

Learning from Indigenous knowledge for improved natural resource management in the Barmah-Millewa in a changing and variable climate

Final Report to VCCCAR

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Executive summary

The integration of different forms of knowledge of the relationships between climate, people and natural resources is an important issue in adapting to climate change. With some of the longest continuing cultures on earth, the indigenous communities of Australia hold valuable knowledge that has not generally been used effectively or equitably in environmental decision making. Indigenous people have not been empowered to participate in decision making processes due, in part, to lack of mutual understanding of western science and indigenous knowledge systems and lack of capacity to capture, manage and present traditional knowledge in indigenous communities.

This project explored how the deep knowledge of country of the Yorta Yorta people on the Murray River could be used to strengthen their participation and influence in regional natural resource management processes affecting the Barmah-Millewa Forest. We undertook a community mapping process to collect Yorta Yorta knowledge and combine it in a GIS framework with conventional environmental and other data. This framework is the basis for producing integrated maps and analyses to support decision making in the region. In addition, we undertook an appraisal of institutional barriers and bridges to sustainable management of the Barmah-Millewa.

The project arose as a community-led initiative following several years of conversation between the Yorta Yorta community and university academics on the threats climate change poses for the community and possible community responses. As a unique partnership, a key principle of this project was ethical and respectful relations among Western researchers and Indigenous partners, and hence authentic engagement with traditional knowledge keepers both within and beyond the research team was embedded in all stages of this project.

Yorta Yorta knowledge of the Barmah-Millewa region was collected through a process of trans-generational transfer, with Yorta Yorta youth volunteers accompanying Elders to places of cultural significance in the Barmah-Millewa National Forest to record knowledge associated with these places with voice recordings, photography and Global Positioning System (GPS). The methodology also included the adoption of legal and ethical protections for all participants, a crucial component.

This activity began the creation of a community archive and raised the community's awareness, knowledge and interest in their heritage. It also forged stronger links between youth and community Elders, and energised the youth to take an interest in their history and culture, as well as in the climate challenges facing their community. It resulted in a community that is much more informed and knowledgeable about climate change and that is now taking action to adapt and to provide leadership to other Indigenous communities on climate change.

The Yorta Yorta knowledge was integrated in a Geographical Information System (GIS) framework with conventional data such as the geographical, ecological, climatic, cultural, political, social and economic environment of the region. Collecting this additional data proved a greater challenge than originally anticipated, with the main difficulties being tracking down who held the various datasets, particularly across state boundaries; obtaining permission to use the data; and dealing with non-uniform data across agencies or state boundaries.

Simply putting all this data in the same GIS framework and exploring it with simple data layering provided significant and powerful new insights about the region for the Yorta Yorta, as they have not previously had good access to GIS capabilities or access to such a variety of information in one place. However, there is considerable potential for the further development of analytic and integrated products to support management of the region. Two examples that are currently under development are analysis of regional climate variability and a study to determine cultural flows.

For the Yorta Yorta, having an archive of their knowledge and access to other regional data means that they are much better informed and confident in participating in policy and regional management discussions. This is valued by both the Yorta Yorta and the Victorian Government. However, effective dialogue depends on good personal relations and changes in roles within the Government have hampered continuing dialogue.

In order to identify the interests at play in making water policy for this region and potential for common ground, we conducted a study of regional viewpoints regarding the changing drought and flood regime and the efficacy of Indigenous co-management. The study identified a wide range of often conflicting

views. However, it indicated that substantive community engagement is desired by everyone in the region. This has not been observed in the Murray Darling Basin planning process.

Allocative efficiency of a resource like water is often enhanced by placing decision-making authority where the participants are best positioned to assess the costs and benefits. Given our analysis that supports collaborative decision-making, is a centralised framework more optimal over more decentralised arrangements? Research indicates that a more centralised level of control tends to lead to stronger environmental outcomes, however this question remains a key element of the unfolding implementation phase of the Murray-Darling Basin Plan.

This research project has provided an opportunity for significant learning, for both for the research team and the Yorta Yorta. It took significant time and effort to build the necessary relationships and trust between the parties, and has barely scratched the surface of the joint research that could be done.

The following policy recommendations would improve the integration of local indigenous knowledge and empower traditional custodians in natural resource decision making in a changing climate.

1. Federal, state and local governments should make every effort to establish common data requirements for natural resource management, including what variables should be measured, how often and to what accuracy.
2. The Victorian Government should continue to facilitate wider and easier access to data collected and owned by the State.
3. The Victorian Government should consider carrying out similar projects with other Indigenous communities across Victoria as a means of raising the capacity within those communities to undertake climate adaptation actions and to enable meaningful engagement in the policy process. The Yorta Yorta would be well placed to take a leadership role in such a process.
4. Where possible, government personnel should be supported to retain long term relationships with Indigenous communities even as their functional responsibilities change. Where personnel come for the first time into positions where relationships with Indigenous people are important, those staff should undertake cultural awareness training and should take time to build relationships and understanding of community values and history.
5. There is the potential for greater use of science in the management of the water resources in the Murray River region. Even more important is the need for genuine, deep, open-minded dialogue with the community at all stages of decision-making, particularly at an early stage before proposals are put forward and views become entrenched.
6. Successfully carrying out research projects with Indigenous communities requires the development of trust built through long term relationships and friendships, flexibility in project design and deliverables, and other requirements that make these projects difficult to carry out within conventional research funding structures. The Victorian Government should invest in a specialised long-term research programme that accommodates these requirements and enables and empowers Indigenous communities to participate in managing natural resources.

