Promoting the inclusion of Indigenous knowledge in natural resource management:

a case study from the Wet Tropics of Queensland, Australia

Thesis submitted by

Monica Gratani

BSc. (Hons), MAppSc.

For the degree of Doctor of Philosophy in the

College of Marine and Environmental Sciences

James Cook University, Australia

February 2015

To my son, Tommaso.

Acknowledgements

I would like to take the opportunity to thank the many people who supported, motivated and encouraged me during this journey.

I will start by thanking my son, Tommaso: For most of your young life I have been busy, distracted, worried, excited and depressed about my PhD research. I spent time away from you while in the field, or overseas for conferences, and often when I was with you I was daydreaming about my research. You have been patient with me and I thank you for this. You have been my main reason for doing this. I just want you to be proud of your mum. The book I was writing is this, and it is done! Now we can get our lives back and have a lot of fun together. I love you immensely!

Thanks to the members of the Malanbarra Ydinji and Dulabed community, the Traditional Owners of the Goldsborough Valley, for allowing me to work with them. I am particularly grateful to the elders of the community, and to Frank, Rita and Agnes Royee among them, for sharing their knowledge of Country, their wisdom and their stories – stories of resilience, courage and strength. You, your stories and your teachings will always be with me and are now a part of my story too, and for this I am immensely thankful. Thanks also to Allison Halliday, Lillian Clubb, Linda Ferrington, Veronica Mays and Lorraine Muckan, as well as the other youth and elders of the community for taking part in my project and for welcoming me in your Country and often in your houses. I will always remember each and every one of you, and will come for a visit every time I can, I promise!

My supervisors: Thank you James for always believing in me, even when you had no reason for doing it. You are committed to making a difference and you surely made a difference in my life. I am deeply grateful to you for your unconditional support. Thanks to Peter Valentine for accepting me as a student even when he was planning a dynamic retirement exploring the beautiful "Land Downunder" and spending time with family. I will always remember (and miss) your wisdom and our deep and meaningful conversations. Thanks also to Steve for having taking me on in my final year of PhD studies when Peter retired. It was risky, but we did it, and I hope it was not too painful for you. Thanks also to Erin, Simon and Damien for challenging my assumptions, views and writing; I certainly learned a lot from each of you.

This is the right occasion to thank some of the distance-mentors who inspired me during my academic years. Helene Marsh, Yetta Gurtner, Emma Gyuris and Erin Bohensky: you are inspirational women for your capacity to be exceptional academics while also being mothers. I am not sure I will ever be as successful as you are, but if I survived my PhD I certainly did so because I looked up to your examples.

My friends and family: Andrea, thanks for coming all this way in search of a better life, and for your friendship. I know I would still be dreaming for all of this to happen if you hadn't taken the risk with me, so thank you! A special mention to Rie, with whom I have shared my years in Australia as well as a house for a couple of them. You are a wonderfully talented woman and I treasure our friendship. Thanks for being there for me all these years. Thanks to Rie, Alex, Milena, Coralie, Kristen, Alvaro and Aurelie for interesting discussion on methodologies, epistemologies, research, academia, etc., and many lighter and perhaps more interesting life-related topics. Thanks also to the turtle (and yes, dugong) lab people for providing a bit of social life in my years at the School of Earth and Environmental Sciences … Taka for being so hilarious, Joao for reading my tarots, Regina, Sara, Amy, Juliana, Mariana and Ibrahim … and Ruth, for being the best office mate I could dream of having, and for sharing laughs and tears in Room 241. Townsville wouldn't have been so much fun without you all!

Mum, Dad, Brother and Sister: I am not quite sure you know what I have been doing "Downunder" all these years, but this is it and it is also thanks to you, your love and support! A special thought to my wonderful niece Sofia: I missed out on you growing up but now this project is finished I promise I will come and visit you more often!

Pranavan ... thank to you too!

Statement of the Contribution of Others

Supervision

- Dr. Steve Sutton, James Cook University
- Dr. James Butler, CSIRO
- Dr. Erin Bohensky, CSIRO
- Dr. Simon Foale, James Cook University

Supervision over the initial phase of the research

- Assoc. Prof. Peter Valentine, James Cook University
- Dr. Damien Burrows, James Cook University

Additional analytical and editorial support

- Dr. Alexander Anderson, James Cook University (Chapter 6)
- Shannon Hogan, Adelpha Publishing & Design

Support during field work

- Warren Ian Canendo, Cultural Broker for the CSIRO

Research funding

- James Cook University, International Postgraduate Research Scholarship
- School of Earth and Environmental Sciences, James Cook University
- CSIRO
- Ngā Pae o te Māramatanga (New Zealand's Māori Centre of Research Excellence), Conference Fee Waiver Scholarship
- Society for Ecological Restoration

Ethical approvals and permits

The research presented in this thesis was conducted in compliance with the JCU requirements for conducted research with Aboriginal and Torres Strait Islander peoples. The study received ethics permit number H4367.

Outputs during candidature

Peer reviewed publications

Gratani, M., E. L. Bohensky, J. R. A. Butler, S. G. Sutton & Simon Foale. 2014. Experts' perspectives on the integration of Indigenous Knowledge and science in the Wet Tropics Natural Resource management. *Australian Geographer* 45(2): 167-184.

Gratani, M., E. L. Bohensky, J. R. A. Butler & S. G. Sutton. In review. Integrating knowledge or worldview? A conceptual framework to promote integration of indigenous knowledge as a worldview.

Gratani, M., J. R. A. Butler, F. Royee, P. Valentine, D. Burrows, W. I. Canendo & A. S. Anderson. 2011. Is validation of indigenous ecological knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management from the Wet Tropics, Australia. *Ecology and Society* 16(3): 25.

Gratani, M., S.G., Sutton, J.R., Butler, E.L. Bohensky & S. Foale. In review. Indigenous environmental values and ethics to inform sustainable water management: broadening understanding through a case study from the Wet Tropics of Queensland.

Conference proceedings

Gratani, M. & J. Butler. 2010. *Stepping out of our paradigm: A path for the integration of scientific and traditional ecological knowledge in natural resource management.* In*: Proceedings of 4th International Traditional Knowledge Conference*, 6-9 June 2010, The University of Auckland, Auckland, New Zealand.

Conferences presentations

Gratani M. *et al.* 2011. *Is action research possible in natural resource management? Reflection from a case study from the Wet Tropics of Queensland*. Oral presentation: Closing the Gap Mini-Conference, School of Indigenous Australian Studies and The Cairns Institute, James Cook University, 2 September 2011.

Gratani M. *et al.* 2011. *Can we prioritise ecological restoration by using indigenous values for the environment? A case study on the use of a TEK-based index of freshwater ecosystem health in the Wet Tropics World Heritage Area, Australia.* Oral presentation: Society of Ecological Restoration, Merida, Yucatan, Mexico, 21-25 August 2011.

Gratani M. *et al.* 2010. *Is validation of Indigenous Ecological Knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management from the Wet Tropics, Australia*. Oral presentation: "Cultural perspectives on biodiversity research and management", New Zealand Ecological Society Conference Biodiversity: 2010 and Beyond, Dunedin, New Zealand, 21-25 November 2010.

Gratani M. *et al.* 2010. *How can we integrate traditional ecological knowledge in freshwater management?* Poster presentation: "Cultural perspectives on biodiversity research and management", New Zealand Ecological Society Conference Biodiversity: 2010 and Beyond, Dunedin, New Zealand, 21-25 November 2010.

Gratani M. *et al.* 2010. *Integrating traditional ecological knowledge in freshwater management: from theory to practice*. Oral presentation: Marine and Tropical Sciences Research Facility Annual Conference, Cairns, Australia.

Gratani M. *et al.* 2010. *Is validation of Indigenous Ecological Knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management from the Wet Tropics, Australia.* Oral presentation: Fourth Indigenous Traditional Knowledge Conference, Ngā Pae o te Māramatanga (New Zealand's Māori Centre of Research Excellence), Auckland, New Zealand, 6-9 June 2010.

Gratani M. *et al.* 2010. *On the need to introduce specific formative activities on how to do research respectful of Indigenous cultures*. Table talk: Fourth Indigenous Traditional Knowledge Conference, Ngā Pae o te Māramatanga (New Zealand's Māori Centre of Research Excellence), Auckland, New Zealand, 6-9 June 2010.

Author's Notes

Prior Publication

At the time of thesis submission, two data chapters – Chapters 3 and 6 – have been published. I would like to thank the journals *Ecology and Society* and *Australian Geographer* for allowing me to reproduce those chapters in this thesis.

Concepts and Definitions

Some of the terms and concepts used in this thesis deserve a dedicated declaration as to their intended use, for the richness and complexity of their semantic.

I use the term *indigenous* in two different ways in this thesis. When I refer to *Indigenous* Australians, the term qualifies a people; it conveys respect for Indigenous Australians. In contrast, I use the adjective *indigenous* when I discuss more generally the original inhabitants of one or more countries.

As for who Indigenous Australians are, I acknowledge the right of indigenous people to self-identify, while converging on the United Nations' definition of indigenous people as "descendants – according to a common definition – of those who inhabited a country or a geographic region at the time when people of different cultures or ethnic origins arrived. The new arrivals later became dominant through conquest, occupation, settlement or other means" (United Nations Permanent Forum on Indigenous Issues). I acknowledge that in non-settled countries the identification of indigenous peoples may not be so straightforward and as a consequence the term *indigenous* is controversial. I do not, however, consider an extended discussion of this concept necessary in the context of Indigenous Australia, where my research took place.

Similarly to *indigenous*, I use the term *country* in two contexts. Country has a special value for Indigenous Australians, as discussed by Rose (1996; p. 8): "Country is multi-dimensional – it consists of people, animals, plants, Dreamings, underground, earth, soils, minerals and waters, air ... People talk about country in the same way that they would talk about a person: they speak to country, sing to country, visit country, worry about country, feel sorry for country, and long for country". In this context I use the capitalised term *Country*, as opposed to indicating a geographic entity such as a state,

land or nation, whereby I refer to *country*.

From *Country*, the notion *Caring for Country* descends, a concept which expresses the nurturing relationship Indigenous Australians have with their Country. As Burgess and colleagues (2005; p.118) summarise, "for many Aboriginal peoples [natural resource management] is 'caring for country' because it embodies deep spiritual obligations and patterns of behaviour prescribed by enduring metaphysical associations with geography".

Finally, I initiated this thesis holding a conceptualisation of *indigenous knowledge* as a special case of *traditional ecological knowledge*, which is a "cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes *et al.*, 2000; p. 1252). I understood *indigenous knowledge* to be the traditional ecological knowledge retained by indigenous peoples of the world, and I agree that indigenous knowledge is biocultural knowledge (Ens *et al.*, 2015). However, soon into my research (Chapter 3) I initiated enquiry into how the term was understood within the context of my case study. This led me to formulate a wider conceptualisation of indigenous knowledge as a *worldview* (Chapter 4), which encompasses and extends Berkes and colleagues' conceptualisation. It is as a *worldview* that I now understand indigenous knowledge.

Abstract

The Indigenous Australian perspectives on how to live in the natural environment and use its resources has been historically marginalised in the post-contact era. Internationally however, the body of knowledge, practice and belief about the relationships between living beings and their environment held by indigenous people, often referred to as *indigenous knowledge* (IK), has been steadily gaining currency over the past few decades on the grounds that IK can support the biological and cultural diversity of ecosystems, can add to the understanding provided by science, and is instrumental to achieving social justice. Hence, combined with advances in Indigenous health, education and law, a higher representation of IK in Australian Natural Resource Management (NRM) is being pursued.

The application of IK in NRM is hindered by some research gaps as well as poor understanding of what IK is and attitudes towards IK. Firstly, debate about IK often implicates its relationship with science. The way and depth in which IK and science are perceived and understood determines how they are approached, and ultimately how they are integrated and used with NRM. Nevertheless, an investigation of perceptions of different knowledge systems is seldom conducted by any parties before cross-cultural NRM is attempted. Secondly, a lack of clarity exists as to whether IK or science should be considered a *worldview*; this conceptualisation is sometimes hinted at in the literature but not fully explored, and the implications of looking at IK as a worldview are not discussed. Finally, while integration of IK in NRM is happening in practice, there are few theoretical frameworks and little academic debate. There is a need to discuss more theoretical aspects of integration processes. My thesis sets out to address these knowledge gaps through a participatory case study conducted in collaboration with the Malanbarra and Dulabed Yidinji people, traditional owners of a UNESCO heritage area within the Wet Tropics of Queensland in tropical northern Australia.

I began by exploring local Indigenous and non-Indigenous NRM experts' perceptions of IK and science, and their integration in cross-cultural NRM (Chapter 3). In this initial phase of the study, I found that, (1) in terms of *knowledge*, conceptualising integration of different NRM perspectives was limiting, and IK is perceived as a worldview; (2) issues relating to the epistemological understanding of different knowledge systems and

their mutual recognition need to be addressed to promote use in NRM; (3) platforms for collaborative knowledge validation need to be specifically developed; and (4) environmental values and ethic are essential parts of IK as a worldview, hence integrating different values is necessary for cross-cultural NRM. My exploration of these themes adds to the current understanding of IK in the Wet Tropics. The findings from Chapter 3 provided research directions that I tackle in the following data chapters.

In Chapter 4, I research conceptualisation of IK and, based on data from my field work and surveys and a systematic review of the literature, I propose that IK should be conceptualised as worldview. I found that themes discussed during my surveys with IK holders and in the literature on integration of IK in NRM align with dimensions of worldviews, as outlined in the worldview literature and, in particular, a model of the "worldview" theorised in the 1990s by the philosophers Apostel and Van der Veken. Based on my results, I argue that the debate on integration should not revolve around integrating IK and science – or scientific knowledge – but rather focus on developing an integrative worldview.

In Chapter 5 I further develop the importance of integrating different environmental values and ethics for NRM. I use a framework to relate human values to environmental ethics that was developed in the field of environmental psychology and is informed by the theory of universal human values prepared by Schwartz. My results show that the community of Indigenous Australians I collaborated with holds altruistic values and an eco-centric environmental ethic. My study is the first in Australia to look at indigenous environmental values as human values through the lens of Schwartz's universal theory of human values. In this chapter I also propose to use such theory as a platform to understanding and integrating different environmental values.

In Chapter 6, I tackle the perceived need in my study area for a better understanding of the epistemological recognition of IK. I do this by shedding some light on the current processes of knowledge production used to produce IK, and I also look at how such processes could be integrated with scientific processes. In this chapter I also discuss how collaborative environmental monitoring and joint hypothesis setting and testing can support the epistemological validity of IK and ultimately cross-cultural NRM in the Wet Tropics. Moreover, the chapter presents an indigenous worldview-informed monitoring system for freshwater environments as an avenue for fostering inclusion of indigenous

worldviews in NRM.

In Chapter 7, I design a platform to support knowledge sharing and validation for NRM. My study brings to light and discusses in favorable terms the process of "validation", which is often perceived as disrespectful to indigenous people. My results for this chapter suggest validation is a natural process of the human mind in seeking to understand, and that collaborative and respectful validation has great potential in building mutual exchange of understanding around the natural world. I argue the adoption of such a platform for knowledge validation by Wet Tropics NRM agencies would increase our understanding and use of IK.

My final discussion, Chapter 8, further develops some themes recurrent in my thesis, and I conclude that, (1) the satisfactory inclusion of IK in Wet Tropics NRM would be achieved by indigenising NRM, and by infusing the eco-centric values and ethic that is held by local indigenous communities, which may also increase the sustainability of local NRM; (2) validation and integration are processes favorable to the representation of IK in NRM; and, finally, (3) the constructivist approach to knowledge production and action research are instrumental to ensuring IK is truly represented in Australian cross-cultural NRM.

