technical and Innovation, BMT, Brisbane, Queensland, Australia

This paper presents systems analysis of climate change and population growth scenarios, and mitigation for the Ballarat region of Victoria that is dependent on groundwater and bulk water allocations from the Moorabool, Campaspe, Goulburn, Loddon and Yarrowee River catchments, and includes towns and irrigation districts. Detailed local inputs, such as demographics, land uses and human behaviour, and linked water supply, sewage, stormwater, economic and environmental considerations, were utilised to build systems analysis based on local scale behavioural inputs (bottom up) rather than traditional analysis of water resources based on regional scale assumptions and averages (top down).

The Ballarat region is highly dependent on water supplies from dryer surrounding regions, and impacts on downstream environments and communities. It is highly sensitive to local variations in land uses and behaviours. Climate change increases costs of water and wastewater infrastructure (overall increase of 9% to 2050), and with additional population growth generates 21% overall cost increases. Increased water demands, wastewater discharges and stormwater runoff with decreased freshwater flows in waterways (> 35%) are expected. Costs attribute to water authorities, citizens and environment.

Local solutions (rainwater harvesting and green infrastructure) reduce costs by 16% - water and wastewater infrastructure and waterway costs are reduced with increased stormwater costs. Addition of wastewater reuse and stormwater harvesting reduces costs by 37%. Diversity of solutions across scales smooths the investment cycle and mitigates effects of climate change. This yields strong economic benefits to water authorities and the environment that are paid by local government, developers and citizens.

### Challenges in developing the first Victorian water sector climate change adaptation action plan

Jill E Fagan<sup>1</sup>

1. Department of Environment, Land, Water and Planning, East Melbourne, VIC, Australia

The Victorian *Climate Change Act 2017* introduces a system-based approach to adaptation. This new approach involves industry and the community in reviewing existing practices, determining adaptation priorities, and identifying actions to help prepare the system for climate change. The water sector is identified as a vulnerable system which will be required to develop a climate change Adaptation Action Plan (AAP) every five years from 2021.

A pilot AAP is being developed for the water sector to test the process, and will be released in June 2018. The scope includes all water sources, sewerage, drainage and flood management. The pilot AAP has been led by the Victorian Government and developed in close collaboration with Victorian water corporations, catchment management authorities and local government representatives.

This paper will explain the process undertaken to develop the pilot AAP, the challenges encountered, and how each has been addressed. Challenges in the process of developing the pilot AAP, include: addressing cross-sector adaptation issues; legislated definitions of system boundaries that don't match organisational functions; and difficulty defining clear, measurable targets that can be measured, monitored and

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evaluated given the actions are being undertaken amongst a backdrop of changing land use, regulatory contexts, population growth and other changes. Challenges facing the sector under climate change will also be discussed, such as: shifting to more complex adaptive or risk-based approaches to decision making; fiduciary risks; and financial implications of climate change for a sector whose revenue is linked directly to water volumes provided.

### Shifting the baseline: planning for Climate Change in the Victorian Water Sector (Speed talk)

**Geoff Steendam<sup>1</sup>**

1. DELWP, East Melbourne, VICTORIA, Australia

Most of Victoria's water sources are climate dependent so planning for future climate variability and climate change is vital for water corporations. The Guidelines for Assessing the Impact of Climate Change on Water Supplies in Victoria were developed by DELWP using the latest findings from the Victorian Climate Initiative, which includes modelling from the CSIRO and Bureau of Meteorology.

A new 'current climate' baseline is from 1975 to date is recommended. The shortening of the baseline period, compared to historical baselines, is designed to reflect climate behaviour at the current level of greenhouse gas concentrations. It recognises the latest findings from the Victorian Climate Initiative that show current climate conditions and their influences are different from earlier decades of the 20th century, and that rapid global warming has occurred over this period. Techniques are presented to extend this baseline using the full historic climate record to incorporate a wider range of natural climate variability.

Victorian water corporations have already used the guidelines in the development of Urban Water Strategies and they may also prove to be useful to others involved in the water sector, including waterway managers, environmental water holders and local councils. The application of the guidelines among the wider water sector will provide a consistent approach to assessing the impact of climate change on water availability across Victoria.

## 22. Adaptation policy and governance

### The Warming War: How Climate Change is Creating Threats to International Peace and Security

**Kirsten Davies<sup>1</sup>**

1. Macquarie University, North Ryde, NSW, Australia

The Cold War moved slowly over a period of 45 years of indirect conflicts. Since this time the planet has experienced metaphoric wars, such as the *War on Terror* and the *War on Drugs*. This paper coins the term, and claims, that we are now in the era of the *Warming War* as the impacts of green-house emissions accelerate climate change, insidiously threatening the security of human life on earth. To date, this threat has been approached through diplomacy and negotiation as climate science continues to affirm the dangers of climate change and warns of its catastrophic impacts in the absence of urgent action. These political processes are too slow, particularly for some states, such as low lying coastal islands. This paper discusses a potential legal basis for the United Nations Security Council to declare climate change as a threat to international peace and security, thus establishing the *Warming War* as more than a metaphor. This paper investigates, whether developing countries, which find their territorial integrity and sovereignty directly challenged, could enlist international law's definition of a 'threat' to declare the impacts of climate change as a threat to their peace, security and sovereignty. In doing so, it could then be interpreted as breaching international law prohibiting acts of aggression and extraterritoriality. Approaching climate change as a national and international security issue promises to create new opportunities for immediate, and much needed action, to limit the emissions of greenhouse gases and support the adaptation of vulnerable nations.