1 Introduction

The Murray River – *Dhungala* – with its rich network of lagoons, creeks, and wetlands, is regarded as the life source and the spirit of the Yorta Yorta people. *Dhungala* comprises the lower half of the Murray-Darling Basin and flows out into the Coorong lagoon system. Inflows to *Dhungala* and its tributaries have their source in the high country in the Basin's south east. The natural flood and drought cycles of the region, driven in part by the El Niño Southern Oscillation (ENSO), mean that the river channels are connected intimately with ecosystems in surrounding floodplains and tributaries. The Barmah Choke, in the heart of Yorta Yorta Traditional Lands (Figure 1), is a region where constricted flows lead to more frequent flooding events, supporting the internationally significant river red gum forests. The floodplains are also locations where bird, amphibian, reptile and fish breeding events take place.

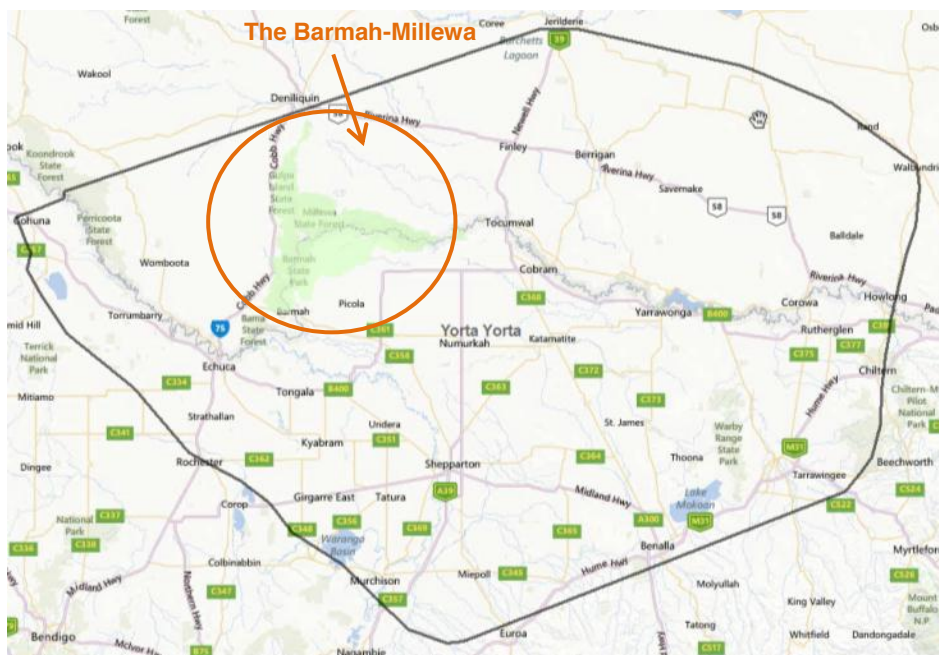


Figure 1: The Yorta Yorta area (grey line) and Barmah-Millewa areas (light green shading).

Currently estimated at around 10,000 individuals on country and half as many in nearby urban centres, the Yorta Yorta have maintained social, spiritual, economic and cultural links with country for over 1,600 generations. As one of the oldest cultures on Earth, the Yorta Yorta provide a unique perspective on their environment, as documented in stories that incorporate events ranging from the Carinae stellar eruption 150 years ago to the displacement of the Cadell fault around thirty thousand years ago. During that time, they have adapted to large changes in landscape, climate and ecology, from the establishment of the iconic river red gum in the Late Pleistocene, to the arid and windy climate of the Last Glacial Maximum, to the rising seas and 'Mediterranean' climate of the Holocene.

An increasing number of researchers are eager to find ways to support the inclusion of insights arising from Indigenous knowledges into a better understanding of climate change and variability, and the development of robust adaptation alternatives. Indeed, local, national, and international organisations have recognised Indigenous knowledges as essential to addressing complex environmental problems and many have demonstrated that such knowledge often facilitates decision-making in ways that are diversified, risk-averse and cost-effective. Indigenous knowledges are not a panacea for the conflict surrounding the many regions of the world experiencing the impacts of climate change, but they can provide a pathway to 'seeing with two eyes' – that is, to articulate an agenda that reflects the strong sustainability and development aspirations of the wider community, Indigenous and non-Indigenous alike.

Many alternative goals for the management of the Murray River answer to the requirement for an evidentiary basis. A choice cannot be made on this basis alone – interests are implicated in any

alternative. For the Yorta Yorta people, the relationship with their Traditional Lands is one of purpose, meaning and duty rather than ownership. The Yorta Yorta have asserted their sovereign rights since the European invasion in the mid-nineteenth century because of this deep purpose – the land, the river, the flora and fauna have needs to be respected and attended. Importantly, this obligation extends beyond those entities native to Yorta Yorta country: Yorta Yorta law states that the well-being of any people on country must be supported. This includes people from neighbouring clans, European settlers, and any other visitors.

Hence, we take as our working approximation that the obligations implied by Yorta Yorta law and culture are both necessary and sufficient to support the common interest of the Australian people in the maintenance of this region as a home to sustainable cultures, ecosystems and industries.

The starting point is the understanding that Indigenous knowledges are not simply local ecological knowledges with a 'cultural twist'. Indigenous knowledges utilise a range of perspectives from physical to allegorical to spiritual which provide significant challenges to researchers trained in scientific paradigms. For example, while sustainability framings typically assume that environmental assets are fungible, the Yorta Yorta framing engages a responsibility to protect and use appropriately each particular place, understood multi-generationally (i.e. 'everywhen'). Thus, the story of Bayadherra the Broad-shelled Turtle, as related in reference to particular landmarks and locations, provides guidance for looking after country in an ontology that is understood to be actually, as well as metaphorically, valid¹.