Contents

Acknowledgements i

Statement of the Contribution of Others iii

Author's Notes vi

Abstract viii

List of Tables xvi

List of Figures xvii

Chapter 1: General introduction 1

1.1 Preamble 2

1.2 The problem of the exclusion of indigenous knowledge in natural resource management 3

1.3 A resurrected interest in indigenous knowledge for natural resource management 4

1.4 Knowledge gaps around indigenous knowledge 5

1.5 Indigenous knowledge vs. western science: a problematic dichotomy 5

1.6 Resolving the dichotomy: bridging or integrating? 6

1.7 Thesis design and objectives 7

1.8 Thesis outline 8

1.9 The social ecological system which provides the context for my case study 10

Study Area 10

The Aboriginal inhabitants of the Wet Tropics and the Malanbarra and Dulabed Yidinji 19

Governance of Country in the Wet Tropics 26

Protection of intellectual property rights associated with Indigenous Knowledge 30

Chapter 2: A methodology for research in indigenous contexts. 31

2.1 Grounded theory and action research 32

2.2 The ethics of conducting research in indigenous context 35

2.3 Community engagement and participant recruitment 36
2.4 Methods for data collection 39

Chapter 3: Experts' opinions on knowledge integration in the Wet Tropics: perspectives on indigenous knowledge, science and their integration in natural resource management 41

Abstract 42
3.1 Introduction 42
3.2 Conceptual Background 43
Defining "knowledges" and their integration 43
The perceived superiority of science and scientific epistemology 45
Indigenous knowledge in the Wet Tropics World Heritage Area 46
3.3 Methods 47
Data collection and analysis 47
3.4 Results 48
Local perceptions of indigenous knowledge and science 48
Factors limiting knowledge integration 52
Opportunities for further integration 53
3.5 Discussion and Conclusion 55
3.6 Chapter summary, thesis map and research questions 60

Chapter 4: Rewording the debate around indigenous knowledge: indigenous knowledge as a worldview and its potential contributions to the integral sustainable worldview. 63

Abstract 64
4.1 Introduction 64
4.2 Modelling Indigenous Knowledge 66
4.3 Conceptual background 69
Worldview theories to date: a synopsis 69
Worldview theory relevance to NRM 71
4.4 Methods 73
Systematic analysis of the literature 74
4.5 Results and discussion 75
The eight dimensions of the indigenous worldview 80

4.6 Conclusion 83
4.7 Chapter summary 85

Chapter 5: Indigenous environmental values and ethics to inform sustainable water management: broadening understanding through a case study from the Wet Tropics of Queensland 87

Abstract 88
5.1 Introduction 89
5.2 Conceptual background: defining environmental ethic, values and associated constructs – insights from philosophy, psychology and social sciences 91
5.3 Methods 97
Study area 97
Choice of participants and interviewing process 97
Data analysis 98
5.4 Results and discussion 100
Indigenous values for the environment 100
Indigenous environmental values and the link with Schwartz's humanitarian values 107
The indigenous environmental ethic inferred from humanitarian values and its contribution to natural resource management 110
5.5 Conclusions 113
5.6 Chapter summary 114

Chapter 6: IK derived environmental monitoring systems as avenue for integration of epistemologies and worldviews 115

Abstract 116
6.1 Introduction 117
6.2 Part 1: The development of an IK derived monitoring system for the environmental quality of the Malanbarra and Dulabed Yidinji traditional estate 118
Methods: interviews and participant observations during collaborative field work 119
Results and discussion 121

Conclusion *125*

6.3 Part 2: Monitoring systems as avenues for integration of different epistemologies 126

Epistemological processes to integrate indigenous and non-indigenous worldviews *131*

Methods: interviews coding and participant observations *135*

Results and discussion: Avenues available for integration of indigenous and scientific epistemological processes *135*

Integrating the production of information from data: inferring cause-effect relationships and long-time trends *137*

6.4 Conclusions 138

6.5 Chapter summary 139

Chapter 7: Is validation of indigenous ecological knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management 141

Abstract 142

7.1 Introduction 143

7.2 Methods 146

Study area *146*

Community engagement *147*

Laboratory tests *148*

Reflections on the validation process *148*

7.3 Results and discussion 149

Laboratory tests *149*

Reflections on the validation process *151*

Toward a framework for knowledge validation *154*

Implications for the adoption of collaborative validation in natural resource management *158*

7.4 Chapter summary 160

Chapter 8: General discussion 161

8.1 Summary of research findings 162

Objective 1 ..... *162*

Objective 2 ..... *163*

8.2 Integrating indigenous knowledge and science: opportunity, limit and equity of the process 165

The opportunity: indigenising NRM? *165*

The limits: does integration imply loss of cultural diversity? *167*

How to "integrate" when local governance systems are so different *167*

The equity: which knowledge paradigm better supports the validity of different epistemologies? *168*

8.3 Concluding remarks and recommendations for future research 170

References 173

Appendix 203

List of references used in the systematic literature review 203

List of Tables

Table 3.1. Research themes explored and corresponding interview questions. 49
Table 4.1. Worldview content and dimensions as identified in Apostel and Van der Veken's model (modified from Vidal, 2008).....71
Table 4.2. Themes raised by participants discussing indigenous knowledge and science, and illustrative quotes.....76
Table 4.3. Worldview dimensions used to discuss indigenous knowledge in the literature, together with percentage of papers discussing them. 78
Table 4.4. Dimensions of IK as identified by different IK models. 80
Table 5.1. Humanitarian universal values, as conceptualised by Schwartz (adapted from Struch & Schwartz, 2002). 93
Table 5.2. Value types as defined by Schwartz (1994).....94
Table 5.3. Pre-set list of questions used to guide semi-structured interviews. 100
Table 5.4. Schwartz's values as verbalised by project participants. For brevity, only quotes to illustrate values with three or more entries are reproduced. 108
Table 6.1. Extract of the scoring sheet used by key participants to score indicators at the study sites. 121
Table 6.2. Indicators and criteria monitored by participants of the Wet Tropics case study. 122
Table 6.3. Scores attributed to study sites by key participants.....125
Table 6.4. Epistemological processes as emerged from the literature review and project participant interviews. 135
Table 6.2. Epistemological processes observed during the case study. 137
Table 7.1. Mean onset time for the two treatment concentrations of W and R applied to the tilapia, *O. mossambicus*. 149

List of Figures

Figure 1.2. The Wet Tropics bioregion and study area (circled). Illustration courtesy of Julie Tsatsaros. 12
Figure 1.3. The Native Title Determination Area for the Malanbarra and Dulabed Yidinji community. 21
Figure 2.1. The iterative cycle of data collection and analysis I adopted for my research. 34
Figure 3.1. Thesis map with summary of results for Chapter 3 and general research questions for data chapters. 61
Figure 4.1. The integral worldview, as conceptualised by van Egmond and de Vries (2011). 72
Figure 5.1. Value orientations, modified from Schwartz (1994). 95
Figure 5.2. Most common values verbalised by project participants, as defined by Schwartz (1994). 110
Figure 5.3. Value types most represented in my sample. 111
Figure 6.1. Epistemological process involved in the creation of data and information, and in its validation to produce understanding and ultimately knowledge as conceptual change. Here, square shapes represent "processes" and rounded shapes represent "outputs". 129
Figure 7.1. The three-step transformational process of knowledge production from new information, modified from Diemers (1999). 155
Figure 7.2. A framework for collaborative validation of indigenous ecological knowledge (IK). Here, trapezoid shapes represent "inputs" to processes, squares represent "processes" and rounded shapes represent "outputs". Dashed arrows represent potential independent accessing of information by western and indigenous knowledge systems outside a collaborative validation process. 157

Chapter 1: General introduction

"What sets worlds in motion is the interplay of differences, their attractions and repulsions. Life is plurality, death is uniformity. By suppressing differences and peculiarities, by eliminating different civilizations and cultures, progress weakens life and favors death. The ideal of a single civilization for everyone implicit in the cult of progress and technique impoverishes and mutilates us. Every view of the world that becomes extinct, every culture that disappears, diminishes a possibility of life!"

Octavio Paz, 1985

1.1 Preamble

In 2009 I was an international JCU Master's student, newly arrived in Australia. I was on a personal quest for social justice, environmental sustainability and personal growth, and was looking for a way to combine all three. I met Dr. James Butler, then leader of the CSIRO Indigenous Livelihoods research group. James and his research group were involved in an ambitious program which aimed to identify and develop enterprises and livelihood strategies to support community resilience, health and environment, poverty alleviation, and cultural and ecosystem benefits for Aboriginal Australia and the Pacific Islands. At the time, the group was had identified the research question, "How can western science and indigenous knowledge best work together to achieve community adaptation and transformation to sustainability?" A network of comparative case studies was being developed to address this and similar research questions in the multifaceted local contexts that researchers and communities' counterparts were working in.

James' leadership, commitment to making a difference and scholarly rigor impressed me. I joined James' Indigenous Livelihood research group and he became my research supervisor. At the time, James had opportunities for students to be involved in a number of case studies. I chose to work with the Malanbarra and Dulabed Yidinji, Traditional Owners of the freshwater environment of the Goldsborough Valley, just south of Cairns. My student-supervisor relationships with James, as well as our partnership with the Malanbarra and Dulabed Yidinji, grew during my Master's years to support PhD, hence this thesis.

When I started work with James, I set out to explore our group's key research question in the context of my case study. In doing so, I also wanted to develop the question in a way that would incorporate the Malanbarra and Dulabed Yidinji's own research agenda in an effort to empower them in the management of their traditional estate. I was, however, initially puzzled on how to serve both the community and academic research needs. I resolved that taking an action research/grounded theory approach to my case study would grant me the support of a solid research methodological framework while allowing me to include the community in the development of my study. This, as I further detail in Chapter 2, translated to me entering the field with initial general research questions to explore the reality of my case study, and to allow my field work

and collaboration with the Malanbarra and Dulabed Yidinji to dictate more refined research questions, the process of which I outline in Chapter 3.

An action research approach also supported my social justice motivation in undertaking work with Indigenous Australians. Initially I could not foresee how my relationship with community members in general and with some of the elders in particular would contribute to my personal growth and to my understanding of environmental sustainability issues. While I have not been able to channel everything I learned from them in this thesis – because a PhD thesis has to have an end at some point – I have highlighted those teachings that could be translated and described in academic terms. I have tried to do so in a way that I hope empowers the community's NRM, and inform enhanced NRM more broadly.

In the following sections I provide an introduction to the research questions this thesis focuses on, and I outline the research questions and objectives. I also describe my field site and the communities I worked with.

1.2 The problem of the exclusion of indigenous knowledge in natural resource management

Langton (1994, p. 99) wrote, "White people do not know and relate to Aboriginal people. They relate to stories told by former colonists". Mostly, such stories depict Aborigines as primitive hunter-gatherer societies, unable to influence the environment and at its mercy, as Elkin in 1974 narrated, "We apparently agree with the Aborigines that Australia was in their time only suitable for a food-gathering and hunting economy. The food-gathering life is parasitical; the Aborigines are absolutely dependent on what nature produces without any practical assistance on their part". The perception of Aborigines as sub-human generated strong preconceptions in early colonists, to the point that, even when they directly observed environmental management practices, they questioned that such practices were underpinned by a systematic understanding of the natural system. For example, when observing poisonous plants used to stun fish by Aborigines, Hamlyn-Harris and Smith (1916) commented that such plants were used because they were abundant rather than because their chemical properties were understood, since Aborigines' "child-mind seeks for no explanation, nor is it legitimate

to press for reason an intelligence that is at best but that of an overgrown youth" (Hamlyn-Harris and Smith, 1916, p. 2). The colonial take was that Aboriginal environmental knowledge was of a collection of practices, bequeathed upon generation without questioning, and implemented in a casual fashion: in the post contact era, the knowledge system of Australian first nations was almost annihilated and science, the knowledge system of the colonists, replaced it (Rigney, 2001). Still today, indigenous knowledge in Australia remains marginalised (Carter & Hill, 2007; Nursey-Bray, 2009).

1.3 A resurrected interest in indigenous knowledge for natural resource management

In the last decades, a strong interest in reviving and applying indigenous knowledge, hereafter referred to as "IK", in natural resource management ("NRM") has been taking place. This interest is supported by three lines of arguments (Bohensky & Maru, 2011). First, IK is essential to support biological and cultural diversity, which are increasingly recognised as interconnected (Maffi & Woodley, 2010, p. 5); by supporting IK, the cultural system that underpins it is also maintained. Second, there is widespread evidence that IK can supplement available scientific knowledge. For example, the Māori case study on IK-informed harvest of the Titi, *Puffinus griseus*, highlights how IK can provide long-term perspectives on trends in wildlife populations, past and current distributions, and associations between different species where scientific data are not available (Lyver *et al.,* 2009). Similarly, data from indigenous communities were aligned with scientists' concerns about the decline of small mammal fauna of tropical Australia, and provided insights into factors associated with species' decline (Ziembicki *et al.,* 2013). In Mexico, the application of the Lacandon peoples' knowledge of forest propagation is used to generate hypotheses about controlling invasive species, hypotheses that are then tested in collaborative research that involves indigenous elders and scientists (Douterlungne *et al.,* 2010). Third, and perhaps more importantly, IK maintenance is "tantamount to social justice" (Bohensky & Maru, 2011; p.1). Indigenous knowledge and the values it is based upon represent the perspectives and interests of marginalised indigenous people, which should be taken into account in contemporary NRM to achieve a more sustainable and participatory way of sharing the natural world (Kimmerer, 2002). Indeed, indigenous people advocate the inclusion of

their IK in NRM as a way to ensure the survivorship of their culture (Wet Tropics Aboriginal Plan Project Team, 2005).

1.4 Knowledge gaps around indigenous knowledge

While the previous sections have outlined the international interest in pursuing a better representation of IK in NRM, how to achieve such representation is still unclear. In reviewing the relevant literature, I identified some foundational gaps in current understanding of how to better include IK in NRM. First, the current focus on integrating IK and science, or scientific knowledge (see Section 1.5) appears problematic, because *knowledge* is a concept that is not univocally defined. The way IK and science are perceived in a specific context is paramount, since it informs the way professionals approach their inclusion in NRM (Nadasdy, 1999; Usher, 2000; Butler *et al.,* 2012; Weiss *et al.,* 2012). Hence, it should be clarified whether IK and science should be approached as knowledges or otherwise. Second, the international literature suggests a relationship between concepts of IK and worldview (Stephenson & Moller, 2009; Hikuroa *et al.,* 2010; Weiss *et al.,* 2012; Berkes, 2012); however, the implications of looking at the issue from a worldview perspective have not been debated. Third, some authors denounce that overall the integration of IK in NRM is happening in practice, with little or no academic debate (Castillo, 2009; Bohensky & Maru, 2011; Hill *et al.*, 2013); hence, there is the need to further the discussion on more theoretical aspects of integration (Bohensky *et al.,* 2013). These knowledge gaps have also been outlined for Australia (Bohensky *et al.*, 2013) and for the Wet Tropics (McDonald *et al.*, 2005).

1.5 Indigenous knowledge vs. western science: a problematic dichotomy

The literature around inclusion of indigenous perspectives in NRM often resolves that IK should be integrated with science. As I further discuss in Chapter 4, over 70% of the papers I reviewed on the issue of IK in NRM adopted the categories "indigenous" as distinct from "western" and "scientific" to present the different available perspectives in cross-cultural NRM. In post-colonial Australia, western science is often perceived as a

social institution that stands on western ontological and epistemological principles. These principles are also adopted by government policies and priorities, and perpetuate the mainstream cultural model. In other words, western science is the knowledge system of the oppressor and the indigenous people of Australia struggle to meaningfully participate in it (Rigney, 2001). Generally, scholars agree that currently supremacy is granted to science in informing NRM in Australia, and lament that the marginalisation of alternative knowledge systems, IK among them, could contribute to enhanced functioning and resilience of Australian social-ecological systems (Ross & Pickering, 2002; Allison & Hobbs, 2006; Nursey-Bray, 2009; Muller 2012; Weir 2012).

The integration of IK and science has, however, been criticised on the ground that it disregards the differences within each and the similarities between them (Agrawal 1995). While I acknowledge this criticism, I also recognise that in Australia the linguistic categories of IK and science are deeply entrenched in the post-contact debate on NRM and that they possess strong heuristic power. Therefore, I adopt such categories in my enquiry as well, as categories that enable me to explore concepts, constructs and perspectives around the issue of inclusion of indigenous perspectives in NRM. However, I remain aware that such terms can indicate different things to different people and remain open to the emergence of new concepts that better serve the debate on cross-cultural NRM.

1.6 Resolving the dichotomy: bridging or integrating?

The literature on cross-cultural NRM presents another set of problematic concepts associated with the dichotomy of IK and science. In fact, once it is established that distinct knowledge systems are available and somehow competing to inform NRM, usually researchers' or managers' efforts aim to resolve this dichotomy to achieve participatory NRM to deliver mutual benefits. Different authors prefer to describe their effort in different terms. Weiss and colleagues (2012), for example, resolve to "bridge" western scientific and indigenous knowledge, probably in an attempt to guarantee the equality of the two knowledge systems. However, this method emphasises that western and indigenous systems are separate entities. Nevertheless, most often the literature focuses on "integration" (Turner & Berkes, 2006; Houde 2007; Bohensky & Maru,

2011; Butler *et al.,* 2012; Stephenson & Moller, 2009; Usher, 2000). Bohensky & Maru (2011) and Bohesky *et al.,* (2013) thoroughly discuss the risks of using the term "integration", especially in a context like cross-cultural NRM, complicated by unequal power-sharing over resources. They conclude, however, that "integration" does not equal "assimilation". Similarly, I hereby adopt the concept of "integration" as a "process in which the originality and core identity of each individual knowledge system remains valuable in itself, and is not diluted through its combination with other types of knowledge" (Bohensky & Maru, 2011, p.6).

1.7 Thesis design and objectives

The overarching aim of this thesis was to investigate how western science and indigenous knowledge can best work together to achieve community adaptation and transformation to sustainability using a case study in the Wet Tropics. In reviewing the literature I identified some foundational gaps on the topic of including IK in NRM. It is not always clear what IK is and how it is perceived. Understanding how IK is perceived, especially by natural resource management professionals, is paramount to addressing integration of IK and other knowledge systems in NRM. Often IK is perceived as competing with science to inform NRM; hence avenues to integration are needed. In this context, to contribute to debate about how to integrate IK and science to inform NRM in the Wet Tropics, I developed two main objectives for my thesis:

Objective 1: Understand how IK and science are perceived in the Wet Tropics, and what hinders or supports their integration, by: (a) exploring the perceptions around IK and science and their integration held by Indigenous and non-Indigenous NRM experts from the Wet Tropics (Chapter 3); and (b) exploring academic aspects of the challenges of integration from a theoretical stand point (Chapter 4).

Objective 2: Identify avenues to further the integration of IK and science in Wet Tropics NRM. Conduct a collaborative ethnographic case study with a community of Traditional Owners of the area (Chapters 5, 6 and 7).