### Incorporating climate change adaptation incentives into bioenergy support policies

**Alex Bamber<sup>1</sup>**

1. University of Technology Sydney, Broadway, NSW, Australia

Climate change mitigation is a commonly-cited goal behind the implementation of renewable energy support policies, alongside energy security and socio-economic development. However, renewable energy also has a role to play in climate change adaptation. In particular, bioenergy has the potential to be developed in a manner that contributes to habitat restoration for enhanced species resilience and soil protection to cope with projected increases in extreme weather events. These risks to ecosystem health and human livelihoods have been increased by anthropogenic climate change resulting from past and present fossil fuel use. As such, a case can be made for requiring energy companies responsible for past and present emissions to fund climate change adaptation through mandates, quota obligations and feed-in tariffs based on the "polluter pays" principle, as well as for governments to fund adaptation through grants, subsidies and tax breaks under "beneficiary pays" principle. This paper presents analysis of bioenergy support policies used in the US, EU, Australia and Brazil to identify potential adaptations that could incentivise the development of bioenergy systems that contribute to climate change adaptation.

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### **A moving target - City of Melbourne responds to change through its adaptation strategy refresh**

**Vicki Barmby<sup>1</sup>**

*1. City of Melbourne, Melbourne, VICTORIA, Australia*

Climate change is already having far reaching impacts across the world and Melbourne has experienced these impacts over recent years; including drought, flooding and extreme heat events. The City of Melbourne's risk based Climate Change Adaptation Strategy released in 2009 was the first of its kind in Australia and since then we have made substantial progress in adapting our city. Updated scientific information, an increasing population and recent policy developments have prompted us to rigorously evaluate our 2009 strategy to determine where we should focus our efforts and update our approach. This strategy refresh takes these developments into account and draws upon expert advice and best practice climate change adaptation strategies from major cities around the world.

Climate change adaptation is an ongoing process and the City of Melbourne is one of the first cities to undergo a process of updating their strategy. This presentation will highlight the process we went through and key goals for Melbourne to reach Melbourne's vision of adapting well to climate change so it can continue to prosper and thrive.

### **Climate Change Adaptation in South Australia: Lessons and Approaches**

**Christopher Wright**

Adapting to the current and future impacts of climate change related events is a crucial part of the overall climate change strategy of the Government of South Australia. We understand the need to enable our communities, businesses and environs to be resilient - and also prosper - in a changing climate.

South Australian's have already experienced the impacts of climate change, mainly through an increase in the intensity and frequency of extreme weather events including drought; heatwaves; storms; floods; bushfires; and coastal degradation via sea level rise.

A key premise is to recognise and identify the risk of climate change to the community. Comprehensive regional engagement and assessment was undertaken. Eleven regions in South Australia developed their own Regional Adaptation Plans. Each region identified what is valued, the potential climate change impacts, and the priority adaptation actions to address those impacts at the local level.

'Towards a Resilient State: The South Australian Government's Climate Change Adaptation Action Plan' released in 2018 was essentially the culmination of the work of the regions. This Plan details actions for agencies and partners to strengthen the economy, safeguard the stability of services, empower communities to increase their resilience, and maintain health and wellbeing in a changing climate.

The approach encouraged local leadership, collaboration and engagement to allow communities to partners to identify and develop ownership of their adaptation actions. The approach recognised that adapting to climate change is a shared responsibility that involves a joint effort of government, business and the community.

### **Defence Climate and Security Advice: A policy frontline perspective**

**Ian Cumming**

I will talk about the current government policies, and commonwealth responses to those policies and greater / wider advice received at the G20, APRA and others. I will talk of department (government at any level responsibilities and roles) with respect to Climate change. I will focus this discussion on Defence behaviour.

I will show how recent direction changes within processes and policies of government will significantly alter behaviour. The investment approach for Defence procurement is now changing, and future procurement may be guided by more significant considerations than the Procurement Rules.

My background as a general service office I will bring an understanding of the complexities of climate and security, in its narrow and in its widest form. I will review the discussion of the Senate hearing on climate change and national security.

I will discuss the good behaviour and bad behaviour of governments (assume that to be at all levels) with respect to a changing climate.

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### Understanding the value of the Adaptation Reporting Power process (Speed talk)

Roger B Street, Vicky Hayman, Tanya Wilkins

To help ensure key organisations prepare effectively for climate change, the UK Climate Change Act 2008 gives government the power to direct organisations responsible for essential services and infrastructure, and those with functions of a public nature, to produce reports on:

- the current and future predicted impacts of climate change on their organisation,
- proposals for adapting to climate change,
- the assessment of progress towards implementing the policies and proposals set out in previous reports.

For each round of reporting (now every five years), the government is required to lay before Parliament a report setting out the intended approach to exercising this Adaptation Reporting Power (ARP). The government may extend the period for laying any such report, but must publish a statement setting out the reasons for the delay and specifying when the report will be laid before Parliament.

To assist in evaluating the ARP2 process, the Adaptation and Resilience in the Context of Change (ARCC) network indicated to Defra that it was interested in exploring with reporting organisations in the infrastructure sector the effectiveness and value of the reporting experience to the organisations involved. There was also an interest in identifying research and knowledge exchange requirements to support future reporting rounds.

### Externality Types as Criteria for Negotiation of Adaptation Responses (Speed talk)

Jonathan Dobson<sup>1</sup>

1. *Integrated Environments P/L, Whyalla, SA, Australia*

Adaptation responses will need to be negotiated.

Negotiation strategies may vary with the type of negative externality requiring the adaptation.

Two typologies in the literature classify externalities. Firstly directionality of the externality is considered: in one situation parties generate externalities that affect the other/s; in the other, the externality is essentially unidirectional. Think of polluting a shared lake, compared to polluting a shared river. Secondly sources of externality are considered. On a spectrum from essentially point sources, to essentially diffuse sources. From a large power station, to millions of domestic open cooking fires.