The challenge in this context is to develop and implement a methodology that provides for the collection of knowledge, some of which remains secret to the researcher, but allows for this knowledge to be accounted for in developing decision support for environmental policy. Our methodology has piloted a model – the Youth and Elders Talking Journey – which includes the adoption of legal and ethical protections for all participants, training of Circle of Youth and Elders in cultural data collection methodologies and supporting them to undertake it; and tagging of landscape elements using a Yorta Yorta developed values. This part of the research is described in Section 2.

The next step in developing decisions support for environmental policy based on this knowledge is to integrate it in a Geographical Information System (GIS) framework with conventional data such as the geographical, ecological, climatic, cultural, political, social and economic environment of the region. This integration allows layering of different kinds of information, as analysis of trends and relationships between the data sets. This part of the research is described in Section 3.

In order to identify the interests at play in making water policy for this region, we also conducted a study of regional perspectives. The part of the research (Section 4) aimed to identify the inherent diversity of viewpoints with regard to the changing drought and flood regime and the efficacy of Indigenous co-management with an aim to identify the potential for common ground.

The products of the research can inform conventional approaches to sustainable management of the environment via an entirely novel way of conceptualising and viewing social-ecological systems in an Indigenous context. The key conclusions, policy implications and recommendations of this research are provided in Section 5.

¹ See Lynch AH, Griggs D, Joachim L, Walker J (2012) The role of the Yorta Yorta people in clarifying the common interest in sustainable management of the Murray-Darling Basin, Australia. *Policy Sciences*, **46**(2): 109–123, doi: 10.1007/s11077-012-9164-8.

2 Community knowledge collection

This component of the project aimed to develop effective and robust approaches to the collection of Yorta Yorta knowledge, and to test and refine them through the collection of actual cultural data to be integrated into the GIS framework.

The challenge in this context is to develop and implement a methodology that provides for the collection of knowledge, some of which remains secret to the researcher, but allows for this knowledge to be accounted for in developing decision support for environmental policy. Our methodology has piloted a model – the Youth and Elders Talking Journey – which combines the following elements:

- adoption of legal and ethical protections for all participants, including non-disclosure agreements and guidelines for decision support product developments;
- training of Circle of Youth and Elders in data collection, archiving, and quality-control, and assisting them in carrying out actual interviews; and
- tagging of landscape elements using a Yorta Yorta developed values label protocol and linkages to other elements.

The principles of this methodology were determined through consultation with the Yorta Yorta Elders Council, who emphasised maintaining the traditional method of transferring the knowledge across generations. The overall approach was for trained Yorta Yorta youth volunteers to accompany Elders to places of cultural significance in the Barmah-Millewa National Forest and record knowledge associated with these places with voice recordings, photography and Global Positioning System (GPS) data. These methodologies, chosen by and endorsed by the Yorta Yorta Elders Council, are also largely employed as community and participatory tools in Indigenous research.

A key driver for this project is ethical and respectful relations among researchers and Indigenous partners, and hence authentic engagement with traditional knowledge keepers both within and beyond the research team is embedded in all stages of this research. Intellectual property protections offer good engagement with local values, concerns and practices. Intellectual Property Right Agreements are important relationship-builders that help to accurately connect the particular engagement with the wider context of Geographic Information Systems. Being clear about what the technology is, and is not, permits users, decision-makers and researchers achieve realistic expectations of what the software can help achieve.

Having long experience with the distortion of their traditions by colonial institutions, the Yorta Yorta have been cautious in these engagements. Collaboration with researchers has involved laying out clear principles for how the technology, technicians, researchers, and even the Internet, were to link with Yorta Yorta practices before commencing data collection.

This engagement started with the articulation of key principles to govern the engagement, which include:

1. The ownership and copyright of cultural data and Indigenous knowledge collected is always held by the Yorta Yorta person from whom it was collected.
2. The right of Yorta Yorta people to keep secret and sacred their cultural knowledge will be respected.
3. YYNAC is to be consulted in all stages of data management, handling and storage.
4. YYNAC has the right to determine their way in which the data and information are to be accessed, presented and delivered.
5. YYNAC has the right to control exploitation of their cultural and intellectual property contained in the GIS database.
6. An approval process and IP agreement with YYNAC will be implemented for the use of the data.

Based on these principles, a 'pack' of safeguards articulating these principles at different stages of the data collection and analysis was developed. The pack includes the following components, most of which are living documents to be updated as further experience is gained:

- **Explanation and consent form:** An explanation for Yorta Yorta Elders providing traditional knowledge as part of this project of how the information they provide will be protected and used. The Consent portion of the document is signed by the participants and is kept at YYNAC. The Explanation portion remains with the participant.
- **Confidentiality agreement:** A confidentiality agreement signed by project team members with access to the traditional knowledge data collected or made available by YYNAC as part of this project.
- **Cultural data collection protocol:** A protocol describing the process for Yorta Yorta cultural data collection under the auspice of this project, including volunteer training, equipment use, preparations for interviews, the interview process, and post-interview data processing.
- **Traditional knowledge GIS protocol:** A protocol for how Yorta Yorta traditional knowledge collected or accessed as part of this project will be stored and protected within the GIS framework developed for this project.
- **Intellectual Property Agreement:** A legally binding agreement that defines intellectual property in this case, identifies ownership of that property now and in the future, and where applicable grants a licence for specifically defined uses. Because of the complexity of IP law, particularly in relation to traditional knowledge, a draft created by an international IP expert is currently being comprehensively assessed by Yorta Yorta pro bono legal representatives for the Australian legal context and for the legal and other arrangements of the Yorta Yorta.