1.8 Thesis outline

This thesis is organised into eight chapters (Figure 1.1), with five data chapters (Chapters 3-7) written as standalone papers to facilitate submission to peer reviewed journals. At the time of thesis submission, two data chapters had been published (Chapters 3 and 5) and two chapters were in review (Chapters 4 and 7). Therefore, the data chapters of this thesis are presented as independent papers, with minor adjustments to improve their sequential readability. Some repetition is unavoidable, particularly in the background sections of the data chapters. A summary and diagram at the beginning and end of each chapter outline how each chapter fits within the thesis as a whole.

Chapter 1 (this chapter) provides a general introduction to the issue of the integration of IK with other knowledge systems to inform cross-cultural NRM. Additional background information is also provided in the background sections of the data chapters. Chapter 1 also identifies the main knowledge gaps my thesis attempts to address.

Chapter 2 presents and discusses the methodology I chose for this thesis: grounded theory and action research. I also detail the methods for data collection and analyses adopted for the data chapters. Further details on the methods are provided in the following stand-alone data chapters.

Chapter 3 is a key chapter for this thesis. I describe my initial exploration of the concepts of IK and science generated through research with Indigenous and non-Indigenous experts of the Wet Tropics region. I use the results from Chapter 3 to generate further research questions, congruous with grounded theory methodology. I wrote Chapter 3 and carried out all data analyses. Dr. E. L. Bohensky (CSIRO), Dr. J. R. A. Butler (CSIRO), Dr. S. G. Sutton (JCU) and Dr. S. Foale (JCU) assisted with study development and design, interpretation of results and editing. Chapter 3 has been published as:

> **Gratani**, M., E. L. Bohensky, J. R. A. Butler, S. G. Sutton & S. Foale. 2014. Experts' perspectives on the integration of indigenous knowledge and science in Wet Tropics Natural Resource Management. *Australian Geographer* 45(2): 167-184.

Chapter 4 investigates theoretical issues surrounding the conceptualisation of IK and, in less measure, science which emerged in Chapter 3. Chapter 4 culminates with a theoretical model to understand IK as a worldview. I wrote the chapter and carried out all data analyses. Dr. E. L. Bohensky (CSIRO), Dr. J. R. A. Butler (CSIRO) and Dr. S. G. Sutton (JCU) assisted with study development and design, interpretation of results and editing. Chapter 4 is currently in review as:

> **Gratani**, M. In review. Rewording the debate around indigenous knowledge: indigenous knowledge as a worldview and its potential contributions to the integral sustainable worldview.

Chapter 5 is the first of three chapters (Chapters 5-7) that present the ethnographic work I conducted in collaboration with the Malanbarra and Dulabed Yidinji community. This ethnographic work was required for my enquiry into IK to be meaningful and inclusive of indigenous inputs. In Chapter 5 I discuss the role of different and often competing values attached to the environment and their role in supporting or hindering integration of different knowledge systems in NRM. I wrote the chapter and carried out all data analyses. Dr. E. L. Bohensky (CSIRO), Dr. J. R. A. Butler (CSIRO), Dr. S. G. Sutton (JCU) and Dr. S. Foale (JCU) assisted with study development and design, interpretation of results and editing. Chapter 5 is currently in review as:

> **Gratani**, M., S.G., Sutton, J.R., Butler, E.L. Bohensky & S. Foale. In review. Indigenous environmental values and ethics to inform sustainable water management: broadening understanding through a case study from the Wet Tropics of Queensland.

Chapter 6 In Chapter 6 I explore avenues to improve the integration of IK and science from the epistemological point of view and present an IK based monitoring system for freshwater environment. I wrote the chapter and carried out all data analyses. Dr. E. L. Bohensky (CSIRO), Dr. J. R. A. Butler (CSIRO), Dr. S. G. Sutton (JCU) and Dr. S. Foale (JCU) assisted with study development and design, interpretation of results and editing. Chapter 6 contains information that the participant community regard as confidential; hence, at the time of thesis submission a publication for this chapter is not planned.

Chapter 7 further discusses the need for platforms for validation of IK to maximise its

inclusion in NRM, an idea which emerged from Chapter 3. I wrote the chapter and carried out all data analyses. Dr. J. R. A. Butler (CSIRO) and Assoc. Professor P. Valentine (JCU) assisted with study development and design, interpretation of results and editing. Dr. A. S. Anderson (JCU), Mr. F. Royee and Mr. W. I. Canendo provided advice regarding the cross-cultural engagement of the collaborating community, guidance during field trips, and provided insight into the interpretation of results. Chapter 7 has been published as:

> **Gratani**, M., J. R. A. Butler, F. Royee, P. Valentine, D. Burrows, W. I. Canendo & A. S. Anderson. 2011. Is validation of indigenous ecological knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management from the Wet Tropics, Australia. *Ecology and Society* 16(3): 25.

Chapter 8 summarises and discusses the findings from the five data chapters (Chapters 3-7), and considers their implications for the current approach to integration of IK in NRM in Australia.

1.9 The social ecological system which provides the context for my case study

Study Area

This research was conducted in the Wet Tropics World Heritage Area (WTWHA), which stretches along the northeast coast of Queensland from just north of Townsville to just south of Cooktown; a strip some 450km long and 50-100km wide (IUCN, 1988) (Figure 1.2). The WTWHA is located within the Wet Tropics bioregion, which covers approximately 2.2 million hectares. It includes Douglas Shire in the north, Hinchinbrook in the south, and extends west to include the Atherton Tablelands and Upper Herbert catchment (FNQNRM Ltd. & Rainforest CRC, 2004). At the time of nomination as a World Heritage site in 1988, the Area comprised 41 National Parks, 43 State forests (or parts thereof), 15 timber reserves and one Aboriginal and Torres Strait Islander reserve. Apart from a small amount of freehold titled and Aboriginal land under private control, land was publicly owned and comprised over 180,000ha under

national parks, approximately 500,000ha under State forests, over 100,000ha under timber reserves, and over 100,000ha of leasehold and vacant Crown land or federally-owned land used mostly by the defence forces. Total area was 920,000ha (IUCN, 1988). Since the nomination, cleared areas have been reforested, habitat fragmentation has been reduced, fire management is progressively being supported by newly developed scientific information, rare and threatened species have received a higher level of protection, and the increase in national parks within the Area has been significant, rising from 14% to 64% (WTMA, 2007).

Dramatic geomorphologic processes have created three main geomorphic regions in the Area; the tablelands of the Great Divide, the lower coastal belt and the intermediate Great Escarpment, which range from sea level to the highlands at 900m, with isolated peaks up to 1,622m in the case of Mount Bartle Frere, the highest mountain in Northern Australia (IUCN, 1988). The Great Escarpment is considered one of the most striking elements of the landscape and its present position is the result of catastrophic erosion. The three main geomorphic regions determine a high variety of geological features in the area and support its high flora and fauna diversity. Wet tropical rainforest is the predominant vegetation community. It is fringed and to some extent dissected by sclerophyll forests, woodlands, swamps and mangrove forests (IUCN, 1988). At the time of World Heritage nomination the rainforests supported some 1,161 species of higher plants, representing 523 genera and 119 families. Of the genera, 75 are endemic to Australia and 43 are restricted to the region. Of the species, some 710 are Australian endemics and 500 occur only in this area. The region is a stronghold for Australian members of the Proteaceae, with 13 genera and 40 species locally endemic, including *Placosoermum coriaceum*, one of the most primitive members of this family. Fauna diversity is the highest in Australia, with 30% of marsupial species, 60% of bat species, 18% of bird species, 30% of frog species, 23% of reptile species and 62% of butterfly species present. Some 54 species of vertebrates are unique to the area (IUCN, 1988).

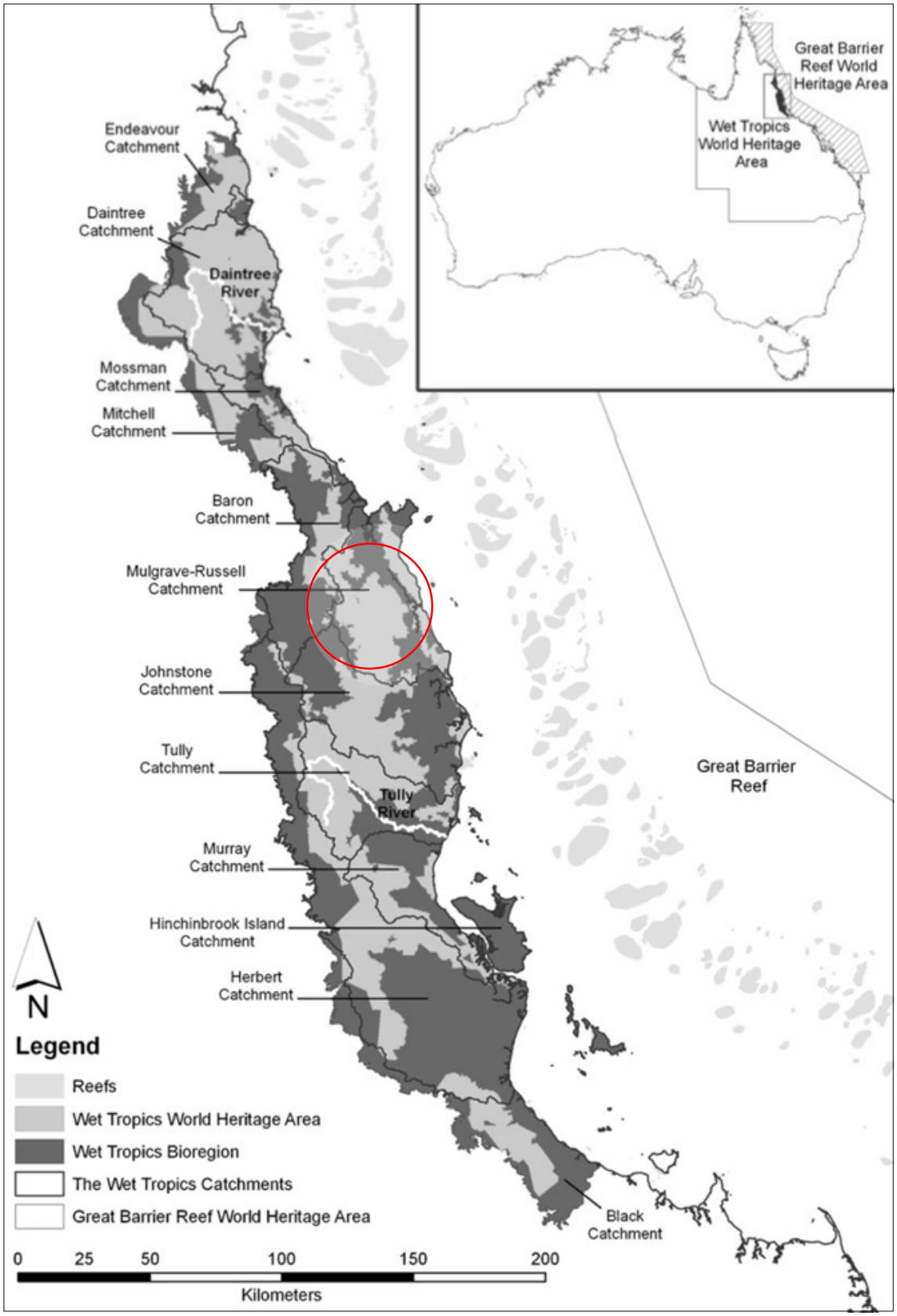


Figure 1.2. The Wet Tropics bioregion and study area (circled). Illustration courtesy of Julie Tsatsaros.

Wet Tropics' rivers support high fauna diversity. Their hydrologic regime represents an exception to the general trend presented by Australian tropical rivers: they experience highly seasonal rainfall, which determines extended periods of low flows during the "dry" season (Beumer, 1980; Bishop, 2001); while for rivers of the Wet Tropics, dry season base flows are maintained at relatively high levels by orographic rainfall. The fish diversity in these rivers is very high, with 107 species, including four exotics (Pusey & Kennard, 1996).

In 1987 the Australian Government nominated the Wet Tropics for listing as World Heritage Area for its cultural and natural values. The nomination was submitted to the UNESCO on the grounds that the area had unique natural conservation value for its evolutionary history, ongoing geological processes, exceptional beauty and conservation of threatened species value, relatively low impact from human activities and unique cultural value for the extant Aboriginal rainforest culture, whose occupation of the Wet Tropics rainforest dated back at least 40,000 years (IUCN, 1988). Indeed, Wet Tropics Aboriginal northern tribes, the Barrineans, are considered to represent the first wave of Aboriginal occupation of Australia, consequently they're the oldest rainforest culture in the world (DASETT, 1986). The Aboriginal rainforest culture differed markedly from that of most other Australian Aboriginal tribes, with its heavy dependence on arboreal skills, everyday use of toxic plants and unique weapons (Horsfall, 1984).

Despite the exceptional cultural value of the area, in 1988 the UNESCO endorsed the nomination of the area as a heritage site only for its natural value, and for representing *"one of the most complete and diverse living records of the major stages in the evolution of land plants, from the very first land plants to higher plants (Gymnosperms and Angiosperms), as well as one of the most important living records of the history of marsupials and songbirds"*. Additional reasons were the exceptionally high levels of *"species diversity and endemism, reflecting long-isolated ancient biota of the Australian wet tropics"* and the exceptional value of being home to numerous rare and threatened species of plants and animals (IUCN, 1988). The UNESCO recommended the management plans for the WTWHA be prepared in consultation with the 18 indigenous groups dwelling in the area. Since then, the Aboriginal first inhabitants of the Wet Tropics have had an advisory role in the management of the heritage area via two positions on the board of the Wet Tropics Management Authority (WTMA)

(WTMA, 2012).

Immediately following declaration of the WTWHA for its natural value, rainforest Aboriginal people indicated their wish to also have the property recognised for its cultural values. The Aboriginal people of the Wet Tropics regard their homelands as a living cultural landscape, and they perceive that the area's natural and cultural values cannot be separated. Cultural values include the living, continuous traditions of the Aboriginal peoples who are associated with the Wet Tropics. For this reason, Aboriginal people see their involvement in land management as essential for the survivorship of their culture (WTMA, 2002). There is widespread recognition that Rainforest Aboriginal people played a significant role in shaping the landscape to its current natural significance and in maintaining the outstanding value of the Wet Tropics region for many generations (WTMA, 2012). Research conducted in the area during the twenty years of the life of the heritage area aimed to outline whether there was a substantive case for a re-nomination of the property, in whole or part, based on cultural grounds (WTMA, 2002). On 9 November 2012, the indigenous heritage values of the WTWHA were included as part of the existing Wet Tropics of Queensland National Heritage Listing (WTMA website, retrieved on 10th April 2013). The listing for cultural values could also support recognition of the property in the UNESCO registry for its cultural values. A higher, formal recognition of the cultural values of the area is considered support for Aboriginal management aspirations for the area.

The exceptional biocultural diversity of the WTWHA faces a number of threats. Human population is rapidly growing in the area (WTMA, 2012), as is water extraction from northern tropical rivers to support household consumption (Cairns Regional Council, 2009). For example, immediately before the commencement of the Wet Tropics Management Plan, the expansion of the Herberton water supply resulted in the inundation of five hectares of open eucalypt forest, and a further one hectare was cleared in upgrading the South Mission Beach water supply pipeline (WTMA, 2002). Water scarcity could become a reality in the "wet" tropical north if water consumption issues are not addressed (Chartres and Williams, 2006), especially considering the threat of climate change to the area (WTMA, 2011). Altered drainage patterns and flow regimes are already direct pressures on the WTWHA (WTMA, 2002). Although water quality is still not an urgent concern in the area, erosion and subsequent stream turbidity and sedimentation, nutrients from erosion, fertiliser use and pesticide residue

contamination could become problems in the future if not halted (Tsatsaros *et al.,* 2013). Issues such as reduced dissolved oxygen, acid sulphate soil runoff, and biological factors such as weed infestation, reduced and degraded riparian vegetation condition, and river flow modification, which mainly arise from agricultural activities, are already impacting local waterways (Tsatsaros *et al.,* 2013). Clearing beyond the property continues, mainly for the establishment of crops and pastures, and in less measure for infrastructure and residential areas. Clearing has been described as a potential threat to long term integrity of the WTWHA because it fragments habitat, effects wildlife corridors, reduces habitat refuges, increases demand for water, reduces water quality, changes water tables, and introduces and spreads pest plants, animals and diseases (WTMA, 2002).

Invasive species also represent a major threat to the biocultural values of the WTWHA. Pest invasions are closely related to human activity disturbances, particularly clearings associated with service corridors such as power lines, easements and roads, which act as both habitats and conduits for pest dispersal (WTMA, 2002). Emerging invasive species such as electric ants (*Wasmannia auropunctata*), yellow crazy ants (*Anoplolepis gracilipes*) and myrtle rust (*Puccini psidii*) are recognised management priorities for the WTWHA (WTMA, 2012). Together with major vertebrate pests like pig, feral cat, cane toad, wild dogs, often crossed with dingos, fox and deer, they are among 28 naturalised vertebrate species within the region (WTMA, 2002). In addition, six exotic freshwater fish species have been detected in Wet Tropics rivers, and the translocation of large predatory native fish outside their natural range as part of regional recreational fish stocking projects is an emerging concern (WTMA, 2002).

Additionally, the exotic and highly invasive tilapia is a major reason for concern. Tilapia species' tolerance for a wide range of environmental conditions and their reproductive strategy enables them to be highly successful colonisers. Severe declines of native fish species have been related to the presence of tilapia in Colombia, Nicaragua, Madagascar and Nevada (Canonico *et al.,* 2005). In Australia two species of tilapia, *Tilapia mariae* and *Oreochromis mossambicus* have been introduced as ornamental species, and they are established in Queensland (Lintermans, 2004; Webb, 2003). Both tilapia species have become established in the Wet Tropics and their rate of population increase is rapid. For example, five *T. mariae* were released into a Port Douglas resort pond in 1989. Three years later over one million fish (18 tonnes) were

destroyed (WTMA, 2007). Tilapia are listed in Queensland as noxious species and considerable resources are devoted to managing their spread (QFS, 2001; WTMA, 2007).