Cross referencing these two typologies results in four different 'hybrid' externalities:

| Examples        | Uni-directional                                  | Reciprocal                                    |
|-----------------|--|---|
| Diffuse Sources | Thousands of people using and polluting a river. | Thousands of people using & polluting a lake. |
| Point Sources   | Industries using and polluting a river.          | Industries using and polluting a lake.        |

Different negotiating strategies indicated:

| Negotiating Strategy Required | Uni-directional   | Reciprocal   |
|-------------------------------|---|--|
| Diffuse Sources               | Requires external regulation, those upstream have no intrinsic motive to help those downstream. | All have a 'mutual benefit' motivation, but the numbers involved requires regulation to avoid free riders.   |
| Point Sources                 | Requires external regulation, those upstream have no intrinsic motive to help those downstream. | A small number of polluters with a 'mutual benefit' motivation may self regulate and self monitor responses. |

Pacific atolls are downstream from everyone! There is no 'mutual assured destruction' protecting them. They are dependent upon global regulation and funding for adaptation. Further development of such criteria will facilitate future negotiations by minimising inappropriate strategies.

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### 23. Assessing and managing risk

#### Integrating consideration of climate risk into major infrastructure projects: LXRA Policy in Action

Allan Klindworth, Fin Robertson

The Level Crossing Removal Authority (LXRA) Sustainability Policy underpins a vision to achieve excellent environmental, social and economic outcomes across all phases of the Level Crossing Removal Project (Project), with specific commitments towards preparing for the challenges presented by climate change. As part of the Authority's project-wide Sustainability Program, LXRA has developed, and now implemented, a **Climate Change Risk Assessment Framework** (the Framework). The Framework defines a holistic approach to assessing climate risks and adaptation planning that is being applied by delivery partners across the Project works.

In order to drive Best Practice in sustainable development, and demonstrate this through a recognised and transparent delivery process, LXRA has undertaken to certify all Project works using the Infrastructure Sustainability Council of Australia's Infrastructure Sustainability (IS) rating scheme. The IS rating tool rewards climate change risk assessment, mitigation and adaptation, along with improved energy efficiencies across the whole lifecycle of an asset.

This approach represents a new benchmark for responding to sustainability governance at a program level, building long-term resilience into Melbourne's transportation network by applying robust standards, such as AS5334-2013 Climate Change Adaptation for Settlements and Infrastructure.

This presentation will provide an overview of the guidance material included in the Framework and practical examples of how the challenges presented by climate change have been assessed and integrated into the program delivery. This includes the critical element of how climate change has been considered in the drainage and engineering planning and design process.

#### A design for climate change framework for the Metro Tunnel Project

Craig A Clifton<sup>1,2</sup>, Phillip Roos<sup>3</sup>

1. Jacobs, Bendigo, VIC, Australia
2. Aurecon-Jacobs-Mott McDonald Joint Venture, Bendigo, Victoria, Australia
3. Aurecon-Jacobs-Mott McDonald Joint Venture, Melbourne, Victoria, Australia

The Metro Tunnel Project (MTP) will free up much-needed space in the City Loop for more trains to run more often on other lines across Melbourne. The project involves constructing five new underground stations twin 9 km rail tunnels from Kensington in the west to South Yarra in the south east to connect the Sunbury, Cranbourne and Pakenham lines. The sustainability vision for MTP commits to delivering infrastructure elements that are future-proofed and resilient to projected changes in climate. The project has an anticipated 100 year operating life and may be exposed to quite different regimes of rainfall and temperature to those currently prevailing.

MTP is planned to be certified under two sustainability rating schemes: the Infrastructure Sustainability Council of Australia (ISCA) rating tool and the Green Building Council of Australia (GBCA) Green Star rating tool (which will apply to each of the stations). The climate change requirements of the two rating schemes are complementary and include: developing and applying climate change projections relevant to the projects' asset area and operational life; assessing and prioritising climate change risks; and incorporating appropriate responses to these risks in a climate change adaptation plan.

The paper will describe how the climate change requirements of these two sustainability rating tools have been satisfied in the development of the design for climate change (DfCC) framework. The DfCC specifies how climate change adaptation was incorporated into MTP's reference design and its subsequent detailed design, construction and operation.

#### Building Climate Resilience into Infrastructure Assets

Melanie Thomas<sup>1</sup>, Stephen Lees<sup>2</sup>, Jacqueline Balston<sup>3</sup>, Jacqueline Grove<sup>1</sup>

1. Northern Beaches Council, Warriewood, NSW, Australia
2. Institute of Public Works Engineering Australasia (IPWEA), Brisbane, QLD, Australia
3. University of South Australia, Adelaide, SA, Australia

Recent coastal storms on the Northern Beaches of Sydney in 2015 and 2016 demonstrated how the impacts of increasing extreme weather events combined with rising sea levels will increase the risk of damage to Council infrastructure.

Funding by a Local Government NSW Building Resilience to Climate Change grant allowed Sydney's Northern Beaches Council to partner with IPWEA to produce the *Practice Note 12.1: Climate Change Impacts on the Useful Life of Infrastructure*. The Practice Note enables asset managers to plan for climate change by considering the likely impact to asset management plans and depreciation rates so that the real costs of climate change can be factored into Council's budget. This adjustment can be done both at the asset class scale and at the business case proposal stage to ensure that whole-of-life costing is factored into projects.

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To assist asset managers to incorporate climate change into the useful lives of assets, a decision tree and worksheets were developed as part of the IPWEA Practice Note 12.1 and piloted on four infrastructure case studies on Sydney's Northern Beaches:

1. Collaroy Stormwater Outlet
2. Mona Vale SLSC
3. Fairy Bower Amenities, Manly
4. Road raising, Macpherson Street, Warriewood.