Under these principles and protections, the process of knowledge collection involved training youth volunteers from the local community in cultural interviewing techniques, and having them accompany Elders to places of cultural significance in and around the Barmah-Millewa Forest. The youth interviewed the Elders, and recorded interviews and the locations visited with voice recordings, photography, GPS and notes (see Figure 2).

An intensive data collection campaign was undertaken in May 2012 after several rounds of training for the youth volunteers and pilot interviews to test the methodology. The campaign involved 13 Yorta Yorta Elders and 6 Yorta Yorta youth. Members of the research team were on hand to support the participants. The campaign yielded around 25 hours of audio recordings at over 100 locations.

The recordings were transcribed and tagged with landscape elements using a Yorta Yorta-developed values label protocol and linked to other elements, including information on strength and directionality, in an affinity network. These values included, for example, healing, system cleansing, and traditional skills. This approach results in a complete but appropriately ambiguated picture of the landscape that accurately reflects Yorta Yorta country.

This information, together with the other cultural data collected, were input into a GIS framework, for the Yorta Yorta community to access and use. All the data was archived at YYNAC. Any data that was passed on to other members of the team for analysis, was deleted when it was no longer in use.

While a considerable amount of cultural data was collected, it none-the-less represented a small portion of Yorta Yorta knowledge. Therefore this initial data collection campaign was intended to not only support capacity building in data collection but, more importantly, initiate an on-going and long-term practice that supports inter-generational oral history tradition. There was considerable enthusiasm within the community for this exercise, and the Yorta Yorta have since conducted several follow-up interviews. One of the youth participating in the collection campaign has put together a digital story, 'My learning on Country'² describing her experience in participating in this exercise and its impact on her.

² My Learning Country by Berniece Joachim, www.youtube.com/watch?v=ycB2E3HwJDI



Figure 2: Cultural data collection: (a) equipment, (b) training, (c) & (d) interviews.

3 Integrated maps and products for the Yorta Yorta region

One of the key aims of this project was to integrate Yorta Yorta knowledge with conventional information in a way that would allow the Yorta Yorta to develop new ways of understanding and articulating their needs and insights about the Barmah-Millewa area, as input to policy and management processes affecting the region.

This was done through a GIS framework that combines the Yorta Yorta knowledge collected as part of this project (Section 2) and other sources with conventional data on the geographical, ecological, climatic, cultural, political, social and economic environment of the region. The latter type of data were collected from many different sources, including the Victorian Departments of Sustainability and Environment (DSE) and Primary Industries; NSW Land and Property and the NSW Office of Environment and Heritage; Goulburn-Broken, North Central and Murray Catchment Management Authorities; the Murray-Darling Basin Authority; the Australian Bureau of Meteorology; the Australian Bureau of Statistics and the Arthur Rylah Institute for Environmental Research. The process for collecting data for the base maps took considerable effort and time, as the region spans two states and many administrative organisations. A full list of the datasets included is provided in Appendix A.

Simply putting all this data in the same GIS framework and exploring it with simple data layering provided significant and powerful information about the region for the Yorta Yorta, as they have not previously had good access to GIS capabilities or access to such a variety of information in one place.

However, through the project the team has identified considerable potential for the further development of analytic and integrated products to support management of the region. Two examples that are currently under development are analysis of regional climate variability and a study to determine the connection between land form and cultural use, both of which are described briefly below.

The first study examined the long records of rainfall and temperature for Yorta Yorta Traditional Lands that are available at Echuca, Rutherglen and Deniliquin (see Figure 3). The records demonstrate two important climatological events in southeast Australian history – the ‘Federation Drought’ at the turn of the 20th century and the ‘Millennium Drought’ at the turn of the 21st century. The records show that the pattern of episodic flooding evident since before colonisation has continued. Indeed, the geomorphology and surface water dependent ecosystems indicate that there were periods of greater flow prior to the development of irrigated agriculture in the region. These floods are regarded by Yorta Yorta people and scientists alike as necessary for the replenishment of the natural food sources and for the survival of the forest-wetlands for the enjoyment of future generations.

During the Millennium Drought temperatures were higher than average, and indeed each drought in the second half of the 20th century has been warmer than the last. There is some basis for the claim that the Millennium Drought was, at least in part, a manifestation of climate change. The higher temperatures have resulted in enhanced evapotranspiration, reduced water availability and reduced flows in the upper Murray River. Despite several seasons of flood after the Millennium Drought, river temperatures have stayed high, and turtle numbers low. ‘Black water’ – oxygen-depleted water that occurs as a result of the decay of organic matter – has remained ubiquitous even after several flushing events. Prolonged flooding has killed the understory in low lying sites, and river red gum has started to encroach into areas that had been grassland. However, nesting water birds have experienced their best breeding seasons in 60 years.

The second study used multivariate analysis to identify the probability of cultural use by landscape features such as proximity to water and elevation. One group of uses identified was characterised as having a low relative elevation and was located close to rivers and streams. Cultural uses within this grouping included permanent and overnight camps, fishing sites, hunting sites associated with aquatic species, and other cultural activities most associated with water. A second group identified had a greater relative elevation and was at a greater distance from streams. Cultural uses associated with this grouping included permanent residences, upland wildlife hunting and plant uses, burial sites, and other uses more associated with drier areas. These results confirm some of the obvious connections we would expect to see between landscape features and cultural uses. Future work will be benefited by better geolocation of cultural activities in order to provide a more robust analysis, as will additional data sets describing current and potential vegetation and landcover, and a more robust analysis of

floodplain inundation. The team is currently investigating using this landscape form approach to prioritise areas for the delivery of environmental flows.