Pest plants are also established in the heritage area. Within the Wet Tropics region, 508 naturalised exotic plant taxa have been identified, which amounts to almost 11% of the region's flora and represents almost 39% of Queensland's naturalised alien plant species total (WTMA, 2002). More than fifty of these regional naturalisations are currently considered environmental weeds which threaten or potentially threaten the heritage values of the Wet Tropics (WTMA, 2004). Several government agencies are responsible for pest control activities in the Wet Tropics. As the principal land manager, the Queensland Parks and Wildlife Service (QPWS) are responsible for the majority of pest control in the area. However, the Department of Environment and Heritage Protection also assists in the eradication and control of feral species under the *Land Protection Act* (2002) (WTMA, 2007).

The Mulgrave-Russell river catchment area covers 1,312km^2 of the Wet Tropics and is the region of the case study presented in this research. The catchment is home to a relatively high human population compared to other parts of the Wet Tropics with around 75,000 people, and it includes parts of Cairns (Gordonvale and Edmonton) and smaller towns like Fishery Falls, Little Mulgrave and Yarrabah. Mulgrave River, Little Mulgrave River, Behana Creek and Trinity Inlet are the key tributaries of the Mulgrave catchment. The main land use in the catchment is conservation, which makes up 77% of the area. Sugar (13%) and urban (5.3%) lands and "water" (4.0%) largely make up the remainder of the catchment area and are concentrated in the middle-lower sections. Small areas of dairy and plantation forestry are located in the upper catchment (Lewis & Brodie, 2011).

The Mulgrave-Russell river catchment (Figure 1.2) receives some of Australia's highest rainfalls. Rainfall is concentrated in the "wet season" months, typically from December to April, and is influenced by the monsoon and tropical lows/depressions. Reaching peak flow during the wet season, the river contains base flows all year round, likely fed by groundwater sources and persistent annual rainfall. In Gordonvale, the mean annual rainfall for the years 1897-2010 was 1,916mm. Rainfall is much higher in the upper catchment with Bellenden Ker recording a mean annual rainfall of 7,985mm between

1973 and 2010. Flow gauges on the Mulgrave River at Peets Bridge show the relatively low inter-annual variability of water flow in the Mulgrave River, with some notable exceptions of low-flow years (Lewis & Brodie, 2011). The mean annual flow data for the Mulgrave River is 730,000 ML (years 1971-2006). Trinity Inlet is the only wetland in the Mulgrave River catchment known for its high environmental values and listed on the *Directory of Wetlands in Australia*. This wetland receives some agricultural runoff and sewerage discharge (Lewis & Brodie, 2011).

Within the Wet Tropics, the Mulgrave River catchment has a particularly diverse fish fauna, with at least 70 species (including estuarine vagrants) sampled in the area (Halliday, 2001). The fish diversity of the Mulgrave River appears to be related to the high level of flow constancy that allows year-round access to the variety of habitats found in the river (Pusey *et al.*, 1995a). Study of fish feeding in the Mulgrave River ascribed 24 species of fish in five feeding guilds, with aquatic and terrestrial invertebrates and fish, supplemented by different types of vegetable material as the main source of food (Pusey *et al.*, 1995b). Detritus and bivalve and gastropod molluscs represent the main source of food for a lower number of fish species in the Mulgrave River (Pusey *et al.*, 1995b). Consistent water level in the Mulgrave River system and healthy riparian stream, which provides integration to the diet of local fish communities, is therefore necessary to maintain the fish diversity of the Mulgrave River system.

Key issues in the catchment are the increasing water demand from a growing population, water quality degradation, and increasing spread of aquatic pest species. For example, the Mulgrave River was identified in the 1970s as the source of a 15 ML/day groundwater intake to contribute to the existing Cairns city water supply. During my PhD research the extraction permit reached the implementation stage with upgrade of the existing groundwater pumping station in Behana Creek. This has raised concerns and opposition of local environmental groups, scientists and indigenous communities who are concerned that the project has not been subject to scrutiny by adequate environmental and social impact assessments. The local community fears the water intake may result in a flow reduction, especially in creeks downstream of the pumping station, which may threaten environmental and cultural values of the area. There is also concern, given the groundwater and surface water connection of the area is poorly understood, that the uptake may threaten a much larger area around the Mulgrave River (MLCG, 2010).

Wetland issues in the area include loss or lack of riparian vegetation (e.g. causing habitat loss and bank erosion), invasive weeds, wetland clearing and acid sulphate soils. Key in-stream water quality issues in the basin include elevated levels of dissolved inorganic nitrogen (nitrate), filterable reactive phosphorus, total phosphorus, and herbicides sourced to crop lands and sewerage treatment facilities. Elevated levels of nitrate are also found in ground water within the catchment. Recent estimates suggest sediment loads exported from the Mulgrave River catchment have increased up to five fold since European settlement (ca. 1860s), while dissolved inorganic nitrogen loads have increased up to ten fold, and total nitrogen and phosphorus loads are approximately five and eight times higher, respectively. The current annual load of herbicides delivered from the Russell-Mulgrave Basin (diuron, atrazine, hexazinone, ametryn, simazine and tebuthiuron) is estimated at 1,780kg. Of these, diuron is currently considered to pose the highest ecological risk in the basin. Another pesticide of potential concern is chlorpyrifos (insecticide) (Lewis & Brodie, 2011). Many terrestrial invasive species are present in the area (WTMA, 2007), and the highly invasive fish *T. mariae* appears to have established self-sustaining populations in the Mulgrave River waters (Burrows, 2009; Webb, 2007).

Water quality targets have been proposed for the Mulgrave River catchment, since the export of pollutants such as nitrate, herbicides, particulate nitrogen and phosphorus and sediment represents a risk to receiving water environments and, ultimately, to the Great Barrier Reef. Targets have been based on a combination of previous targets set for the Great Barrier Reef catchment area under the *Reef Water Quality Protection Plan* (DPC, 2009), and aim to achieve water quality concentration targets set by the Great Barrier Reef Marine Park Authority. The targets require for the Mulgrave catchment an 80% reduction in dissolved inorganic nitrogen (nitrate) loads, a 62% reduction in photosystem-II herbicide loads and a 20% reduction in sediment loads (and associated particulate nitrogen and phosphorus loads). The proposed targets may be achieved through the implementation of improved fertiliser and herbicide management practices on agricultural lands and the incorporation of riparian and grass buffers on cropping lands. Some of these purported practices have been adopted in the Mulgrave River catchment, although it will take some time before water quality monitoring programs can confidently measure reductions in pollutant exports (Lewis & Brodie, 2011).

The Aboriginal inhabitants of the Wet Tropics and the Malanbarra and Dulabed Yidinji

The Wet Tropics region is the most densely populated area in tropical Australia, home to 220,219 people (WTMA, 2007). This population is growing fast and is estimated to exceed 700,000 by the year 2031 (WTMA, 2012). In addition to the local population, about 4.4 million tourists visit the WTWHA every year (WTMA, 2012). Prior to World Heritage listing in 1988 the rainforests of the Wet Tropics region were extensively harvested for timber. Listing led to an outright ban on commercial logging in the area and to some other restrictions in usage. These restrictions polarised the community and determined adjustment to the new status and conversion of some businesses to alternative industries, such as tourism (WTMA, 2012). After twenty years however, the heritage area is entrenched in the life of the local community, the vast majority of which is satisfied with the current level of protection of the area despite the usage restrictions it determines (WTMA, 2012). Nowadays the area provides livelihood opportunities for residents, such as research and tourism, and recreational opportunities related to its natural and cultural values for both residents and visitors (WTMA, 2012).

There are nineteen Traditional Owner tribal groups within the Wet Tropics NRM Region. Eighteen of these are Rainforest Aboriginal groups, with a total of more than 20,000 rainforest Traditional Owners[1]. The Rainforest Aboriginal groups include Bandjin, Djabugay, Djiru, Girramay, Gugu-Badhun, Gulnay, Gunggandji, Jirrbal, Koko Muluridji, Eastern Kuku Yalanji, Mamu, Ngadjon, Nywaigi, Warrgamay, Warungnu, Wulgurukaba, Yidinji and Yirrganydji. Mbarbaram reside within the Wet Tropics NRM Region around Herberton, however they do not regard their group as being Rainforest Aboriginal people (RAPA, 2011). The traditional estate of 17 of the 18 Rainforest Aboriginal groups falls within the boundaries of the WTWHA (WTMA, 1998). Within the main tribal groups there are hundreds of family groups, each of them with its traditional estate, and at least 56 named and over fifty incorporated land and/or culture related Aboriginal governance organisations (RAPA, 2011). In the area there are also two Deed of Grant in Trust (DOGIT) regions located at Yarrabah and Wujul Wujul, which have Shire Councils established under the *Local Government (Aboriginal*

[1] Traditional Owners are Indigenous Australians who have been formally recognised as Native Title holders by a Native Title tribunal.

Lands) Act (1978) (FNQ NRM Ltd. & Rainforest CRC, 2004). Rainforest Aboriginal people are collectively represented through the Rainforest Aboriginal Peoples' Alliance (RAPA), a newly constituted Aboriginal governance institution in the area (WTMA, 2012) which aims to be one of the main Aboriginal governance actors in the area.

Aboriginal occupancy of the Wet Tropics dates around 40,000 years. The forest provided food, water, shelter, medicine and other numerous services to the original inhabitants of the Wet Tropics (Lee long, 1992). The Wet Tropics still provides a range of spiritual, ecological, social and economic values for Traditional Owners (WTMA, 2007). Approximately 80% of the WTWHA is potentially claimable under the *Native Title Act* (1993) (WTMA, 2002). In 2002, there were sixteen Native Title claims lodged with the National Native Title Tribunal over land in the World Heritage Area (WTMA, 2002). At the time of writing, the Djiru, Eastern Kuku Yalanji, Mandingalbay Yidinji, Wanyurr Majay (Yidinji), Malanbarra and Dulabed Yidinji and Gunggandji Traditional Owners have signed Indigenous Land Use Agreements (ILUAs), which also involve the Wet Tropics Management Authority (WTMA, 2012). ILUAs offer an opportunity to formally involve Wet Tropics Traditional Owners in managing the heritage property and in sharing economic benefits arising from the WTWHA (WTMA, 2007). In addition to ILUAs, other agreements are being negotiated by WTMA under the auspices of the Native Title Tribunal (WTMA, 2012) that aim at improving the indigenous governance of the area.

Malanbarra and Dulabed Yidinji estates are largely within the boundaries of the WTWHA. The language name for the Malanbarra traditional estate is *Bulmba Malanbara*, known also as the Goldsborough Valley, and this area is located between the Atherton Tablelands and the Mulgrave River (Figure 1.3). Traditional main campsites used by the Malanbarra were at the lower end of the Goldsborough Valley opposite Toohey's Creek, and on the Tablelands at Warrama Bora grounds, southeast of Lake Eacham (Nungabana, 1996). The Malanbarra belong to the language group of *Yidinji* (Tindale, 1974). The name *Malanbarra* means "people of the stony river bed": Malanbarra people traditionally depended on the Mulgrave River and surrounding rainforest resources and developed a deep knowledge on how to use them (Nungabana, 1996).

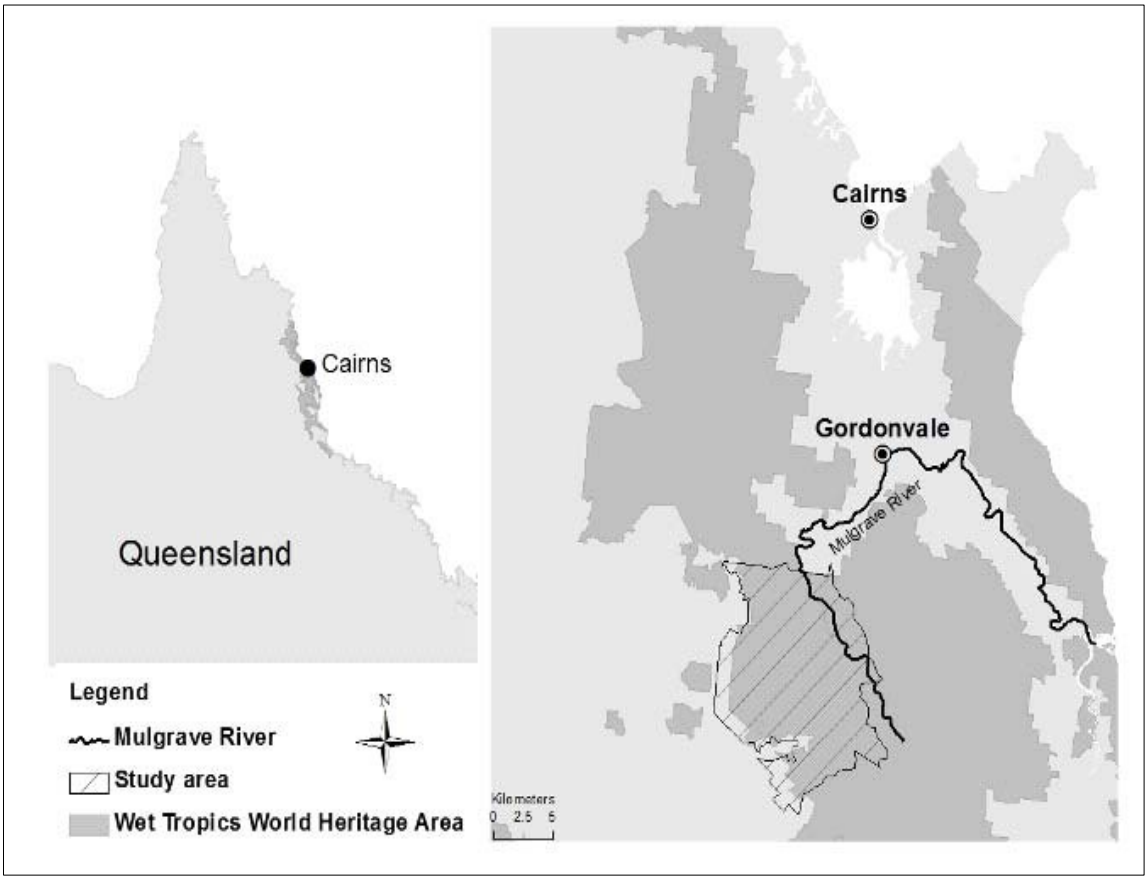


Figure 1.3. The Native Title Determination Area for the Malanbarra and Dulabed Yidinji community.

Lee Long reconstructed the post-colonial contact history of Malanbarra, mainly based on the work of Bottoms and Dixon, ethnographers who worked in the area, and of Savage, who referred to the expeditions of Christie Palmerston, an explorer who visited the Goldsborough Valley in 1882 and 1886. According to Lee Long, contacts between Europeans and Malanbarra were sporadic until 1879 (Lee Long, 1992), but still dramatic as testified by the following extract from an 1878 report by Police Commissioner Seymour (cited in Inglis, 1880, p. 66):

> *"The whole coast from the Mulgrave to the Mossman is studded with timber-getters and settlers, by whom the blacks are disturbed and prevented from obtaining their natural food while on the other side of the range the Country is all occupied by small cattle stations which again cut them off from their hunting and fishing grounds. The intervening scrub is small, affording but a scanty supply of fruits in their season, and the natives are*

> *literally starving, and take advantage of the cover afforded by the scrub to make sudden raids on the cattle and huts."*

In 1879 gold was discovered in the Goldsborough Valley, in the centre of Malanbarra territory. Conflicts increased due to the resistance of natives to European invasions and consequent development of mining and agriculture activities in the valley. Shooting and relocation of Malanbarra became common, especially after the passing of the *Aboriginal Protection and Restriction of the Sale of Opium Act* in 1897, with families taken to reserves such as Yarrabah and Palm Island (Lane-West, 1991). The consequent disruption of the traditional lifestyle and the forced removal from their traditional estate were devastating for the Malanbarra Yidinji. Despite their tormented past however, many contemporary Malanbarra managed to relocate to the areas of Innisfail, Gordonvale, Cairns and Atherton, close to the Goldsborough Valley. Today there are an estimated 400-500 Malanbarra dwelling in the proximity of the Goldsborough Valley (Delisle, 2008).

Contemporary Malanbarra reflected on whether they wanted to undertake cultural renewal and in 1989, with the foundation of the Malanbarra Tribal Aboriginal Corporation, they began to take action to re-awaken their traditional culture and regain control of their land (Lane-West, 1991). The first Malanbarra Tribal Aboriginal Corporation five-year plan prioritised anthropological and archaeological research to establish cultural links between Malanbarra and their traditional country, in order to form the basis of a Native Title claim for the Goldsborough Valley (Lane-West, 1991). Following this research, Native Title claims were lodged by different family groups of the Malanbarra and Dulabed Yidinji between 1994 and 1995 (Spender, 2009).