These case studies demonstrate how the impacts of increasing severe weather events such as floods and coastal storms exacerbated by sea level rise as a result of climate change, were considered in the project planning stage and how adaptation measures were applied to build resilience into the Northern Beaches Council assets.

### Cascading climate change impacts: Implications for adaptation across linked socio-economic and ecological systems in New Zealand.

**Paula Blackett<sup>1</sup>, Nick Cradock-Henry<sup>2</sup>, Judy Lawrence<sup>3</sup>**

1. NIWA, Hamilton, WAIKATO/NEW ZEALAND, New Zealand

2. Landcare Research, Christchurch, New Zealand

3. Victoria University, Wellington, New Zealand

Climate change will have direct impacts on New Zealand's infrastructure, industries and communities, but will also drive indirect impacts, creating cascading changes across linked socio-economic and ecological systems. Such cascades can arise in multiple ways: through the slowly emerging impacts of climate change (e.g., sea level rise); extreme events (e.g., floods); increasing climatic variability (e.g., increase in droughts); multiple combinations of impacts occurring simultaneously; and surprise or unanticipated events. We demonstrate the ways in which different types of cascading impacts ripple out across spatial scales, social and economic domains, and sectors, exposing and straining interconnections and interdependencies. In particular, we focus on flood protection, drainage systems and storm water management in urban and rural sectors. Gaining insight into the scope of interconnectivity between sectors and systems will support adaptation planning, help avoid maladaptation, and mitigate the likelihood of negative cascading impacts across the economy. This understanding can help inform how stakeholders conceptualise impacts and implications of climate change and facilitate linked-up approaches to adaptation planning at multiple scales that can consider upstream and downstream decision implications.

### Disclosing Physical Risks – a new driver for private sector adaptation?

**Anita Foerster<sup>1</sup>, Jacqueline Peel<sup>1</sup>**

1. University of Melbourne, Carlton, VIC, Australia

Since the resolution of the Paris Agreement in late 2015, there has been a notable shift in the way in which climate change is approached by the business and investor community. Climate change is increasingly framed as a material financial risk for companies and the large institutional investors which own them – a risk with the potential to impact on a company's bottom line and therefore the value of investments over time. There are two dimensions to climate risks. Transition risks include a range of interacting legal, technological, market and reputational risks. For example, new laws and policies to address climate change are likely to impose compliance costs and liabilities and lead to restrictions on the use of carbon-intensive assets. The rapid development of clean energy technology and changing energy markets also pose significant risks for many companies, particularly traditional energy generators and fossil-fuel based industries. Physical risks, associated with both acute weather events and longer-term changes to rainfall, temperature and other factors, include potential disruptions to operations, transportation, supply chains; damage to physical assets; and reduced resource availability. This new framing of climate change as a material financial risk enlivens a range of obligations under corporations law, including requirements to disclose these risks and the strategies used to manage them to shareholders and the broader market. There is growing interest among market regulators in Australia and internationally in enforcing these obligations and institutional investors are increasingly pressuring companies to improve their disclosure and demonstrate how they will preserve corporate value in the context of climate change. This paper focuses specifically on the physical risks posed by climate change and explores how these risks are likely to impact Australian companies across a range of sectors. It outlines the legal obligations of companies to disclose and manage these risks and draws on preliminary results of an empirical study to comment on the potential of these legal obligations to drive and hasten the uptake of adaptation measures by the private sector.

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## 24. Tools, knowledge and communication: building support for action

### Keeping it real(istic): The importance of internally consistent datasets for impact assessment

**John Clarke<sup>1</sup>, Michael Grose<sup>1</sup>, Craig Heady<sup>1</sup>, Vanessa Hernaman<sup>1</sup>**

*1. CSIRO Oceans & Atmosphere Flagship, Aspendale, VIC, Australia*

There are many different uses for climate projections data. Some of these rely on results for a single climate variable while others need to combine results for multiple climate variables. In the latter case, the data are often used as inputs to sophisticated models (such as for crop growth or species distribution models). When using multiple variables in this way, it is vital that the climate datasets are internally consistent. In other words, the combinations must be plausible in the real world.

Herein lies a difficulty. In general, there are good reasons to prefer the combined results from multiple climate model simulations. This permits the calculation of median or mean values along with other useful statistics. Unfortunately when combining variables, the multi-model values are very unlikely to be internally consistent (and the more variables there are, the less likely this becomes). One solution to this problem is to source all of the data needed from a single climate model. However, this is also problematic. Which model should be used? What about representing the full range of the projections? What about model skill? The CSIRO Climate Futures Framework addresses these issues by facilitating the selection of a small subset of models to represent Key Cases that are relevant to the specific assessment being undertaken.

In this presentation, we explain the issue of internal consistency and illustrate a solution using the Climate Futures Framework approach.

### Implementing Resilience Monitoring and Evaluation in the Real World

**Rohan Hamden<sup>1</sup>**

*1. Rohan Hamden & Associates, Campbelltown, SOUTH, Australia*

The idea of resilience has been applied to disaster risk management for many years. The broader application to climate change adaptation has been a more recent development. It has emerged from the need to recognise that the investments we make today are of benefit to society in the future. The idea of resilience epitomises the need for flexibility on the one hand, and sturdiness on the other, as a formula for managing during and after natural hazards and permanent changes in climate.

This paper has been prepared through interviews with leading researchers and practitioners, literature review and examination of best practice approaches. The purpose of these activities was to identify theoretical frameworks for resilience MER and practical examples of where these had been applied at scale. This report has focused on examples where:

- The research or practical example had lessons that were applicable to a western cultural context, a government program or a program of similar scale.
- The main context of the research or practical application was resilience, rather than general monitoring and evaluation
- The practical examples had sufficient detail to understand the context, drivers and issues with implementation.
- This presentation will detail the practical lessons and pitfalls in monitoring resilience, and how these have been overcome through real world application.