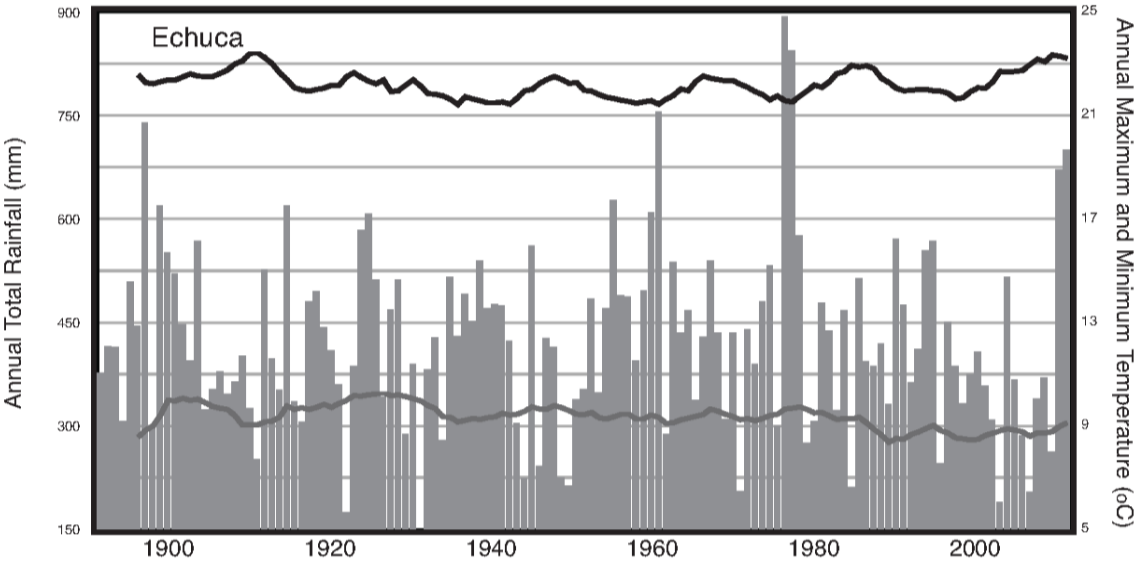


Figure 3: Long-term climate records at Echuca: total annual rainfall (bars), annual average maximum temperature (black line) and annual average minimum temperature (grey line) (data source: Australian Bureau of Meteorology).

4 Community perspectives of regional water policy

In order to identify the interests at play in making water policy for this region, we conducted a study of regional perspectives³. We used Q methodology, an approach that elucidates patterns of subjectivity and describe a population of viewpoints, to explore the perspectives of residents, practitioners and decision-makers in the region. We addressed the inherent diversity of viewpoints with regard to the changing drought and flood regime and the efficacy of Indigenous co-management with an aim to identify the potential for common ground.

Q methodology is carried out by first identifying a set of statements that represent all aspects of the debate on the given topic (the “concourse”), and then asking participants to sort those statements relative to how much they agree or disagree with them. A factor analysis is then used to identify participants with similar sets of responses or viewpoints.

In this study, the concourse development began with an extensive literature and media review of printed material and electronic sources to identify statements that are congruent with elements of the framework. Approximately 140 files and document sources were reviewed. A theory-led sampling process was then used to develop the concourse. Through an iterative process, coverage of a spectrum of opinions was validated through identification of duplications and recurring patterns; this is termed the concourse saturation point. From this pool a final set of 27 statements were selected that captured the general themes and reflected the analytical framework of policy innovation and diffusion (see Appendix B).

For the purposes of this study, we were primarily interested in soliciting views and opinions from individuals who live and work in the Barmah-Millewa region and surrounding districts. In Q methodology, a limited number of participants is both acceptable and appropriate. Through the assistance from the Office of the Commissioner for Environmental Sustainability and YYNAC, the survey invitation was distributed through a range of networks in the region in a semi-targeted approach. Three different means for survey dissemination were employed: (1) a brief email for direct communication with potential participants; (2) a general invitation suitable for posting on social media outlets such as the Commissioner’s personal blog and Facebook page; and (3) a brief email for dissemination by YYNAC to their networks in the region. The survey was administered entirely online, and a total of 37 valid and complete responses were collected.

A key finding arising from the Q analysis of these responses was the identification of three distinct perspectives or ‘discourses’ on policy processes in this community. The first perspective presents a viewpoint that promotes protecting the river through government regulation, and supports both the Commonwealth water buyback scheme to underpin environmental flows, and the engagement with traditional owners through co-management agreements. Respondents who shared this perspective were 25% self-identified Indigenous people, and the respondents’ occupations were split evenly among local government, state government and non-governmental organisations. There was a particularly strong focus on the management of floods, and an understanding that over-bank flooding is a natural part of ecosystem functioning in this region.

The second perspective presents a viewpoint that supports government investment in the Murray-Darling Basin but demonstrate very low respect for the Murray-Darling Basin Plan and the federal government and its experts in developing appropriate policies. There was, indeed, particular concern by those sharing this perspective that the planning process in place at the MDBA was not flexible enough to respond to the rapidly changing circumstances as the region moved from long term drought to extreme flood. This perspective also places the viability of the agricultural industry in a broader context, invoking the valid common interest goal of food security for Australia and local community vitality.

Participants who held the viewpoints characterised by third perspective, of whom less than half self-identified as Indigenous, considered that legitimate engagement with the Yorta Yorta people should largely outweigh broader economic, social or environmental outcomes.

An aspiration in this analysis was to determine if there was common ground that could serve as a starting point for a more positive discourse around the Murray Darling Basin planning process.

³ See also Lynch, A.H., Adler, C.E. & Howard, N.C. (accepted). Policy Diffusion in Arid Basin Water Management: A Q-method Approach, *Regional Environmental Change* for further details.