A second priority of the five-year plan was to interact with local research organisations to develop a community-based and culturally-sensitive environmental assessment of the Goldsborough Valley to evaluate impacts of mining, agriculture, forestry and other land use on water quality and ecology of the area. The assessment would facilitate the community's own management of the traditional estate and would facilitate negotiations for joint co- management with local government agencies. My PhD research has been informed by this second priority of the five-year plan, and as such has contributed towards the fulfilment of the community's own research agenda. My work with the community especially informed Chapters 5-7. In addition to what is discussed in these

chapters, I collaborated with some of the community elders and key informants to this project (see methodology discussed in Chapter 3) to develop a criteria and indicator monitoring plan that reflects community values and indigenous knowledge, part of which is discussed in Chapter 6, while part is omitted from this thesis due to confidentiality issues raised by the community members who shared the related knowledge.

The Native Title claims lodged by the community between 1994 and 1995 resolved in 2009 with the "Combined Dulabed and Malanbarra Yidinji Native Title" determination (determination PR09-27, 16 December 2009, registered in August 2010). By virtue of that determination, under the Native Title Act (1993) the Malanbarra and Dulabed Yidinji were recognised as Native Title holders of the claimed area. The determination area for Malanbarra and Dulabed Yidinji consists of 16,460ha of land and waters, about 37km south of Cairns. Exclusive Native Title rights have been recognised over a third of their claimed area, 6,540 ha of unallocated State land, while non-exclusive Native Title rights have been recognised over 9,920ha of reserves and national parks. Most of the determination area falls within the WTWHA (Justice Jeffrey Spender, who awarded the Native Title determination for the "Combined Dulabed and Malanbarra Yidinji Native Title Claim"; see Spender, 2009). At the time of writing, the Malanbarra and Dulabed Yidinji are awaiting a decision from the Native Title Tribunal on additional claims put forward for surrounding areas.

The Native Title legislation is a contentious issue in Aboriginal Australia. The *Native Title Act* (1993) results from the High Court of Australia decision on the Mabo vs. State of Queensland case of 1992, which was the first court decision to acknowledge Indigenous Australians' ownership of their traditional lands. The Mabo decision overturned more than two hundred years of doctrine of *Terra nullius* and posed the basis for the claim of land by the Indigenous of Australia. The *Native Title Act* (1993), as well as related legislation and policies today represents the most important legal framework that regulates how indigenous people can regain control and ownership of country and associated natural resources (McRae *et al.,* 1997). The Act however is deemed too weak to ensure any real benefit to Traditional Owners' communities. As summarised by Pearson (1998), the Act established:

> *"The blackfellas keep whatever is left over, the white-fellas keep everything*

> *they've already gained and the big area in between, you have to share it, but in sharing, the Crown title prevails over native title".*

Since 1993, it has become clear the litigation process to achieve the determination is slow, costly and stressful for individual and communities. It can create conflicts between Indigenous residential and Native Title communities, and it imposes "a burden of proof that would be difficult for anyone to meet, let alone people whose traditions are bound in oral transmission and limited selective written records" (Davies, 2003). Increasingly, indigenous communities in Australia argue that the Native Title process is more effective in validating the existing post-colonial land tenure than in returning land rights to the legitimate Traditional Owners. For example, commenting on their experience with the Native Title process, one of the participants of this research suggested:

> *"With Native Title we couldn't really choose, we got told 'you get this deal or you get nothing'."*

In association with the Native Title determination, ILUAs were negotiated between Malanbarra and Dulabed Yidinji people and the Cairns Regional Council, Tablelands Regional Council, Wooroonooran National Park, The State of Queensland, Ergon Energy and WTMA, and more were being negotiated at the time of writing. Themes discussed in the ILUAs range from infrastructure management, protocols for accessing areas to carry out works or activities, protocols for communications and assessments of proposed activities in the area, procedures for conducting works in the area and to rehabilitate the area following those works, the declaration of nature refuge areas and other areas for conservation, and the conduct of cultural practices and ceremonies in the area. ILUAs also validate the current land tenures in place in the determination area and outline the renunciation to the rights of pursuing compensation for present and future governments and to other Native Title rights by the Malanbarra community. The signature of such ILUAs was a prerequisite for the Native Title to be granted to the Malanbarra and Dulabed Yidinji people, as for Native Title process.

Since Native Title recognition, the Malanbarra community has established a Prescribed Body Corporate (PBC) to administer the determination area. The PBC represents today the main engagement and governance structure of the community. At the time of

writing, the PBC involved around one hundred adult members and another hundred underage members (Allison Halliday, pers. comm.). These PBC members represent the more active members in the management of the determination area.

In the governance structure adopted by the Malanbarra, twelve directors sit on the PBC administration board, three for each of the main clans existing within the community. Each clan represents the traditional custodians of an "area of responsibility" along the Mulgrave River within the determination area. Areas of responsibility controlled by the three main clans are the Upper, Middle and Lower Mulgrave River, for the tract of the river that is comprised within the Goldsborough Valley. The Middle Mulgrave clan, however, has not been acknowledged as Native Title holders in the Native Title determination. The clan's representatives therefore sit on the PBC board in an advisory capacity only and with no voting power, so as to reflect customary laws on the management of Country. Members of the Middle Mulgrave clan have appealed numerous times to the Native Title Tribunal to have the Native Title determination reviewed to include their Native Title on the area. Their appeals have to date been unsuccessful but the clan is determined to continue its legal fight to see what they consider their legitimate rights over Country recognised.

The disagreement on the Native Title determination is creating social conflict, tension and disruption in community governance and is taking a toll on claimants, as demonstrated by the following quote from two participants of this project:

> *"We are the legitimate local descendants, but we are not recognised, even if I am not sure that being recognised would change anything. I had a stress related disease for what happened for the Native Title thing. Unfortunately I took it as a personal thing, and became sick about it, it was not about Country anymore and I became very sick about it and I got very down, I crashed, I became depressed."*

> *"All the problems with Country here started when we* [submitted] *the Native Title claim. Before the Native Title process, family groups lived in peace and all clans knew their place, but with the Native Title they started attacking each other."*

Despite the limitations of the Native Title process and despite some scholars arguing

that Native Title legislation is in fact the principal hurdle to actual land rights for Indigenous Australians (Foley & Anderson, 2006), overall Native Title recognition in Australia has the potential to strengthen the role of the community in the co-management of their traditional land and offers additional potential benefits such as recognition and status, economic benefits arising from possible mining and exploration activities, and compensation from past government activities (Davies, 2003).

Governance of Country in the Wet Tropics

Several government agencies are in charge of managing the natural resources of the Wet Tropics, with the already cited QPWS and WTMA among them. The lead agency involved in stakeholder and Traditional Owner engagement is Terrain Ltd. (formerly FNQ NRM Ltd.), which is the regional board in charge of managing the Wet Tropics bioregion (FNQ NRM Ltd. & Rainforest CRC, 2004). In Australia, NRM responsibilities and funds are increasingly devolved to 56 regional bodies, one for each of the bioregions identified (McAlpine *et al.,* 2007). The philosophy behind such bioregionalisation is that natural resources are better managed by people residing in the area, and with a high level of local involvement. Australian bioregionalism emerged in the 1990s in response to the impacts of globalisation and metropolitan growth (Peterson *et al.*, 2007). Key strengths of the regional approach are that it is flexible, it facilitates landscape scale management, it enhances integration across agencies and governments, and it builds partnerships between local stakeholders (Paton *et al.*, 2004). Weaknesses have been identified in poorly developed methodologies that have limited integration at the regional scale, the high transaction costs involved in operating across the federal structure, insufficient autonomy for regional groups, and a lack of forward funding commitments to support the increasing load of work (McAlpine *et al.,* 2007; Paton *et al.*, 2004).

The WTMA provides general strategic guidance to meet obligations for the protection, conservation, presentation and transmission to future generations of the WTWHA, which mostly falls into the Wet Tropics bioregion, and for which the Australian government is contracted to a conservation obligation with the UNESCO (WTMA, 2012). WTMA collaborates with Terrain Ltd. and QPWS to identify and implement measures to protect the values for which the property is listed under UNESCO. However, Terrain Ltd. and QPWS are responsible for delivering these measures on the

ground. This is especially important when considering any implementation of measures of indigenous natural and cultural natural resource management, such as the deployment of water and riparian habitat monitoring plans.

Commonwealth, State, regional and local governments and their natural resource management departments also undertake direct planning activities within the area of the Wet Tropics. In 2011, State agencies interested in land and sea management numbered at least seven (the Department of Infrastructure and Planning, Department of Employment, Economic Development and Innovation, Department of Environment and Resource Management (DERM), Department of Transport, Department of Main Roads, Queensland Rail and Department of the Premier and Cabinet (RAPA, 2011). Within DERM, many sections dealt separately with stakeholder engagement in land and sea issues, namely sections concerned with water resource allocation, water quality management, vegetation management, national park management, cultural heritage management, the Wild Rivers legislation, community NRM and land administration (RAPA, 2011).

Indigenous independent planning processes are increasing in the Wet Tropics in addition to government led ones. For example, Rainforest Aboriginal people undertook a unique indigenous controlled planning exercise to develop and produce *Caring for Country and Cullture: Wet Tropics Aboriginal Cultural and Natural Resource Management Plan,* a document which outlines their aspirations for the management of the area. Locally, it is known as *The Bama Plan*, "Bama" being an Aboriginal term to collectively indicate the Rainforest Aboriginal people of the Wet Tropics. The Bama Plan advocates for greater recognition of the Aboriginal worldview and traditional ecological knowledge in informing the management of the WTWHA and identifies the need to create, as a priority, culturally appropriate employment opportunities for the Traditional Owners of the area (Wet Tropics Aboriginal Plan Project Team, 2005). Another example of independent indigenous planning processes is the preparation of a position paper on water planning, produced by the Rainforest Aboriginal People Alliance (RAPA), which enabled Wet Tropics Traditional Owners to clarify their position on the preparation of the controversial *Wet Tropics Water Resource Plan* (RAPA, 2011).

The plethora of planning processes in the Wet Tropics should be better integrated across

scales than they presently are (Tsatsaros *et al.*, 2013). Otherwise, there is a risk of miscommunication and lack of knowledge sharing, which can affect the resilience of a social ecological system (Weiss *et al.,* 2012). Moreover, the high number of agencies operating in the Wet Tropics introduces a source of complexity and hence frustration for indigenous governance institutions that possess limited personnel and resources (RAPA, 2011). Unless integration, communication and knowledge sharing paths are clearly outlined and endorsed by the agencies operating in the area, the complexity of the management framework may hinder the success of adaptive management of the area.

The increasing acknowledgement of Native Title rights over land and waters is feeding efforts to understand and include indigenous values and management aspirations in Wet Tropics NRM planning. The importance of protecting and managing indigenous cultural values, through maintenance and transmission of cultural knowledge, practices and identity and the protection of associated intellectual property rights was outlined in the background report prepared for *Sustaining the Wet Tropics: A Regional Plan for the Wet Tropics*, hereafter referred to as the Wet Tropics Regional NRM Plan (McDonald *et al.,* 2005). In addition to that report, The Bama Plan outlined the expectations Aboriginal people have for their knowledge of Country to be considered parallel and equally important to mainstream scientific knowledge for Wet Tropics NRM (Wet Tropics Aboriginal Plan Project Team, 2005).

The Bama Plan summarises indigenous cultural and ecological knowledge of Country as being intertwined. This eco-cultural knowledge is related to the historical distribution of species, breeding patterns, life-cycles and food requirements, use of natural resources as food and medicine, procedures for the ceremonial management of plants and animals, names for a wide range of species and their seasonal patterns of growth, impacts on Country by post-contact land use practices, affiliations of Aboriginal people with Country, and kinship between people, Country and plant and animal species (Wet Tropics Aboriginal Plan Project Team, 2005). The Plan also outlined the desire of Aboriginal people for their knowledge to be combined with scientific knowledge and applied in the management of the Wet Tropics to prevent it from being lost, and to avoid further erosion of the spiritual and social wellbeing of Aboriginal people (Wet Tropics Aboriginal Plan Project Team, 2005).

The Plan indicates some practical contributions of indigenous environmental values and

knowledge to NRM in the Wet Tropics. For example, it outlines how threatening processes such as vegetation clearing, terrestrial habitat fragmentation and the impacts of chemicals used in agricultural practices can jeopardise Aboriginals' access to bush tucker plants and fish species, which are economically and culturally important for the Aboriginal population of the Wet Tropics. Furthermore, Aboriginal values for determining the significance of weeds can differ from non-Aboriginal ones, like in the case of Bellyache Bush, *Jatropha gossypifolia*, which was identified as a particular concern for Bar-Barrum people of the Wet Tropics because of its toxicity and impact on waterways where Aboriginal children swim (Wet Tropics Aboriginal Plan Project Team, 2005).

Terrain Ltd. included recommendations from the background report and Bama Plan in its Wet Tropics Regional NRM Plan, which is considered the foundation for management of the Wet Tropics bioregion (FNQ NRM Ltd. & Rainforest CRC, 2004). The Regional NRM Plan incorporates a great number of references to the importance of Aboriginal knowledge for the management of the Wet Tropics. It states, "…incorporating traditional ecological knowledge and customary practices is recognised as a critical asset that can provide substantial benefits to the management of natural resources in the region. As such, the maintenance and revitalisation of this knowledge and customary management practices is critical" (FNQ NRM Ltd. & Rainforest CRC, 2004).

Reference is made throughout the Wet Tropics Regional NRM Plan to the relevance of Aboriginal knowledge to creating and maintaining biodiversity in the area through the use of fire, to understanding seasonal climate patterns and hence variation introduced by climate change and to monitoring water quality degradation and possible impacts on the values of Aborigines in the area. When listing management actions to implement the plan, the application of Aboriginal knowledge is suggested for biodiversity conservation, e.g. by supporting feral species management and species monitoring, for climate change monitoring and carbon abatement plans and for water quality monitoring (FNQ NRM Ltd. & Rainforest CRC, 2004). The plans' section on land management, however, mainly focuses on local industries and only marginally touches on Aboriginal interests (FNQ NRM Ltd. & Rainforest CRC, 2004). The plan concludes by identifying lack of understanding of Aboriginal values and knowledge for the environment as one of the main threats to Aboriginal culture in the area and recommends research into the

production of cultural indicators for monitoring Aboriginal values (FNQ NRM Ltd. & Rainforest CRC, 2004).

Protection of intellectual property rights associated with Indigenous Knowledge

Historically, Indigenous Knowledge (IK) related to natural resources and was mined freely by interested parties. It was only at the end of the twentieth century that the free appropriation of IK by Western gatherers started to be questioned (Drahos, 2006). Drawing from notions of human rights and entitlement, Aboriginal groups were recognised as holders of IK. Human rights activists promoted the need for the intellectual property rights (IPRs) associated with IK to be protected (Drahos, 2006). Soon after, the Convention on Biological Diversity (CBD) and its associated Nagoya Protocol bound signatory implemented provisions to warrant equal benefit sharing for knowledge holders and other knowledge users (Wynberg & Niekerk, 2014).

Protection of IPRs associated with IK is not straightforward, mainly because available IPR systems are grounded in Western notions of "property" as individual, while the property of IK is usually communal (Kendall & Meddin, 2004). Globally, there is a need to raise awareness within indigenous societies of available forms of protection for IPRs, however changes to current regimes and even the creation of sui generis forms of protection of IK-associated IPRs may be necessary to fully meet all the needs of indigenous people (WIPO, 2001).

Chapter 2: A methodology for research in indigenous contexts

2.1 Grounded theory and action research

I framed my PhD research within the qualitative social research methodology of grounded theory and action research. A methodology developed in the 1960s by two sociologists, Barney Glaser and Anselm Strauss (Glaser & Strauss, 1967), grounded theory was conceived to address a tendency of the social science of the time to mostly verify established social theories to the detriment of developing new ones. By contrast, the grounded theory approach warranted the emergence of new perspectives and understanding, and in some cases new theories, from the actual data collected in the field (Strauss & Corbin, 1998).

Grounded theory is particularly recommended for inductive exploratory case study research on topics where little theory has been previously generated or where a new perspective is need (Glaser & Strauss, 1967). It is also a methodology recommended to researchers who are new to a field. Indeed, grounded theorists encourage neophytes to adopt the methodology when they enter a new field of research for the potentially powerful insights that a fresh look can generate for new and old issues (Glaser & Strauss, 1967). Grounded theorists maintain that, when adopting grounded theory, existing literature on the research topic should be minimally consulted at the beginning of the project to avoid preconceptions on the phenomenon observed and to avoid adopting a standpoint before entering the field (Glaser & Strauss, 1967). The field work should be the only source of interpretive frameworks in order for the emerging theory to be truly grounded in the reality of the case study (Glaser & Strauss, 1967). The literature should only be used later in the research process, when findings have emerged (Birks & Mills, 2011). Castillo (2009) claimed that more theory is needed around indigenous knowledge integration in NRM and that more academic debate is needed on the issue. My research contributes to academic discussion by preparing a grounded theory on the integration of IK with science for more sustainable NRM.

Grounded theory also provides freedom in using different data sources, qualitative and quantitative, such as non-academic input like words and actions, one's own participant observations, and the literature. Each is an acceptable source of data for theory generation (Strauss & Corbin, 1998). My research was collaborative in nature and I

included the research priorities of the participant community in the project design. I could not foresee at the beginning of the project how data would present itself. Grounded theory enabled such uncertainty to be accommodated and provided opportunity to maximise the serendipity proper of conducting research in indigenous contexts. The data sources I used for this thesis largely consisted of transcripts of qualitative, semi-structured ethnographic interviews. However, I also relied on the literature (Chapter 4) and participant observations I conducted during field work (Chapter 6).