### Learning by Doing – Key ingredients for building resilience to climate change at a Local Level

**Suzanne Dunford<sup>1</sup>, Denise Anderson**

*1. Office of Environment and Heritage, NSW, Australia*

This presentation will detail the successes and challenges of the 3 year Building Resilience to Climate Change contestable grants program in NSW. This program funded 21 adaptation projects in local government organisations to accelerate adaptation responses and foster a community of practitioners across professional disciplines. The projects provided direct experience in overcoming barriers and applying climate change information to local decision making in NSW. A successful cross scale partnership between the Local Government NSW and NSW Office of Environment and Heritage, the BRCC program has revealed some key learnings about the framing, governance and evaluation challenges of on ground adaptation projects.

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### The Global Covenant of Mayors for Climate and Energy: committing locally determined contributions to the Paris Agreement

Bernie Cotter

The Global Covenant of Mayors for Climate and Energy is an international alliance of cities and local governments with a shared long-term vision of promoting and supporting voluntary action to combat climate change and move to a low emission, resilient society.

- **Local Governments are Key Contributors:** The Global Covenant of Mayors works to organize and mobilize cities and local governments to be active contributors to a global climate solution.
- **City Networks as Critical Partners:** Local, regional and global city networks are core partners, serving as the primary support for participating cities and local governments.
- **A Robust Solution Agenda:** Focusing on those sectors where cities have the greatest impact, the Global Covenant of Mayors supports ambitious, locally relevant solutions, captured through strategic action plans that are registered, implemented and monitored and publicly available.
- **Reducing Greenhouse Gas Emissions and Fostering Local Climate Resilience:** The Global Covenant of Mayors emphasizes the importance of climate change mitigation and adaptation, as well as increased access to clean and affordable energy.

This is an historic and powerful response by the world's cities to address the climate challenge. It is the broadest global alliance committed to local climate leadership, building on the commitment of over 7,500 cities, representing over 690 million people worldwide and nearly 10% of the global population.

This presentation will detail the framework it provides for councils undertaking emissions reductions and climate adaptation work and the contributions already made by International and Australian local governments constituency.

### Queensland Climate Resilient Councils (Q CRC) – establishing the foundations for effective, ongoing climate change decision-making.

Dorean F Erhart, Catie Dunbar

This presentation will provide an overview of the Queensland Climate Resilient Councils ([Q CRC](#)) program, its objectives and outcomes to date. The 3-year program is designed to establish the internal knowledge, governance arrangements and resources to facilitate continuous capability to implement climate change responses e.g. Coastal Hazard Adaptation Strategies resulting from the [QCoast<sub>2100</sub>](#) program.

Key Program components are:

**Face to face climate briefings** with councillors and executive staff, providing the opportunity for council's leadership to discuss the impacts of climate change on their priorities with relevant climate specialists.

**Detailed governance assessments** assess and rate 17 governance indicators against world leading climate practice standards and provide clear recommendations for improvement.

**Leading practice resources for councillors and staff** to support planning and decision making for climate change mitigation and adaptation, derived from an international scan of existing resources, to catalogue, curate and create a tailored package.

**Local Government Community of Practice** facilitates knowledge and experience sharing and peer to peer learning.

**Grant funding** to pilot the development of 2 local government led, multi-sectoral climate change strategies in a local government area or at a regional scale.

Since the program's commencement in March 2017, 31 councils have committed to participate, 23 face to face briefings have been delivered to more than 200 elected members and senior executives and 15 governance assessments have been completed. The leading practice resources component is underway, and the Local Government Community of Practice is holding its first group workshop in March.

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## 25. Cities and infrastructure: planning for liveability under climate change

### Building resilience in public infrastructure through collaborative adaptation: XDI Sydney project

Rohan Hamden<sup>1</sup>, Liesl Laker<sup>2</sup>, Karl Mallon<sup>3</sup>

1. XDI Cross Dependency Initiative, Sydney, NSW, Australia

2. NSW Office of Environment and Heritage, Sydney, NSW, Australia

3. Climate Risk, Sydney, NSW

Critical infrastructure is highly interdependent, which means the ability to contain climate related disruption to services and assure resilience is quite limited without a system-wide view. The NSW Office of Environment and Heritage (OEH) is leading a partnership with Sydney Water, Transport for NSW, City of Sydney and Climate Risk to co-develop the Cross Dependency Initiative in Sydney – (XDI-Sydney). The project is identifying areas where there are critical extreme weather and climate change risks to assets, and importantly the dependencies between different types of infrastructure across the entire Sydney Basin.

The XDI Platform is able to identify cross-dependent climate change impacts in water, electricity, transport, telecommunications, and built environment infrastructures. It uses GIS spatial data for weather, engineering and financial data to analyse large numbers of utility assets for risks and the effect of co-dependencies.

XDI Sydney will provide computationally detailed insights into hazards, exposure and vulnerability across a complex system. In this way, asset owners can see which risks to third party infrastructure assets will affect their own system and equally the consequences of their own vulnerability to other critical infrastructure. Their interdependent risks are quantified not just financially, but in non-financial KPIs such as the number of customers affected by outage.

The tool encourages 'collaborative adaptation' so that all affected providers can contribute to the costs of upgrading or replacing an asset, making considerable savings compared to adapting their own assets independently.

### Coastal disaster resilience and application of smart city framework: current state, challenges and opportunities

Fahim Tonmoy, Rodger Tomlinson

72% of the 63 most populated cities in the world are located on or near the coast which exposes large populations and assets to sea-level rise, storm surges and floods with potentially significant financial impacts in cities. As climatic changes are likely to increase these impacts in future, increasing coastal disaster resilience has become a major priority in coastal cities. At the same time, recent development in information technology, smart city, data science and availability of big data sources such as social media, mobile devices, and ubiquitous sensors allow us to collect data with details and coverage unimaginable before and can assist in better managing coastal risks. In this paper, we discuss applications of smart city frameworks and big data analytic techniques in the field of coastal disaster management. We critically analyse a set of peer-reviewed literature in this field with an aim to understand trends, research gaps, challenges and opportunities.