However, the perspectives identified in this analysis share little common ground on the goals of water policy in the region and on how the planning process should be undertaken, suggesting that there is little scope for mutual interests to emerge. There is one key exception to this, and that is that all perspectives strongly and genuinely desire substantive and respectful community engagement, and perhaps this has not been observed in the planning process so far.

5 Policy implications and recommendations

This project aimed to understand how the deep knowledge of country of the Yorta Yorta people could combine with state of the art climate science to strengthen their participation and influence in national and regional management processes and how climate adaptation could be incorporated in those decisions to deliver improved management outcomes.

At the outset of the project it was anticipated that the main tool through which this would be carried out was a GIS database. Into this database as much information as possible would be collected from conventional sources to capture the current state of knowledge within the region. Although data was often disparate and difficult to obtain the resulting database has succeeded in pulling together in a common framework, in a single system, a vast array of climate, hydrology, biodiversity, administrative, imagery, socioeconomic and cultural data. Lack of coherent information accessible to all greatly hinders the ability to make sound management decisions regarding management of natural resources within a region. Hence, even without any Indigenous information a GIS database of the type developed here is a valuable tool as a basis for sound decision making, including on climate adaptation. The main difficulties encountered in the process of collecting the data were (1) tracking down who held the various datasets, particularly across state boundaries, and getting in contact with (and getting responses from) the right people; (2) obtaining permission to use the data, and to show to other stakeholders; and (3) dealing with non-uniform data (e.g., for vegetation) across agencies or state boundaries.

Policy recommendation 1

- Federal, state and local governments should make every effort to establish common data requirements for natural resource management, including what variables should be measured, how often and to what accuracy.

Policy recommendation 2

- The Victorian Government should facilitate wider and easier free access to data collected and owned by the State.

Following the creation of the GIS database the next step was to collect and also incorporate into the database Indigenous knowledge from the Yorta Yorta. The process of having the Yorta Yorta youth collect the Indigenous knowledge facilitated transfer of knowledge from one generation to another, raised community awareness and knowledge; it also energised the Yorta Yorta youth to take an interest in their history and culture, as well as in the climate challenges facing their community.

This has resulted in a community which is much more informed and knowledgeable about climate change and which is now taking action to adapt and even to provide leadership to other Indigenous communities to start them on the journey of understanding the potential impacts of climate change on their community.

The fact that the Indigenous knowledge in the GIS database has been created by and is owned by the Yorta Yorta means that they have something of value to bring to policy and regional management discussions, so that they are able to participate in those discussions on equal terms. Also, the increased knowledge and capacity developed within the community now means that they are much better informed and confident in those discussions. This is valued both by the Yorta Yorta and the Victorian Government equally, the latter now feeling they are able to have a more informed dialogue about shared management of natural resources. However, this dialogue has been hampered by changes in personnel within the Government, in particular the change in personnel as a result of the restructuring of DSE and DPI to form DEPI. This set-back has been magnified by the fact that Indigenous culture is based on development of trust and the establishment of long term relationships.

Policy recommendation 3

- The Victorian Government should consider carrying out similar projects with other Indigenous communities across Victoria as a means of raising the capacity within those communities to undertake climate adaptation actions and to enable meaningful engagement in the policy process. The Yorta Yorta would be well placed to take a leadership role in such a process.

Policy recommendation 4

- Where possible, government personnel should be supported to retain long term relationships with Indigenous communities even as their functional responsibilities change. Where personnel come for the first time into positions where relationships with Indigenous people are important, those staff should undertake cultural awareness training and should take time to build relationships and understanding of community values and history.

The study of the wider community perspectives on the use of water resources in the Yorta Yorta region identified a wide range of often conflicting views. However, one statement stood out as the one that the vast majority of participants agreed on, namely:

Decisions about who gets the water should be informed by the best available science, but they also require community input and political deliberation.

While this statement could be said to contain ‘something for everyone’, it does indicate that substantive community engagement is desired, and perhaps has not been observed, in the planning process so far.

Policy recommendation 5

- There is the potential for greater use of science in the management of the water resources in the Murray River region. Even more important is the need for genuine, deep, open-minded dialogue with the community at all stages of decision-making, particularly at an early stage before proposals are put forward and views become entrenched.

Reform of natural resource management protocols in times of challenge often fail when the credibility, admissibility, or domain of scientific knowledge is called into question. During the public discourse surrounding innovations in policy in which valued outcomes are at stake, all of these characteristics can be challenged and thereby delay or prevent policy implementation.

It has been observed, particularly with respect to common good resources such as water, allocative efficiency is often enhanced by setting decision-making authority where the participants are optimally positioned to assess costs and benefits. This concept is known as the subsidiarity principle, which places the burden of proof for greater centralisation on those who make demands for a high-level authority to perform a function.

Recent literature seems to make a strong case that certain aspects of centralised water management are more efficient and effective. With specific respect to water quality, decentralisation – particularly in federalist governments – results in weak environmental outcomes, with significant free-rider problems. Given our analysis that supports collaborative decision-making, ongoing opposition to innovative approaches to ensuring environmental sustainability, and academic literature that leans towards some level of centralised control (either politically or for coordination purposes), is a centralised framework more optimal over the former, more decentralised arrangements? This question remains a key element of the unfolding implementation phase of the Murray-Darling Basin Plan.

This research project has been an enormous learning process, both for the research team and the Yorta Yorta. Prior to the research project beginning there had been a two year period where both parties simply talked together about issues, each learning to see things from the others perspective and building trust. Even then when the project started it was viewed with suspicion by many within the community and this suspicion has only been eased as the research project has progressed and the community have seen that their concerns have been respected. Even though the project has lasted two years this has only been enough time to begin to scratch the surface of the joint research that could be done.