Grounded theory recommends reiterative cycles of data collection and analysis, which enable the inclusion of emerging perspectives (Charmaz, 2008) and discourages researchers from entering the field with a rigid research plan. I implemented iterative data collection and analysis as depicted in Figure 2.1. Grounded theory offered a rigorous analytical approach to my data analysis, which enabled theoretical inferences from my observations while still keeping them *real* and *grounded* in the reality of the case study (Charmaz, 2008).

I transcribed and coded interview transcripts for theme analysis, consistent with the grounded theory methodology (Strauss & Corbin, 1998). The coding process was conducted in two phases. In the first phase, the open coding, I identified themes as they were discussed by participants, and therefore inductively, to allow for the emergence of a meaning that was truly grounded in the data. According to grounded theory, I collected and coded data in this way until a saturation point in the coding process was achieved and no new themes emerged. I then collapsed themes identified through the open coding process into more general theoretical categories during a second (or further) round of coding, the theoretical coding (Strauss & Corbin, 1998). In some cases (Chapters 6 and 7) I also coded transcripts deductively and applied pre-set categories identified in the literature (Fereday & Muir-Cochrane, 2006), consistent with grounded theory tenets (Birks and Mills, 2011). Coding processes used in each data chapter are detailed in the chapters' methodology sections.

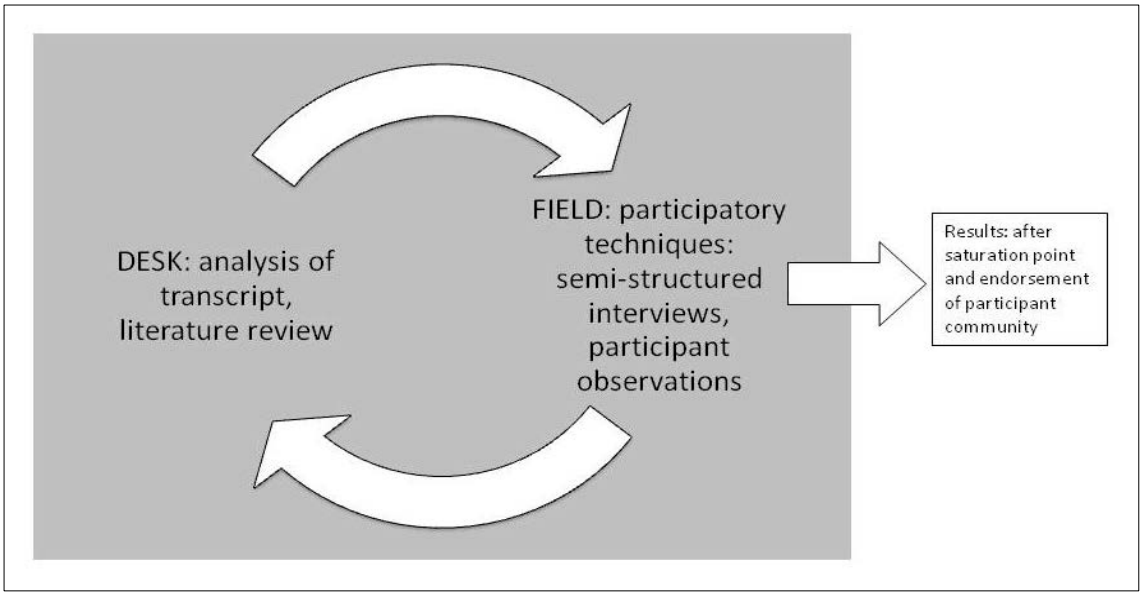


Figure 2.1. The iterative cycle of data collection and analysis I adopted for my research.

The iterative cycle of data collection and analysis I adopted for grounded theory resonated with another cycle, the plan-act-observe-reflect spiral of action research. Action research is a philosophical stance towards the world, an attitude of enquiry that enables people to question and improve taken-for-granted ways of thinking and acting to produce positive social change (McNiff & Whitehead, 2009). Researchers adopting action research wish to explain a phenomenon, but also trigger positive social change. Collaborative participatory action research enables participant communities to become prominent actors in building a fresh perspective on the researched problem and in achieving social change, rather than being the object of the research (Moller *et al.,* 2009c). During my PhD, I committed to do my best to empower the participant communities in the management of their estate NRM, according to their own wishes and research agenda. I included participant community members as equals, in terms of co-researchers, and devolved a consistent degree of control over the research project to them, so as to decolonise my methodology as much as I could (Tuhiwai Smith, 1999).

My choice of action research was to address a research question that has been suggested many times by the indigenous people I have met around the world and by my own co-researchers: "How can I help you to better look after your land"?[2] This was the underlying question that, even if not formalised in academic terms, guided my efforts of serving the research needs of the Malanbarra and Dulabed Yidinji community.

Overall, grounded theory and action research methodologies allow for the incremental sharing of knowledge adopted by many indigenous communities in Australia (Muller, 2014) and elsewhere (Moller *et al.,* 2009c), therefore they are particularly well suited for research in indigenous contexts.

My decision to adopt grounded theory and action research was also supported by one of the elder co-researchers, who explained to me:

> *"When we work with researchers we want to check* […] *how things are presented, so we do a bit of work and then see how the knowledge we shared is used, and* [if we like the way it is used] *we do the other bit of work".*

2.2 The ethics of conducting research in indigenous context

Because my study involved cross-cultural research, specific considerations were made with respect to engaging in an ethical and culturally sensitive way with research participants. To improve my understanding of the sensitivities associated with working with Indigenous Australians, prior to commencing my PhD I undertook the subject *Indigenous Environmental Management* offered by JCU and delivered by Dr. Joan Bentrupperbäumer. During the course of the subject I became familiar with the history of colonisation and the associated dispossession experienced by Indigenous Australians, with issues in eliciting and applying indigenous knowledge to natural resource management and the legal and ethical aspects of doing so. The subject also provided an introduction to the main pieces of international and Australian legislation that influence

[2] This question was posed by Linda Different Cloud, an environmental science researcher and Indigenous American, during her presentation at the 2011 Society for Ecological Restoration conference in Merida, Mexico.

the participation of indigenous people in natural resource management in signatory countries. In addition to this subject, I attended an Indigenous Cultural Awareness workshop offered by the JCU School of Indigenous Australian Studies, which was focused on understanding the cultural distinctiveness of Indigenous Australians, their communication preferences and their need to be engaged in a culturally sensitive way.

During my initial interactions with the Malanbarra and Dulabed Yidinji community and for the entire first year of my fieldwork, I was supported in the field by a professional cultural broker who was employed by the CSIRO to support researchers working in cross-cultural domains. My project aims and methodology were also subject to the JCU research ethics clearance process. I based my research protocol on guidelines for ethical conduct in Aboriginal and Torres Strait Islander research developed by the National Health and Medical Research Council (NHMRC, 2003) and by the Australian Institute for Aboriginal and Torres Strait Islander Studies (AIATSIS, 2011).

For the aspects of my work which specifically related to indigenous knowledge I became familiar and followed in particular the Aboriginal Rainforest Council's (ARC) cultural knowledge kit as well as guidelines within *Caring for Country and Culture – The Wet Tropics Aboriginal Cultural and Natural Resource Management Plan* (The Bama Plan).

In addition to the academic and operational support offered to my project by JCU and the CSIRO, some elders and indigenous scholars supported me on a personal basis and for this I am grateful to Uncle Phil Obah, chief of the Wadja Traditional Knowledge Centre, and Prof. Yvonne Cadet-James, former head of the JCU School of Indigenous Australian Studies.

2.3 Community engagement and participant recruitment

As discussed in Chapter 1, I conducted my research with the Malanbarra and Dulabed Yidinji community because some of its elders were willing to collaborate, were interested in a project focussed on their knowledge for the environment and how to further its inclusion in local natural resource management efforts, and because a contact was already in place prior to my project though my supervisor, Dr. James Butler, who

had previously collaborated with the community.

The engagement of the Malanbarra and Dulabed Yidinji community required extensive time and effort to allow for the building of a trustful relationship. I worked to further strengthen the engagement and despite my efforts and commitment to doing well, I unintentionally made some mistakes. In recruiting participants for my project, I identified the "correct persons, who have the right to speak for Country". I first contacted the Royee family, with James' help. In seeking the engagement of this family we were legitimated by the fact the Royees were one of the families who submitted the original Native Title claim, and therefore we assumed they were legitimate Traditional Owners. Uncle Frank Royee was one of the prominent elders of the family, and overall he supported our work with the community. Approaching Uncle Frank was easy because of his interest in collaborating with research organisations and his commitment to improving local environmental management in a way that was more inclusive of Traditional Owners' perspectives. When I met him, Uncle Frank had been chief of the Malanbarra Tribal Aboriginal Corporation since 1989. The corporation was founded when Malanbarra decided to claim their land back to undertake cultural restoration. As mentioned in Chapter 1, one of the main objectives of the corporation was to conduct a culturally sensitive assessment of the community's traditional estate to understand the environmental state of the Goldsborough Valley. The objective provided a common ground for development of a collaborative research project to document what the community valued in the environment, how they monitor it and the indigenous knowledge associated with their vision of the environment (discussed in particular in Chapters 5-7).

Uncle Frank facilitated contacts with two other Royee elders and one elder belonging to the Ambyrum family group. He also helped to recruit three younger members belonging to the Royee family who were interested in taking part in the project. The seven community members are regarded as "key informants" for this thesis. They took part in interviews, participant observations and field trips with the cultural broker and me over four years, 2009 to 2011. They represented 3.5% of the total Malanbarra and Dulabed Yidinji adult population and 14% of the adult population of the Royee family. They also represented 7% of the registered PBC adult members, members who are most active in the management of the determination area (these percentages reflect the number of PBC members at the time of writing).

Engagement with families other than the Royees was delayed due to unease within the community as well as the burden of the Native Title claim, which kept the community busy during my study. I worked mostly with the Royee family and chose study sites in their area of responsibility for collaborative field work (described in Chapter 6). This was desirable in order to respect community cultural protocol, which requires outsiders to be introduced and accompanied on Country by legitimate custodians of that country.

At the end of 2009, while I was conducting my project the Native Title claim process for the Malanbarra and Dulabed Yidinji traditional estate resolved with the determination of the "Combined Dulabed and Malanbarra Yidinji Native Title" and the Native Title was registered in August 2010. A PBC was then created to administer the determination area, as per Native Title legislation requirement. Since then the PBC has become our principal referent for further engagement with the Malanbarra and Dulabed Yidinji community.

Following an initial period of negotiation, the community elected PBC directors, who would sit on the PBC board for the first year and administer the determination area by functioning as spokespersons for their family groups and channelling their families' wishes into the formal decision making process. The PBC also elected an official contact person to facilitate reaching the board of directors, and through that, the entire community.

Despite the fact I was working with some members of the Malanbarra and Dulabed Yidinji from 2009, was supported by a professional cultural broker, and numerous times requested, through the contact person, to meet the PBC directors to present my project, I was admitted to present the project to the PBC board in September 2011. As I understood it, the delay was due to internal resistance to my project by some community members. When I did have the opportunity to present my project to the PBC board, I offered to extend the engagement to whoever was interested. On that occasion it became clear that some of the PBC directors were unhappy with the research team because, from their perspective, they had not being contacted soon enough to have input into initial phases of the project. From my perspective, however, the engagement was complicated by the fact the community is large and scattered over an extended geographical area, and so members are difficult to find without the help of contact persons, "gate keepers" and mediators, who in my case were possibly caught in the

same community internal resistance, division and "politics". A further element of complication was the period of time over which I conducted my project; in terms of community internal cohesion, divisions had developed during the long and troubling Native Title process, which added to longer term and unsettled tribal disputes.

The solution to the conflict manifested in 2011 required extra time and energy from my part, to build a relationship with those members who had had no chance to participate in the project from the beginning. In doing so, I partially reconciled with the entire PBC board, even if some PBC directors were, and remain, doubtful about my motivations for working with the Malanbarra and Dulabed Yidinji. Following this reconciliation, I received unanimous support for the project from the PBC directors and I was able to extend engagement with the community to include an additional 17 members who were willing to volunteer and who were authorised to do so by the PBC. As a result, in 2012 I conducted an additional round of interviews to include the perspectives of the newly recruited participants. Unfortunately, due to time and funding limitations, I was not able to conduct any further collaborative fieldwork.

Taking the additional interviewees into account, a total of 24 community members gave direct input to the project, equal to 12% of adult Malanbarra and Dulabed Yidinji community members and around 25% of the PBC adult registered members. Of the total number of participants, 14 were women, three of which were less than 40 years of age, while seven of the ten male participants were less than 40 years of age.

During a workshop conducted in May 2013 I presented the results from this project to the PBC board of directors, who endorsed my interpretation of their inputs. I then moved to the write-up phase of my PhD.

2.4 Methods for data collection

I used interviews and participant observations to collect the necessary data for my PhD research. Both methods are classic tools for ethnographic research typical of social science and anthropology. Interviews can be, (1) informal, where the conversation lacks any structure and control, (2) unstructured, where discussion appears casual but the interviewer mindfully follows a plan, (3) semi-structured, where the interviewer asks a series of open questions and allows the conversation to develop in unexpected directions

but remains consistent the data intended to be collected, and (4) structured, with closed questions (Bernard, 2006). Informal and unstructured interviews are ideal when the researcher is new to a community; once a relationship of mutual trust has been developed the collection of data can become more structured (Bernard, 2006; Kumar & Kumar, 2002).

For my work with the Malanbarra and Dulabed Yidinji, I relied on informal and unstructured interviews during the first exploratory phase of the project, building the relationship with community members and collecting their input to refine project aims. In doing so, I relied on mental notes of conversations and transferred these to typed notes once back from the field (Bernard, 2006). Once the relationship was established and a mutual understanding of project expectations had been developed (Bernard, 2006; Kumar & Kumar, 2002), I used semi-structured interviews to refine my understanding and collect additional data on community members' perspectives on natural resource management. I seldom used structured interviews; though when I did it was to validate my understanding with some interviewees with whom I felt I could be more direct. Similarly, I used semi-structured interviews when interviewing managers and researchers working in cross-cultural management of the Wet Tropics (Chapter 3).

Whenever participants agreed, I made audio recordings of their interviews. When participants did not consent to recording I took only written notes of our conversations. Finally, whenever participants requested, group interviews were conducted as an alternative to individual interviews. Often, interviews were conducted on Country, during collaborative field work, which is preferred by many Indigenous Australians (Robinson & Wallington, 2012), or at a location chosen by participants.

Throughout my study, I conducted participant observations (Bernard, 2006). Participant observations were useful to supplement the understanding I gained from interviews, to triangulate data to make sure informants were consistent in time, and to validate interview content by comparing responses from different interviewees.

I committed to visit the community once a month during the more intense period of data collection (2009-2011). My visits were usually one week in duration. Therefore, overall I spent considerable time with the Malanbarra and Dulabed Yidinji people.

Chapter 3: Experts' opinions on knowledge integration in the Wet Tropics: perspectives on indigenous knowledge, science and their integration in natural resource management

In Chapter 1, I identified some operational knowledge gaps which may hinder efforts to integrate indigenous knowledge and science in natural resource management in the Wet Tropics. The first of these is a lack of understanding about indigenous knowledge and science, and how their integration should be approach. In Chapter 3, I address this knowledge gap by exploring the perspectives held by Wet Tropics natural resource management experts on the issue of integration of indigenous knowledge and science.

Manuscript associated with this chapter:

Gratani, M., E. L. Bohensky, J. R. A. Butler, S. G. Sutton & S. Foale. 2014. Experts' perspectives on the integration of Indigenous Knowledge and science in Wet Tropics Natural Resource management. *Australian Geographer* 45(2): 167-184.

Abstract

Aboriginal inhabitants of the Wet Tropics of Queensland advocate for greater inclusion of their indigenous knowledge (IK) in natural resource management (NRM) to fulfil their customary obligations to Country and to exert their Native Title rights. Despite a legal and institutional framework for inclusion of IK in NRM, IK has so far been applied only sporadically. In this chapter I report an ethnographic case study that I conducted to investigate perceptions on IK, science and how they affect integration of the two knowledge systems in the Wet Tropics. My results show that IK and science are perceived as different concepts; that integration is limited by weak indigenous internal and external governance; and that stronger Aboriginal governance and more focused engagement strategies are required to further the application of IK in local NRM. I conclude by arguing that NRM in the Wet Tropics needs to be reconceptualised to accommodate IK holistically, by considering its epistemology and the values and ethics that underpin it.

3.1 Introduction

In the last few decades, recognition of the failure of top-down approaches to indigenous natural resource management (NRM), increasing legal rights and land ownership of indigenous people, and current policies of self-determination have triggered attempts to integrate indigenous perspectives in modern NRM worldwide. This is exemplified in international science programs and policy, including the Millennium Ecosystem Assessment, the Ramsar Convention on Wetlands, the Convention on Biological Diversity and the more recent global Strategic Plan for Biodiversity 2011-2020 (Ens *et al.,* 2012a). In all cases, the inclusion of indigenous knowledge (IK) in NRM has been identified as paramount for biodiversity conservation, enhancement of the resilience of social ecological systems, and social justice. As a signatory to these conventions, Australia is committed to increasing the representation of indigenous perspectives in NRM.