We find that, although smart city has become a 'buzz' word, its application in increasing coastal disaster resilience has been limited, specifically in Australia. As 'smart cities' are run by connected devices based on IT system, they are likely to become the weakest link in the chain and essential public services such as water supply, transportation, health-care etc. can become vulnerable to any disturbance in the IT or electric supply system due to coastal disasters. However, we find that very few studies have attempted to understand these interdependencies of the connected 'system of system' at a local scale.

### The city as nature – new visions and logics for creating the bio-cities of the Anthropocene

Jason Alexandra<sup>1,4,2,3</sup>

1. Alexandra And Associates Pty Ltd, Eltham, VIC, Australia

2. Canberra Urban and Regional Futures – University of Canberra and ANU, Canberra, ACT, Australia

3. School of Global, Urban and Social Studies, RMIT, Melbourne, Victoria, Australia

4. School of Global, Urban and Social Studies, RMIT, Melbourne, Victoria, Australia

The 21st Century is the urban century with humans the dominant force shaping the planet. Radical transformations in production and habitation systems need to be based on new logics and new visions of the city as nature, and the nature of the city. Fundamental reconceptualisation will enable transformations supported by technical and social innovations, including ecological design.

The world's cities are forming a global megacity linked by gargantuan flows of information, goods and people. To satisfy its rapacious appetites this megacity draws resources from its vast global hinterlands, threatening planetary boundaries with its consumption and waste. But the city is also a place of social production, engendering the cultural and technological innovations needed for adapting to changing circumstances. This

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production is evidenced by thousands of climate responsive, biophilic communities utilising multiple strategies for re-naturing the city and its degraded hinterlands.

Cities are evolving assemblages of intertwined cultural, material and ecological elements, spawning novel ecosystems in and beyond traditional urban boundaries. These are human created in at least three ways. Firstly, all nature exists within inherently politicised, cultural environments. Secondly, novel combinations of biotic and non-biotic elements are forming. Finally, the Anthropocene breaks down simplistic definitional boundaries of 'human' and 'natural'.

This paper argues that new visions of the city as nature are needed. These require logics based on recognising the novel co-produced nature of ecosystems. These logics enable forward-looking planning objectives, instead of attempting to derive strategic goals based on idealised past 'natural' states.

### Growing the ACT's Living Infrastructure

**Tim Sides<sup>1</sup>, Catherine Keirnan<sup>1</sup>**

*1. ACT Government, Dickson, ACT, Australia*

The Capital region's climate change impacts - more frequent and severe heatwaves, droughts, storms and bushfires, are already impacting people and nature, urban and farming systems. This includes the resilience of our urban forest and Canberra as 'treetopia'.

The Australian Capital Territory's *Climate Change Adaptation Strategy*, commits to a suite of actions to reduce vulnerability and manage climate change risks including developing a *Living (green) Infrastructure Strategy*.

This new policy respects the vision of Canberra's founding designers for a city in the landscape, with leafy boulevards, parks, water features, and an open space system that is the setting for the city. This living infrastructure legacy makes Canberra one of the most liveable cities in the world, our urban forest has nearly 800,000 trees, twice the number of people! To enable our 'treetopia' to cope with future conditions, we need a new business-as-usual, one that recognises the many facets of the contribution that trees make in the urban setting and prioritises investment in maintenance of the living infrastructure as an asset class.

Our approach includes engaging early with key influencers. The ACT Government has established the Sustainability Alliance, a group of peak bodies, academia, business and industry, a 'brains trust' at policy development stage. By taking this collaborative approach to development of the *Living Infrastructure Strategy* policy and targets, it is hoped they will be 'advocates' thereafter, when the changes to existing codes and standards take effect, to achieve our vision for a smart, sustainable, liveable and resilient, carbon neutral city.

### Green Infrastructure - A vital step to brilliant Australian Cities

**Victoria Chantra, Roger Swinburne**

Trees and parks have the potential to transform the quality of life in Australian cities, but remain vastly undervalued.

The number of residents in Australian cities is forecast to boom in the next few decades with Melbourne's population to reach 8 million in 2050. Population growth will increase demand for housing and jobs, and will place enormous pressure on health systems and transport. Energy consumption will increase as temperatures rise due to climate change. As our cities become increasingly crowded, there will be less space for the trees, parks and the other photosynthetic elements we call green infrastructure and yet they are essential for the liveability of our cities.

The holistic costs and benefits of Green Infrastructure at city scales is not well understood. The ownership of the costs and benefits is fragmented and therefore as a form of infrastructure it is not well protected, maintained or enhanced.

Our research aims to calculate the value street trees provide in Australian cities. Our intent was to gain better insights into their benefits and understand how these could inform discussions about street trees, and other green infrastructure.

### Climate-proofing our cities with green infrastructure (Speed talk)

**Maisie Auld, Joana Almeida, Tom Davies**

Green infrastructure encompasses most ecological structures and assets that, by providing an ecosystem service, deliver also engineered functions. Green infrastructure can be as sophisticated as a green wall or a biological water treatment facility, or as simple as a row of trees lining a road. Although most Australian urban dwellers have access to some form of green infrastructure, namely in the shape of parks and gardens, there is a sense of urgency to green our cities which is, in part, linked to curbing the negative impacts of climate change.