Policy recommendation 6

- Successfully carrying out research projects with Indigenous communities requires the development of trust built through long term relationships and friendships, flexibility in project design and deliverables, and other requirements that make these projects difficult to carry out within conventional research funding structures. The Victorian Government should invest in a specialised long-term research programme that accommodates these requirements and enables and empowers Indigenous communities to participate in managing natural resources.

Appendix A GIS data collected

Hydrology

Dataset Name	Description	Geographic Extent	Data Source
Hydrological features	Includes watercourses, connectors, lakes, dams, flats wetlands, rapids, waterfalls, shorelines, junctions, and springs, wells, navigation features, water-related structures	Victoria	DSE, Vic
Groundwater measurements	Water level and salinity measurements from State Observation Network bores	Yorta Yorta area	DSE, Vic
Hume dam management	Time series of Hume Dam releases and storage levels	Hume Dam	NSW Office of Water
Surface water measurements	Includes time series of water flow and level, electrical conductivity, temperature and dissolved oxygen	Yorta Yorta area - NSW	NSW Office of Water
Surface water measurements	Includes time series of water flow and level, electrical conductivity, temperature, dissolved oxygen, water quality	Yorta Yorta area - Victoria	DSE, Vic
Blackwater monitoring	Weekly measurements of dissolved oxygen from Nov 2010 to April 2011	Murray-Darling Basin	MDBA
Phytoplankton counts	Measurement time series, 1980–2008	MDB	MDBA
Water bodies	Locations of water bodies	Barmah-Millewa Area	DSE, Vic
Regulators in Barmah area		Barmah-Millewa Area	DSE, Vic

Meteorology

Dataset Name	Description	Geographic Extent	Data Source
Estimated mean climate variables	Estimated long-term mean monthly evaporation, monthly maximum temperature, monthly minimum temperature, monthly rainfall and annual rainfall. Interpolated to a 500m grid cell using the DEM250 layer and the ESOCIM software	Victoria	DSE, Vic
Long-term climate time series	Time series of maximum temperature, minimum temperature and rainfall since 1930 in Deniliquin, Echuca and Rutherglen.	Yorta Yorta Region	Bureau of Meteorology / Brown University
Seasonal probability density functions of daily climate variables	Seasonal probability density functions of daily maximum temperature, minimum temperature and rainfall for Rutherglen, Deniliquin and Echuca over the		

Biodiversity

Dataset Name	Description	Geographic Extent	Data Source
Native vegetation, 2005	Modelled dataset of native vegetation and major water-based habitats in 2005. Includes extent, quality, and the Bioregional Conservation Status of Ecological Vegetation Classes (EVCs)	Victoria	DSE, Vic
Barmah Dissolved EVCs	Ecological vegetation classes	Barmah area (Victorian side)	DSE, Vic

		only)	
Victorian bioregions	Includes areas designated as rainforests, wetlands, Ramsar wetlands, areas of significance	Victoria	DSE, Vic
Victorian Biodiversity Atlas	Snapshot of data as at July 31, 2011, including fauna and flora taxa	Victoria	DSE, Vic
Tree cover and tree cover change	Woody vegetation greater than 2 metres in height and with a crown cover greater than 10%, and it's change over the period 1990 and 1995	Victoria	DSE, Vic
VicMap vegetation	Vegetation features within the VicMap dataset. Includes tree density levels and presence/absence of tree cover	Victoria	DSE, Vic
Vegetation maps of the Barmah-Millewa	Includes Vegetation map of the Barmah National Park DRAFT data (2010) and Vegetation map of Murray Valley National Park DRAFT data (Millewa) (2010)	Barmah-Millewa area	NSW OEH
Murray vegetation mapping	Native Vegetation of the Murray Catchment Management Authority Area	North Yorta Yorta areas (in NSW)	NSW OEH
Annual ground surveys of waterbird communities	Seasonal monitoring results for waterbirds and bush birds within Barmah-Millewa from 1999-2012	Barmah-Millewa area	Rick Webster, Ecosurveys and NSW NPWS via MDBA
Monitoring of fish species and abundance	Fish monitoring over 2007-2011	Barmah-Millewa area	Vic DSE Arthur Rylah Institute via MDBA
Turtle distribution in the Barmah-Millewa		Barmah-Millewa Area	DSE, Vic

Administrative, cadastre, planning, addresses and infrastructure

Dataset Name	Description	Geographic Extent	Data Source
Administrative areas in Victoria	Vicmap Administrative Dataset, including local government areas, locality boundaries, postcodes, township boundaries, parish boundaries, state electoral boundaries (1991 and 2001), wards and region boundaries	Victoria	DSE, Vic
Australian Standard Geographical Classification	Boundaries of administrative and statistical areas used in Census 2006, Census 2011 and other ABS publications	Victoria and NSW	ABS
Planning	Land-use zones and overlay controls for planning.	Victoria	DSE, Vic
VicMap Property dataset	Includes land parcels and property boundaries	Victoria	DSE, Vic
Vicmap Address	Includes number, road name and locality details.	Victoria	DSE, Vic
NSW Digital Cadastral Database	Includes parcels, roads, water features, administrative boundaries, crown land, corridors	Murray-Murrumbidgee	NSW LPI
VicMap Features of Interest dataset	Includes Register of Geographic Name, build-up areas, utility features, buildings, fences and landmarks	Victoria	DSE, Vic
VicMap Transport	Includes rail infrastructure, road	Victoria	DSE, Vic

dataset	infrastructure, ferry routes, airport infrastructure		
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Satellite and aerial imagery