Numerous contributions of IK to NRM have been identified in Australia. Indigenous knowledge-based NRM can support the conservation of biocultural diversity (Hill *et al.,*

2011a), provide information on the distribution and abundance of wildlife (Butler *et al.,* 2012; Ziembicki *et al.,* 2013), and identify baseline conditions and trend of change in highly variable environments (Wiseman & Bardsley, 2013). When included in environmental monitoring, IK can address concerns about national biodiversity and ecological monitoring gaps (Ens *et al.,* 2012b). Restoring the worldview associated with IK in NRM can also ensure the diversity in thought, skills and outlook necessary to support the resilience of social-ecological systems (Cork, 2009). Finally, the recognition of IK in NRM is necessary to foster social justice, sovereignty, autonomy and indigenous identity (Agrawal, 1995; Nelson, 2005; Aikenhead & Ogawa, 2007; Bohensky & Maru, 2011). Despite the numerous purposes it serves, applications of IK in Australian NRM are still limited (Edwards & Heinrich, 2006; Hill *et al.,* 2012). Promoting IK and its integration with other knowledges available for NRM is therefore needed.

In this context, this chapter aims to investigate some of the cultural and social dimensions that influence NRM practitioners' approach to IK, science and their integration. Previous research has shown how personal perspectives shape the way NRM practitioners engage with different available knowledges and how they apply them within the available legal and institutional frameworks (Butler *et al.,* 2012; Weiss *et al.,* 2012). I considered these factors through an ethnographic study involving interviews with indigenous and non-indigenous experts in the Wet Tropics of Queensland. From the results, I highlight the barriers NRM practitioners face when attempting to integrate different forms of knowledge in the Wet Tropics, and potential opportunities to facilitate this process.

3.2 Conceptual Background

Defining "knowledges" and their integration

Indigenous knowledge parallels the concept of traditional ecological knowledge (TEK) as a knowledge-practice-belief complex of indigenous societies across the world (Berkes *et al.,* 2000). The term "indigenous knowledge" avoids limiting the scope of this body of knowledge to that which is considered traditional and to ecological issues, allowing the consideration of spiritual and cultural aspects. The use of the term

"knowledge" in "indigenous knowledge" is, however, highly problematic. In 1999 Nadasdy observed how the central assumption that the cultural beliefs and practices of indigenous societies can be aligned to the western concept of knowledge, usually understood as data and information, represents a serious flaw in the entire effort to integrate indigenous and non-indigenous perspectives on NRM. Knowledge is used to indicate different concepts, from scientific knowledge as mere collection of information (Ackoff, 1989), to knowledge as conceptual change requiring value judgement and enabling problem solving (Arendt, 1978). A decade later, Bohensky and Maru (2011) concluded that little progress has been made in clarifying the nuanced meanings of the language used to discuss processes of bringing knowledge together. The way in which scholars and practitioners understand and conceptualise IK determines how they engage with it and what measures they implement to include it in NRM. Hence, understanding how IK is conceptualised in a specific context is paramount to promoting its application (Nadasdy, 1999; Usher, 2000; Butler *et al.,* 2012; Weiss *et al.,* 2012).

Arguments on how to include IK in NRM often resolve that IK should be integrated with science (Usher, 2000; Stephenson & Moller, 2009; Moller *et al.,* 2009a; Bohensky & Maru, 2011), likely due to the prominence of the latter in informing NRM (Ross & Pickering, 2002; Suchet, 2002; Nursey-Bray, 2009). Science is, however, another problematic concept. Science is mostly defined as an activity of enquiry to systematically study the structure and behaviour of the physical and natural world through observation and experiments[3], but this conceptualisation often results in reducing science to the exercise of the deductive hypothesis-testing method typical of biophysical sciences (Ryder *et al.,* 2010), although less relevant in the social sciences. Science is also used to indicate scientific knowledge, probably because the Latin root of the word science, *scientia*, translates to knowledge. Finally, science has been paralleled to a belief system and to a worldview (Stephenson & Moller, 2009; Hikuroa *et al.,* 2010). These different nuanced meanings attached to science reflect the degrees to which the role of values and beliefs in scientific process is acknowledged.

The concept of integration is again controversial. Integration may suggest the extrapolation of some IK to be utilised in mainstream NRM, while disregarding the cultural context that produced IK (Nadasdy, 1999; Brook & McLachlan, 2005;

[3] Oxford Online Dictionary (http://www.oxforddictionaries.com)

Bohensky & Maru, 2011; Weiss *et al.,* 2012; Bohensky *et al.,* 2013). When understood as the process of harmonising different parts to produce a unified whole, integration may appear less threatening, for it excludes cultural assimilation but it may still result in cultural erosion of already marginalised indigenous minorities. Nevertheless, in cross-cultural societies, building integrative NRM may in fact signify harmonising diverse outlooks on the environment to produce a shared, common way to interact with it, which encompasses multiple epistemologies and worldviews in a way that is respectful to them all (Weiss *et al.,* 2012; Ens *et al.,* 2012b).

The perceived superiority of science and scientific epistemology

Historically, the way in which science interacts with other knowledge systems has been shaped by the belief that scientific knowledge is superior to lay understanding (Ewing *et al.,* 2000). This belief, coupled with the need to ensure transparency and objectivity in natural resource decision making has increasingly encouraged decisions to be made on the best available science (BAS). BAS is evidence-based scientific knowledge relevant to a policy and planning issue, collected and analysed by established protocols, and formalised as peer-reviewed published literature or expert advice (Brennan *et al.,* 2003; Ryder *et al.,* 2010): IK is unlikely to fit this definition. The mandate to use BAS in environmental decision making may contrast with the need for cross-cultural NRM inclusive of IK. As a consequence, natural resource managers may find it difficult to address these apparently conflicting needs. The production of scientific evidence to validate traditional measures of NRM may offer natural resource managers a way out of this conundrum. Validating IK, especially against science, is, however, controversial because it may reinforce the current superiority of western epistemology in NRM and be disempowering for communities (German *et al.,* 2010).

Notwithstanding these risks, the production of scientific evidence to support IK-based NRM measures has proved effective in promoting IK in Australia and elsewhere, for it enables understanding and support of IK amongst scientific communities (Russell-Smith *et al.,* 2009; Moller *et al.,* 2009b,c; Douterlungne *et al.,* 2010; Ens *et al.,* 2012b; Ziembicki *et al.,* 2013). The requirement for scientific validation of IK prior to its application has been raised in the Wet Tropics. For example, in 2011 the director of the Wet Tropics Management Authority commented that it is difficult to consider the re-introduction of traditional burning of the Wet Tropics rainforests based on current

knowledge, but "if the research becomes more definitive than it is now, that might be a driver for a review of the policy and supporting legislation in the future" (McKillop, 2011). Similarly, in a report from the Ethnobotany Centre, established in the Wet Tropics to promote IK-derived applications (Hill *et al.,* 2011b), it is stated that if IK of medicine is to be applied in contemporary contexts it needs "scientific proof to back it up" (Standley & Hill, 2011, p. 30).

Indigenous knowledge in the Wet Tropics World Heritage Area

The case study I conducted explores the concepts of IK, science and their integration in the Wet Tropics of Queensland, a region about 450km long and 50-100km wide along Queensland's northeast coast, from Townsville to Cooktown. The area is largely gazetted as the Wet Tropics World Heritage Area (WTWHA) and is home to about 20,000 residents of Aboriginal descent (WTMA, 2012).

The status of IK and its integration in Wet Tropics NRM reflects a history of Australian and international interests in the natural values of the region, and evolving institutional arrangements to manage it collaboratively. The Wet Tropics was nominated by the Australian government for World Heritage listing due to its cultural and natural values (IUCN, 1998). Despite the existence within its boundaries of an old and unique Aboriginal rainforest culture (Horsfall, 1984), the UNESCO endorsed the nomination of the area only for its natural values. UNESCO recommended the management of the area be conducted in consultation with local Aboriginal traditional owners. The traditional owners, however, argue for more than a consultative role: they continue to hold customary obligations for Caring for Country under Aboriginal laws and customs, and thus perceive that a greater involvement in NRM is vital to the preservation of their culture (Hill *et al.,* 1999; Muller, 2008; WTMA, 2002).

Wet Tropics traditional owners suggest their involvement in NRM may be strengthened by considering IK as equally important to scientific knowledge, and by combining the two in NRM (Wet Tropics Aboriginal Plan Project Team, 2005). IK for the area has been discussed as including folk taxonomies, animal and plant seasonal patterns of growth, historical distribution, breeding patterns, life-cycles and food requirements, traditional use of natural resources, ceremonial management of species, post-contact land-use changes, and kinship systems between people and the ecosystem (Wet Tropics

Aboriginal Plan Project Team, 2005). Presently, such IK is applied only to a limited extent due to the lack of clarity on possible paths for integration, the lack of understanding of the variety of its potential applications (McDonald *et al.,* 2005), and because natural resource managers face difficulties applying vague policies on integration of knowledge systems (FNQ NRM Ltd. & Rainforest CRC, 2004). For the Wet Tropics, research on how local natural resource managers understand IK and science, and what factors influence integration of the two knowledge systems, is also lacking.

To address the above issues, I conducted an ethnographic study in the Wet Tropics, where I explored, (1) how IK and science are perceived in respect to NRM; (2) what the perceived factors are that limit their integration in NRM; and (3) what opportunities are available in the area to further integration. Numerous themes emerged during the semi-structured interviews I conducted, which I present in the results and discussion sections.

3.3 Methods

Data collection and analysis

My case study takes a grounded theory approach. Following a purposive (Glaser & Strauss, 1967) snowballing (Bernard, 2006) sampling method I selected indigenous and non-indigenous researchers and managers employed by Wet Tropics science and NRM agencies. Criteria for selection of participants were their association with my study area and their exposure to local issues of cross-cultural NRM, which was reflected in their publications, the position they held in their organisation and in their professional reputation.

Participants were invited to participate via email and/or phone after being given an information sheet about the project. Interviewees who accepted the invitation were then interviewed in person using semi-structured questions, lasting 60-90 minutes. The grounded theory methodology recommends the number of interviews conducted should be determined by the emergence of themes in the field, rather than interviewing a pre-determined number of respondents (Glaser & Strauss, 1967). Interviews should therefore be conducted until no new themes emerge in subsequent interviews. In my case, a total of 16 interviews were required to achieve saturation point.

The final interviewees included members of local and national science organisations (JCU and CSIRO), national and State government agencies (Wet Tropics Management Authority, Queensland Department of Environment and Resource Management and Queensland Parks and Wildlife Service) and local non-government entities (Terrain Ltd. and the Australian Conservation Foundation). In addition, representatives of a local Landcare group and two community-based managers and practitioners were included. The vast majority of interviewees (13) had been working in the Wet Tropics for more than ten years.

Interviewees are identified in the text by a letter-numerical code. The first letters indicate *indigenous* (*I*) or *non-indigenous* (*NI*) interviewees, followed by *R* (researcher) or *EM* (environmental manager), and number. I interviewed five non-indigenous researchers (*NIR*), two indigenous researchers (*IR*), five non-indigenous environmental managers (*NIEM*) and four indigenous environmental managers (*IEM*).

Questions asked during the interviews explored themes I was interested in (Table 3.1). Interviews were recorded with participants' permission and transcribed. Transcripts were coded using *NVivo* software and analysed inductively for themes. Consistent with the grounded theory methodology, a first round of analytical coding was conducted to explore data. Themes were continuously updated until no new ones emerged. Themes identified in this way were then collapsed into overarching theoretical categories during a second round of coding (Glaser & Strauss, 1967; Strauss & Corbin, 1998). Overarching categories are hereby presented as main points for discussion.

3.4 Results

Local perceptions of indigenous knowledge and science

The majority of interviewees commented that IK is not valued and used enough in the management of the Wet Tropics, due to lack of understanding of what IK is and what contributions it can make to NRM, ineffective engagement with traditional owners, lack of trust towards the validity of IK, and managers' requirement to simplify decision making, while including IK in the process complicates this.

Indigenous interviewees discussed their perception that the management of the Wet

Tropics area is based on scientific knowledge, to the detriment of their IK. Some non-indigenous interviewees, however, lamented that science was also under-utilised in NRM. One reason interviewees gave for this was that local NRM – and NRM in general – is essentially a political, social and cultural process, more than a technical one, hence science is not so influential in determining directions for management. As a result, the role of science in NRM was not guaranteed, let alone a role for IK:

> *"It is hard enough to apply science, my system of knowledge, before I take on board all the mysteries of IK and try to find out how to apply it. I will confess that once I know the issues out there, I cannot think of any example where we have applied IK to the management of this landscape. The closest we got is fire management."* (NIEM3)

Table 3.1. Research themes explored and corresponding interview questions.

Theme 1: Local perceptions on indigenous knowledge (IK) and science
a) How do you think IK is currently valued / used in NRM?
b) What is your understanding of what IK and science are?
c) In which ways do you think IK and science differ or are similar?
Theme 2: Factors limiting knowledge integration
a) What do you think are current limitations and barriers to the use of IK in NRM in the Wet Tropics?
Theme 3: Avenues to further integration
a) How do you think can we bring IK and science together?
b) Do you think IK has a contribution to make to modern environmental management?
c) Can you give an example of possible applications of IK?
d) What would you need, as a manager, to adopt IK based "solutions" in the management of the Wet Tropics? Or: What would you need as researcher to include IK in your research?

I found no significant differences in the way indigenous and non-indigenous interviewees discussed their understanding of IK. IK was discussed as a system aimed at understanding the natural world, how it functions, how it has changed from the past, and how to manage its resources. Additional themes that emerged were the cultural and

ethnic dimensions of IK, intergenerational transmission, underpinning values, spiritual foundation and rules, and wisdom. One interviewee discussed IK as a "worldview", with greater holism and depth compared to science:

> *"I would think to an Aboriginal person IK is much more than science, it is somehow where science should be. IK is integrated spiritual and pragmatic knowledge in terms of survival; it is a very sort of view of the world integrated much more than science, which is more reductionist. IK always incorporates more than just the factual knowledge."* (NIR3)

Interviewees also discussed IK as being concerned with the relationship between people and the environment, whose wellbeing is interconnected, as including tangible content (e.g. indicators for environmental monitoring), and intangible content (e.g. customary obligations of Caring for Country), and as related to different aspects of life, and thus not only technical knowledge but also social knowledge.

Science, on the other hand, was discussed by the majority of indigenous and non-indigenous interviewees in terms of rationality and universality, and as technical and formal. Only a few interviewees directly pointed out the cultural context, values and worldview underpinning science, which in their opinion conferred validity to science as a culturally specific way of acquiring knowledge. Nevertheless, science was often associated with the adjective *western*, and thus was culturally and ethnically defined by many of the interviewees. In addition to this, science was framed as an institution with rules, aiming to serve personal ego, individual achievement and power.

Differences between IK and science were also identified in terms of epistemologies. In this regard, many interviewees discussed the centrality of hypothesis testing and the peer-review scrutiny of science:

> *"Europeans had a fantastic thing called Enlightenment, so we moved to a point where observations and hypothesis and testing of hypothesis emerged and pushed religious beliefs away. I think Aboriginal cultures did not have it. Aboriginal people know things because they believe things and have been told. IK is taught down, it is passed down, and it is spiritually based."* (NIEM3)

Some conceded that hypothesis testing may have occurred in the past in IK systems, but it was not applied systematically:

> *"Of course, at the beginning there must have been some testing, but then you learn. So over the years a very detailed system was developed, a very detailed system of lore and custom that was brought around."* (IEM4)

Observation of nature was discussed as a process common to both IK and science. Attuning to the natural world, and *feeling* it in addition to *seeing* it, repatriation of displaced IK, and integration of other forms of knowledge were listed as processes typical of IK.

As for openness to criticism and scrutiny, IK was sometimes discussed as privileged and shared only partially, due to social rules on cultural transmission, and as accepted as given, based on protocol of respect for elders, with little or no scrutiny. This perspective was challenged by one interviewee, who stated:

> *"The peer discussion is going on all the time* [and] *in some way is even more open in traditional community. People, in traditional societies, debate their knowledge and change their mind on the basis of that discussion. On a daily basis they discuss their knowledge, there is a historical* [knowledge] *handed down through generations, but it is continually reviewed."* (NIEM2)

In the opinion of some interviewees, IK and science have the same underlying epistemological processes, especially in an era when the two are continually exchanged, whether formally or informally, and the divide between the two is erected only for political and ideological reasons:

> *"There is some mythology about the separation of IK and science. I think this is part of another, bigger mythology, which is the separation of indigenous people from non-indigenous people. I think this is increasingly a political separation, rather than a real one."* (NIR4)

To summarise, IK and science were discussed as culturally situated and differentiated mainly on ethical and epistemological grounds. For some interviewees, perceived epistemological differences provided the grounds for the devaluation of IK in favour of science:

> *"I don't* [IK] *is valued at all. Science puts emphasis on quantification but since IK cannot be quantified and measured and relies more on the memory of people then it is less valued. So it needs to be tested."* (IR2)

Factors limiting knowledge integration

A range of factors were discussed as limiting the integration of IK and science. Half of the non-indigenous interviewees listed the limited capacity and initiative of Aboriginal communities as one of the main factors limiting their involvement in NRM. Aboriginal communities of the Wet Tropics were discussed as facing many challenges today, from internal disruption and loss of social cohesion to limited capacity and economic resources to engage with NRM agencies. For example, one interviewee pointed out the expectation from NRM agencies for communities to initiate engagement:

> *"Our door is open to everyone, but they* [the Traditional Owners] *never come. If you have time and resources you go and look for them but otherwise they have to come. They are not proactive. When finally they come to look for assistance, their ideas are too vague to do anything with them. They seem to be struggling because they don't know 'our' system and how it works, they don't know how to follow up on something and keep things going."* (NIEM5)

Another interviewee pointed out that this perceived lack of initiative and capacity in communities was due to an expectation of what Aboriginal governance should be, which resulted in the perception of communities who do not meet this expectation as unable to deliver and difficult to engage:

> *"Many people think that unless indigenous communities can organise themselves and have strong governance structures so that they can engage at their level then they are not serious and they are not reliable. For example, the Rainforest Aboriginal People Alliance is a loose alliance, they are not incorporated, they have a loose governance system and they don't meet regularly because they don't have infrastructure and all people involved do it on top of their private life and/or mainstream job. So they struggle to engage with agencies, and agencies believe they are inconsistent."* (IEM3)

While challenging governance contexts were discussed for indigenous communities in general, some examples were made of more successful communities that developed internal governance structures grounded in their traditions, but at the same time able to function in the current western-derived local institutional and governance context.