This presentation will report on research findings on the ecosystem services provided by green infrastructure, namely those that can be used in climate change adaptation: local climate and hydrology regulation and protection of communities from extreme weather events and erosion. We will present the evidence that vegetation has the potential to mitigate urban heat island effect and decrease storm-water run-off. This in turn reduces the exposure risk of citizens and assets to heat waves, excessive rainfall and rising sea-levels.

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This study also identifies the main gaps in knowledge and in practice. The main challenges are: assessing the triple bottom line costs and benefits of green infrastructure and their magnitude across Australia; mapping fit-for-purpose solutions in terms of design and species fitness against regional variability and climate change projections; and educating and rewarding the property and infrastructure industries for sound implementation of green infrastructure.

### Plights, camera, action: climate and managing for change and loss at cultural heritage sites (Speed talk)

Caitlin Vertigan, David Roe

At the historic Coal Mines Historic Site in Saltwater River, Tasmania, irreplaceable cultural heritage is steadily and measurably washing away into the rising sea, or as Justin Gillis so eloquently phrased it, «Cause? Meet effect" (New York Times 2017). The same values which make this place worthy of inclusion in the Australian Convict Sites World Heritage listing are eroding before they have been properly understood. This is not a situation in which we have time to plan for management; this is now, and it is not isolated. Across Australia, a large number of Indigenous and European colonial sites are located on and near coasts. However, cultural heritage sites present a unique planning challenge when it comes to climate adaptation. We can't retreat, rebuild or protect without sacrificing the values that make these places significant in the first place. We can accommodate but only within a narrow window. In some situations it may be that all we can do is manage loss although we are not sure how best that might be done. At the Port Arthur Historic Site Management Authority we are beginning a program to understand the spectrum of effects that climate change will have on our fragile cultural heritage; design data acquisition regimes for demonstrating and quantifying that change; and are developing long-term management responses for both inevitable loss and operating in increasingly dynamic and challenging environments.

### Additional abstracts from posters (that were not presented in Speed talks)

#### Climate change vulnerability assessment and an agriculture based economy

Faisal Nadeem<sup>1</sup>, Brent Jacobs<sup>1</sup>, Dana Cordell<sup>1</sup>

1. University of Technology (UTS) Sydney, Ultimo, NSW, Australia

Agriculture is the major sector of the economy of Pakistan supporting, directly and indirectly, around 67% of the national population. This sector is particularly vulnerable to the direct impacts of climate change with flow-on effects on rural livelihoods and national food security. Climate vulnerability assessments provide both a first step in understanding climate impacts and a bridge to the development of adaptation strategies. This paper reports a review of literature towards the establishment of a climate change vulnerability assessment for the agriculture sector in Pakistan. The review focused in particular on the application of geospatial mapping to vulnerability. The findings indicate that, to date, assessments of vulnerability in Pakistan have focused on several themes including: human health, social impacts, natural hazards, coastal geographies and gender. Despite differences in scope, methodology and spatial aspects, vulnerability assessments and geospatial mapping of their components have rarely focused comprehensively on the agriculture sector, particularly at provincial scale. We conclude that, given the importance of agriculture to Pakistan, there is an urgent need to begin a process of climate change vulnerability assessment for the Pakistan agriculture sector. Furthermore, we suggest that geospatial mapping of vulnerability aspects will assist in identifying adaptation priorities and catalysing the development of informed policy to support adaptation action at a range of scales.

#### Proposed Western Sydney Transport Network, and enhanced Camellia Bioenergy scheme

Anthony J Parrington<sup>1</sup>, Charles C Sorrell<sup>1</sup>

1. UNSW Australia, Sydney, NSW, Australia

This poster envisages the integration of the: AquaNet Rosehill recycled water project; EarthPower Technologies anaerobic digester; and SOPA WRAMS operations as part of an integrated bioenergy, and vehicle refuelling scheme.

Accordingly through the combination of biogas, renewable energy, and the treatment of wastewater, this facility will assist in the provision of an expanded Western Sydney transport network, thereby facilitating some emerging: hydrogen fuel cell car; bus; truck; and tram technologies; and the refuelling requirements required for their operation.

Primarily this will be achieved through the development of a multi-modal refuelling infrastructure for: the reformation of biogas; and electrolysis of recycled water into hydrogen; with industrial symbiosis methodologies considered in the transformation of waste into mobility, as the area is redeveloped, and integrated into surrounding areas over time.

Moreover through the NSW Government's investment in transport infrastructure, this presents an opportunity to provide additional capacity through the conversion of underutilized assets, thereby creating a large refuelling infrastructure that may facilitate the adoption of some emerging low emissions transport technologies [i.e. the CRRC Tangshan hydrogen hybrid / battery / super capacitor light rail carriage], and/or other hybrid electric vehicles as they are introduced across an expanded network.

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Thus with the recent reconfiguration of the Shell Clyde Oil refinery, there is a once in a generation chance to remediate, and redevelop land long polluted by industry, by embracing the possibilities of the circular economy, and the transformation already demonstrated in: Kalundborg, Denmark; the Kokkola Industrial Park, Kokkola, Finland; and Jurong Island, Singapore.

### Proposed White Bay Power Station Boiler House no. 2 Brewery / Distillery, and District-scale Bioenergy scheme

**Anthony J Parrington<sup>1</sup>, Charles C Sorrell<sup>FAIE</sup><sup>1</sup>**

*1. UNSW Australia, Sydney, NSW, Australia*

My poster considers the design of a combined Brewery/Distillery, and Bioenergy scheme within the footprint of the former White Bay Power station, Boiler House No. 2, with the new generating capacity to be powered by both: syngas produced by a biomass boiler; and biogas produced anaerobically by a nearby anaerobic digester.