Dataset Name	Description	Geographic Extent	Data Source
SPOT5 satellite imagery	2.5 m resolution satellite imagery for 2006, 2008 and 2010	NSW	SPOT Image via NSW OEH
Colour infrared aerial orthophotography	Taken in March-May 1996	Barmah-Millewa Area	GBCMA
Aerial imagery	25cm resolution aerial image for Barmah-Millewa Area from 2007	Barmah-Millewa Area	GBCMA
Aerial imagery	50 cm resolution aerial imagery from the Digital Image Acquisition System	Murray Murrumbidgee (NSW)	NSW LPI
Infrared aerial photography		Barmah-Millewa Area	GBCMA

Land features

Dataset Name	Description	Geographic Extent	Data Source
VicMap elevation dataset	Includes elevation, morphology features, ground type, relief features	Victoria	DSE, Vic
Digital elevation mapping (DEM)	5m pixel DEM of Barmah-Millewa Area	Barmah-Millewa Area	GBCMA
Southern MDB LiDAR	DEM derivative products	Southern Murray area	NCCMA
Salinity	The extent of dryland salt-affected soil and statewide coverage of dryland salinity discharge sites	Victoria	DPI, Vic
GeoVic maps	Includes geology and geological and structural features, mine and mineral areas, minerals, petroleum and groundwater boreholes	Victoria	DPI, Vic

Socio-economic

Dataset Name	Description	Geographic Extent	Data Source
Statewide Land Use		East-Victoria	DPI, Vic
Catchment-scale land use		Yorta Yorta area	Australian Government, Department of Agriculture, Fisheries and Forestry
Public land management		Victoria	DSE, Vic
Census Data 2011	Data from the 206 and 2011 Census, including total population, population density, Indigenous population, Indigenous language spoken population	Yorta Yorta area	ABS
Regional population growth, Australia	Population estimates by Statistical Local Area, 2001 to 2011, including	Yorta Yorta area	ABS

(3218.0)	growth rates and population density		
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Cultural data

Dataset Name	Description	Geographic Extent	Data Source
Yorta Yorta Use and Occupancy Mapping 2008		Barmah-Millewa Area	YYNAC
Cultural data 2012	Cultural interview data including GPS points, photos, audio and transcripts.	Barmah-Millewa Area	YYNAC
Murray CMA Aboriginal assets	Cultural assets in the NSW Murray CMA area identified through community workshops run by Murray CMA and OEHL in 2010.	Murray CMA Area	Murray CMA

Appendix B Statements for community perspectives

The final set of 27 statements used to capture the discourse on policy innovation and diffusion in relation water management in the Murray-Darling Basin region, used in the community perspectives study.

1. The proposed Murray-Darling Basin Authority Basin Plan hardwires in the need to optimise social, economic, and environmental outcomes.
2. The Murray-Darling Basin Authority ignores the potential impacts from record breaking flood waters by refusing to include new flows in scientific modelling for its water planning measures.
3. The Australian Government should engage with Aboriginal people around the country to develop a legislative framework that provides for protection of their traditional knowledge, such as knowledge on rivers.
4. Both NSW and Victoria should not agree to support the Basin Plan, given the Murray-Darling Basin Authority's failure to explore other options available for achieving environmental outcomes.
5. If floods are too high they will damage the river banks. Protecting the banks is more important than protecting the environment.
6. The conversion of state forest into national park, with some co-management by local Aboriginal people, has been a successful strategy for managing public lands.
7. Farmers need access to reliable information on regional seasonal outlooks and farm management practices based on specific needs so they can decide what's best for their own business.
8. The Murray-Darling Basin Authority should listen to practical alternatives offered by farmers, such as the offer of land for flood easements to enable increased environmental flows.
9. Aboriginal people should be supported in their efforts to quantify the amount of water needed to keep their cultural and spiritual legacy intact.
10. Farmers should work together to monitor and compare weather and soil conditions that yield good crop outputs for their region.
11. There is sufficient information from professional associations like Dairy Australia for farmers to rely upon for information on how to cope with floods.
12. Indigenous peoples have managed these lands and waters in a sustainable manner for many thousands of years.
13. Decisions about who gets the water should be informed by the best available science, but they also require community input and political deliberation.
14. The relationship between the Commonwealth and the States regarding the River Murray is the single biggest water management issue to be resolved.
15. Co-management of the Murray River between Government and Aboriginal people could provide a mechanism for negotiating both environmental and cultural objectives.
16. It is better for individual dairy farmers to respond to drought with their own efficiencies that balance the cost of growing grass and using water with that of buying feed.
17. Buying up cheap water during floods when the prices are low helps to moderate the volatility of water price.
18. Water should be allocated to Aboriginal communities directly to promote environmental management and economic development.
19. Flexible farm management, using for example crop diversification and soil monitoring, provides effective insurance against variable seasons.
20. Farmers can take advantage of changing rainfall patterns by adapting their management of pastures and calving programs.
21. There are economic benefits for Aboriginal people from eco-tourism and cultural tourism.
22. There should be Government assistance available to improve the efficiency of water use. Where there is public benefit, there should be public investment.
23. Rivers should be protected by Government regulations from abuse and overuse.
24. Elders are held in Aboriginal society with respect, and this needs to be given empowerment by Government through an effective decision-making role.
25. Milk production in the Goulburn Murray Irrigation District could dip to drought-like levels of 1.6 billion litres if the Federal Government pursues further general water buyback tenders.
26. The red gum forest and its wetlands have come back naturally after the drought and so concerns about environmental flows are unfounded.
27. Pursuing legal avenues, such as Native Title Claims, divert Aboriginal people from participating in mainstream Australian economic activity.