This concept replicates existing projects developed by Diageo at the: Cameronbridge; Roseisle; and Glenlossie Distilleries in Scotland; thereby demonstrating Circular Economy concepts between enterprises, where the waste of the brewery/distillery fuels the power station; and waste heat assists in the production of brewing; and distilling products produced therein. In doing so the proposed brewery/distillery is envisaged to transform the former power station in a similar manner to the recent Bombay Sapphire Laverstoke Mill Distillery in Hampshire, UK, or the Diageo Roseisle distillery whereby the facility is comparable in terms of scale, and potential production capacity for boiler house no. 2.

Subject to the scale of the installation the scheme may also export power within the Bays Precinct, similar to the Kings Yard Energy Centre, Stratford, London; or the comparable Energiebunker, Wilhelmsburg, Hamburg where biomass, and other renewable technologies assist in powering the community.

Subsequently the proposed Boiler House bioenergy scheme may draw upon the history of both: power generation; grain storage; and waste disposal at White Bay, by integrating a modern facility into the existing building fabric, and by re-interpreting the operations of the former power station; grain silo's; and nearby Walter Burley Griffin designed Glebe incinerator, Blackwattle Bay.

### Extreme Droughts and Floods in Changing Climate – A New Normal & Adaptation Pathways for Lancang-Mekong Basin

**Minh N Nguyen<sup>1</sup>, Ziniu Xiao<sup>2</sup>, Trung H Nguyen<sup>3</sup>**

*1. Land & Water, CSIRO, Clayton, VICTORIA, Australia*

*2. Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China*

*3. DRAGON Institute, Can Tho University, Can Tho, Vietnam*

The Lancang-Mekong River is a trans-boundary river, flowing through China, Myanmar, Thailand, Laos, Cambodia, and Vietnam, with an estimated length of 5,000 km and basin area of 800,000 km<sup>2</sup>. The basin houses 70 million people, most of whom are rural poor with livelihoods directly dependent on the river water. This is one of the most dynamic, productive and diverse river basins in the world, and also one of the most vulnerable to the changing climate.

In recent years, extreme drought and flood events have become a climate 'new normal' with stronger intensity, higher frequency, and longer duration. The 2009 drought and recent floods in the Upper Mekong Basin, and the 2015 drought in the Lower Mekong Basin caused widespread damages to regional economy and disruptions to livelihoods of millions of people. Understanding the climate 'new normal' and its impacts, and promoting appropriate adaptation pathways to enhance the local resilience are therefore urgently needed.

This Poster outlines a new collaborative R&D between the CSIRO Australia, the Chinese Academy of Sciences, and Can Tho University Vietnam. The focus is on understanding extreme drought & flood events and their impacts; and promoting adaptation strategies and practices to this climate 'new normal'. The collaboration allows an integrated and legitimate approach for the whole Lancang-Mekong River Basin, aiming at fostering the much-needed regional collaboration. It is also a timely response to the new initiative of the Lancang-Mekong River Cooperation, which aims to facilitate collaboration from all six countries in the basin for a regional sustainable development.

# Day Three:

## Tuesday 8 May 2018

### Decadal Variability of Tropical Cyclones in the Southwest Pacific – are the last 10 years unusual?

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The Southwest Pacific (SWP) region is a vast ocean space, home to rich marine life and island nations with diverse cultures, but susceptible to natural disasters. A distinctive feature of this region is the frequency of tropical cyclones (TCs), which are capable of causing significant impacts to properties, lives and infrastructure. Research has suggested that anthropogenic climate change is likely to result in an increase TC intensity causing variability. Hence, it is essential to review the climatology of TCs that have occurred to improve the resilience of the vulnerable island nations of the SWP. The aim of this study is to place any recent changes in TC activity into a perspective of long-term variability. This is achieved by assessing the historical variability of TC frequency, TC tracks and the spatial distribution of TC genesis points, peak-points as well as decay points over the last 76 years. To facilitate this investigation, Best Track Data from South Pacific Enhanced Archive of Tropical Cyclones (SPEARTC) over the period 1941 – 2017 TC season was used to assess variability on a decadal scale. It is shown that, while TC frequency over the last decade does not appear unusual, there is some evidence of a southeastward progression of TC genesis and in particular, decay points. The findings from this study increase our understanding of decadal to multidecadal variability in the risk impact of TC activity for the SWP island nations and place recent events in the historical context.

### Workers' Health and Safety at High Temperatures: new perspectives on injury prevention

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#### Introduction/Aim:

Heatwaves are predicted to increase in frequency, intensity and duration with climate change, but their direct or indirect impact on occupational injury has received little attention. This study aims to explore the relationship between heatwaves and occupational morbidity in Adelaide, South Australia.

#### Methods:

Two administrative data sources of occupational morbidity, namely workers' compensation claims and work-related ambulance call-outs for the Adelaide metropolitan area, were obtained for the years 2003-2013. Heatwave metrics were either (1) three or more consecutive days of daily Tmax of  $\geq 35^{\circ}\text{C}$ , or (2) heatwave severity categories (low, moderate and high) calculated using the Excess Heat Factor (EHF), which quantifies heatwave intensity relative to local average temperatures and accounts for acclimatisation. A time-stratified case-crossover regression model was used to examine associations between heatwaves and workers compensation claims; and ambulance call-outs.

#### Results:

There was an increase in work-related ambulance callouts and compensation claims during low-intensity and moderate-severity heatwaves, and a decline during high-severity heatwaves. During moderate-severity heatwaves a significant increase of 8.8% was observed in compensation claims, and a non-significant 20% increase for work-related ambulance callouts. Using cross-validation methods, the two metrics used to define heatwaves (EHF and Tmax) were found to be similar predictors of heat-related outcomes.

#### Conclusion:

The greatest injury risks were during moderate heatwaves rather than high-severity heatwaves. This may be because of differing behaviours and work practices, whereby mitigating actions are taken on extreme days but less protective measures are adopted during less intense heatwaves.



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