For indigenous interviewees, the main factors thought to be limiting the application of IK were the risk of losing control of IK due to inadequate protection of associated intellectual property rights, a lack of trust in the validity of IK compared to scientific knowledge, and a lack of serious commitment by government organisations to engage with traditional owners. In summary, indigenous interviewees largely blame the disempowerment that Aboriginal communities experience within the current institutional and governance framework of the Wet Tropics.

Opportunities for further integration

When discussing how integration of IK and science in NRM could be furthered in the Wet Tropics area, overwhelmingly interviewees suggested there was a need to bring people together, so they could share IK for NRM:

> *"Well, maybe there could be a symposium* [where] *you bring scientists and traditional owners in the same room, together with farmers, all stakeholders, they need to be all brought together and so that they can work out means and ways they can actually bring the two together."* (IEM1)

Despite general support for integrative approaches, some interviewees suggested there is limited understanding of how to bring people together for knowledge integration:

> *"It seems that the current framework for engagement that the Government is using is not the right one, it seems to be patchy, it seems that in terms of actually integrating the knowledge systems I think we don't know what we are doing, it is just happening and evolving."* (NIR3)

Many interviewees suggested IK could be validated for NRM applications and acknowledged and incorporated in planning documents:

> *"If the information can be shared it should be incorporated into actual plans and used, so that TEK is applied. We would probably always have to*

validate the TEK anyway." (NIEM1)

Despite the general respect interviewees showed towards IK, a quarter doubted IK can contribute to NRM because it was developed long ago, when the landscape was very different, and therefore it has limited relevance to the environment today. Interviewees suggested that showcasing the relevance and effectiveness of IK for current NRM would facilitate the acceptance of IK for local NRM. Different strategies were suggested to showcase the effectiveness of IK:

> *"*[To apply IK] *I would need evidence. I go back to my science culture. I would say, 'Well, if you have observed that particular plant is active against crazy ants, I would say great, let's have a look, and show me'. My culture and my training are to be sceptical, and I need to see that the null hypothesis has been disproved."* (NIEM3)

> *"I need to believe, or be led to believe, that the environmental processes have responded previously to that method.* [As evidence I would accept] *traditional owners' records, just them saying, 'in the past we used this', just trusting their words, but depending on the reputation of the person, of the traditional owners who refer the IK. If a guy comes and tells me about women's knowledge, well, I won't believe that. They have to be well respected in their community."* (NIEM4)

Some interviewees outlined the role personal values and attitudes have in influencing approaches to knowledge integration, and warned against the risk of superimposing values when trying to integrate IK in NRM. Values were also identified as important determinants of how practitioners engage with IK. For example, interviewees pointed out how the natural values of the Wet Tropics determine priorities for management, to the detriment of more cultural objectives for management:

> *"In a way, a lot of our beliefs and values are not much different from traditional owners' ones, but we do have to spend more time working on threats to national parks, while we would like to work more on conservation in national parks rather than the threats all the time, like pests for example."* (NIEM4)

Interviewees highlighted how, when integrating IK in NRM, the need for risk assessment of proposed applications should be considered. Local natural resource managers view themselves as being held responsible for NRM initiatives in terms of safety for the environment and the people of the Wet Tropics. Hence, they suggested risk assessment to be conducted prior to IK application:

> *"*[To apply IK-based NRM measures I would need] *to look at the context of the application, the context of the application now it is completely different, now the ecosystem is different. There are the expectations of other people and there are the values of other people involved. The Minister is always accountable, I am accountable. We are prepared to give you a little room to move in this landscape, but we need to know what you are going to do, and we need to make sure it is safe and acceptable for all other people involved."* (NIEM3)

3.5 Discussion and Conclusion

In Section 3.5 I presented numerous themes that emerged from my discussions with interviewees. Here, I further discuss five overarching themes which recurred when discussing different aspects of the inclusion of IK in NRM, and/or are under-represented in the literature on cross-cultural NRM of the Wet Tropics. Themes include the perceived different nature of IK and science, the perceived need for validation of IK, the need to further explore how governance affects the application of IK, the need to develop and implement platforms for dialogue between different stakeholders for knowledge sharing, and the need to consider environmental values and ethics underpinning knowledge systems when attempting to integrate them.

Science and IK were discussed as culturally situated and ethnically defined: IK represents holistically traditional owners' vision of the environment and how to live in it, while science is largely addressed as a methodology aimed at producing scientific knowledge. As such, the understanding expressed by interviewees aligns with a conceptualisation of IK as a belief system, as explored by Stephenson and Moller (2009). Science, on the other hand, mostly emerged as the methodology of the non-indigenous worldview. Dimensions of values, ethics, culture, validity of knowledge and

norms of behaviour towards the environment emerged during discussions of knowledge systems, but in different ways. For IK, they were discussed as constituents that cannot be divorced from knowledge and information, as observed in other Australian contexts (Wallington *et al.,* 2010; Maclean & Robinson, 2011; Leonard *et al.,* 2013). For science, dimensions were mainly considered to be external, even if interacting with it. My case study suggests IK and science are understood as two different concepts in the Wet Tropics. As such, my results align with research that suggests a focus on integrating IK with science in NRM is misleading, and that more holistic models should be adopted to inform such integration (Nadasdy, 1999; Usher, 2000; McDonald *et al.,* 2005; Stephenson & Moller, 2009; Bohensky & Maru, 2011; Walsh *et al.,* 2013).

Overall, my results revealed that many local practitioners perceived a need for validation of IK prior to its application. By contrast, a similar concern was not expressed for scientific knowledge. This is likely because interviewees considered such knowledge as already validated through the scientific peer-review process. Validation was discussed mainly in terms of proving the effectiveness of IK for a specific application and in terms of ascertaining its safety for people and the environment. Such validation was advocated as enabling practitioners to actually implement IK-based NRM measures in management, or as a way to integrate IK and science. While many interviewees emphasised validation in scientific terms, an understanding that reflects the current perceived primacy of scientific epistemology in informing local NRM, others proposed to validate IK within its own knowledge and cultural domain and epistemology.

It is not my intention to hereby uncritically praise scientific validation of IK-derived NRM measures; nevertheless, my case study highlights that, even if at a personal level, interviewees would not require any proof of the validity of IK, because the role they have in NRM organisations and for the liability associated with such roles meant they would not take the risk of using IK in NRM or in their research without validation and risk assessment. Hence, my study sheds light on an issue which may not be openly addressed in an official forum for political reasons, but which may be holding back the application of IK in NRM. Despite validation being controversial, case studies describing cross-cultural partnerships for co-generation of knowledge show that indigenous communities are comfortable with the process when it is conducted within a collaborative research framework and under Aboriginal control (see, for example, case

studies discussed in Newman & Moller, 2005; Standley *et al.,* 2009; Moller *et al.,* 2009a,c; Douterlungne *et al.,* 2010; Ens *et al.,* 2012b).

Indeed, collaborative validation of IK and science can be inclusive and respectful of the cultures, values and worldviews associated with the information that is validated. In fact, a body of literature exists which discusses the potential for validating value systems and worldviews holistically, so to better serve global society's goals (e.g. van Egmond & de Vries, 2011; Vidal, 2012). This issue needs to be further explored in the Wet Tropics and in Australia more generally to build an honest debate around how to integrate IK and science in NRM.

The main constraints to integration that emerged from my case study relate to governance issues. Governance is the set of evolving processes, relationships, institutions and strictures, formal and informal, that communities put in place to organise themselves collectively in order to achieve the things that matter to them (Hunt & Smith, 2006). Participants suggested the extent to which IK is engaged, shared and applied strongly depends on the indigenous NRM governance and power sharing in place, as also argued by Hill and others (2012). Governance issues raised by interviewees related to indigenous governance, both internal (e.g. how things are done within communities) and external (e.g. how communities operate in the external world). During my case study, non-indigenous interviewees mostly blamed governance internal to communities for the insufficient engagement of indigenous people and knowledge in NRM. By contrast, indigenous interviewees largely blamed the weak empowerment that communities have when dealing with the outside world.

Overall, my results indicate a widespread frustration among project participants concerning the challenges generated by divergent models of indigenous and mainstream governance. In the Wet Tropics, and elsewhere in Australia, post-colonial state governance erased traditional indigenous governance institutions (Yunupingu & Muller, 2009). As a result, presently not all indigenous governance systems are up to the task of dealing with and delivering within the constraints of current NRM systems (Hunt & Smith, 2006). Indigenous groups of the Wet Tropics are rebuilding their own governance systems by indigenising techniques from the outside, and modernising traditional practices and values, as observed for other indigenous societies worldwide (Morgan *et al.,* 2004). Good indigenous internal governance is effective in developing a

vision, implementing it, making decisions and applying them, developing leadership and ensuring leadership succession to youth[4]. Interviewees suggested many Wet Tropics indigenous communities are challenged in these regards. Hence, while overall Aboriginal-led governance models are more effective in promoting IK sharing and application in the Wet Tropics (Hill *et al.,* 2012), my results suggest that locally there is the perceived need for some communities' internal governance to be strengthened before they can meaningfully participate in NRM. Successful community governance models for the Wet Tropics need to be identified and held up as examples (Maclean *et al.,* 2013).

With regard to external indigenous governance and NRM power sharing in the area, paths are being explored to empower traditional owners within the existing governance framework, and to develop new frameworks more inclusive of different understandings. Some of the strategies in place are the recognition of the WTWHA for its cultural values and the introduction of Indigenous Protected Areas (Hill *et al.,* 2011a, 2012; Davies *et al.,* 2013). Up to now, however, indigenous institutions and individuals in the Wet Tropics have been bearing the burden for finding new ways of restoring their governance and negotiating higher stakes in NRM, as observed elsewhere in Australia (Marika *et al.,* 2009). From the perspective of mainstream Wet Tropics NRM institutions, a change is needed to support this effort in terms of greater flexibility and in recognising and incorporating the social-ecological interactions at the core of indigenous "Caring for Country" philosophies (Wiseman & Bardsley, 2013).

In the way project interviewees dealt with the issue of knowledge integration, and based on the strategies they suggested to further this integration, I recognised the "integrative", "utilitarian" and "political" attitudes to integration described by Weiss and colleagues (2012). In my case study, most participants showed an attitude that I interpreted as "integrative". Only two participants envisioned integration strategies based on unilateral extraction of data and information from IK, an attitude that I interpreted as utilitarian. Finally, two interviewees (one indigenous; one non-indigenous) discussed the integration of IK and science mainly in terms of political power and ideologies. Weiss and others (2012) suggest the most productive and just attitude to knowledge integration in NRM is integrative, because it enables managers to

[4] http://governance.reconciliation.org.au

build better collaborations and partnerships, vital for cross-cultural NRM. It follows that, if my participant sample reflects the broader managerial and research culture of the Wet Tropics, there is broad support for the integration and application of IK in NRM.

Participants also highlighted the need for clearer guidelines for engaging Aboriginal communities when the goal is to apply their IK. Promising approaches have been tested, such as the creation of cross-disciplinary and cross-cultural teams to mutually validate IK and science (further discussed in Chapter 6), the application of theories of boundary work to knowledge sharing (Robinson &Wallington, 2012), and indigenous-driven partnerships for IK applications (Hill *et al.,* 2012). All these paths have in common the involvement of different NRM stakeholders in the process of sharing, producing and assessing different knowledges. My results point out the perceived need for such engagement processes to be formalised in NRM agencies' operational procedures, and for consistent funding.

Despite the fact that I did not explicitly ask a question regarding values, almost all interviewees used the term *values* at least once. Interviewees used the term to indicate principles guiding individuals' thoughts and actions (Dietz *et al.,* 2005; Reser & Bentrupperbäumer, 2005; Bentrupperbäumer *et al.,* 2006), and as principles informing environmental management priorities (Foale & Macintyre, 2005). Personal values were discussed as influencing attitudes towards different people and knowledges, willingness to better integrate NRM, and the type of evidence required to validate IK. Values attached to the Wet Tropics were discussed as defining management priorities, which currently favour ecological objectives to the detriment of indigenous preferred cultural and social objectives (Wiseman & Bardsley, 2013). Interviewees suggested integration of IK in NRM requires the development of a shared set of personal and environmental values and ethics. The acceptance of the role of traditional owners in the management of the Wet Tropics is increasing, and at the same time traditional owners are in the process of attaching their cultural values to the area. These changes are likely to improve the representation of IK in the local NRM. However, further research to understand indigenous environmental values and ethics in the area and more widely in Australia is required (Jackson 2005, 2006; Jackson *et al.,* 2008; Bohnet & Kinjun, 2009; Maclean & Bana Yaralji Bubu Inc., 2011; Grice *et al.,* 2012).

To conclude, my findings point out that IK in the Wet Tropics is perceived as a holistic

belief system. Therefore, its integration in NRM cannot be achieved through a utilitarian attitude, aimed at extrapolating parts of it, but needs to be targeted holistically. Co-generation and co-validation of different knowledges via platforms for engagement of different stakeholders can enable an increasing understanding of the different dimensions of IK: IK needs to be promoted not only as a source of information useful for ecological outcomes, but as a philosophy of NRM alternative to the currently dominant paradigm. My case study suggests targeting integration holistically means integrating methodology for knowledge and information production, developing shared values and ethics for the environment, and achieving more effective NRM governance. This means the core issue is not so much how we integrate IK and science, but how we reconceptualise NRM for it to embrace the entire indigenous worldview.

3.6 Chapter summary, thesis map and research questions

This chapter has identified four main issues in the way integration of IK and science in NRM is currently addressed in the Wet Tropics[5]:

a. The need to investigate a conceptualisation of IK as worldview and reframe the debate on its integration in NRM accordingly;
b. The need for considering values and ethics associated with IK in its integration;
c. The issue of the epistemological validity of IK and
d. The need for a specifically designed platform for knowledge integration.

These issues are investigated further in the other data chapter, Chapters 4-7. Following the direction for research emerged from Chapter 3 I identified general research questions that I tackle in Chapters 4-7. The map to navigate this thesis and the general research questions identified for each chapter are summarised in Figure 3.1.

[5] This chapter has also identified the issue of indigenous internal and external governance in the Wet Tropics, and told how governance affects the sharing and application of IK. Due to time and budget limitations, the issue of governance is not further addressed in this thesis. I return to this aspect of the research problem in Chapter 8.

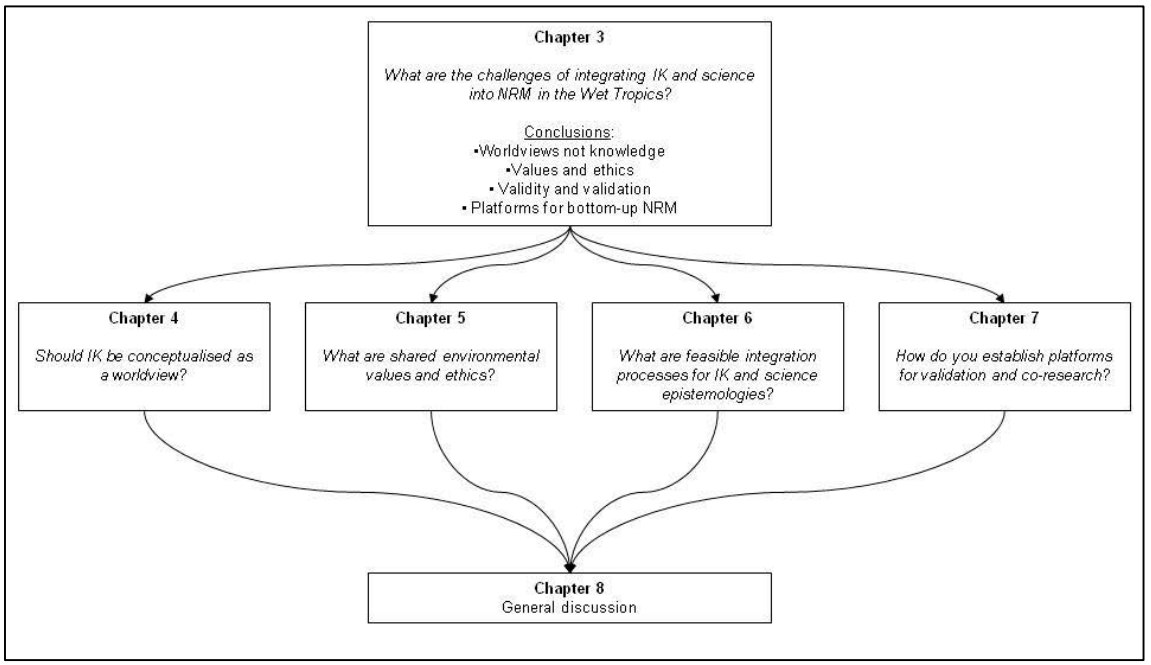


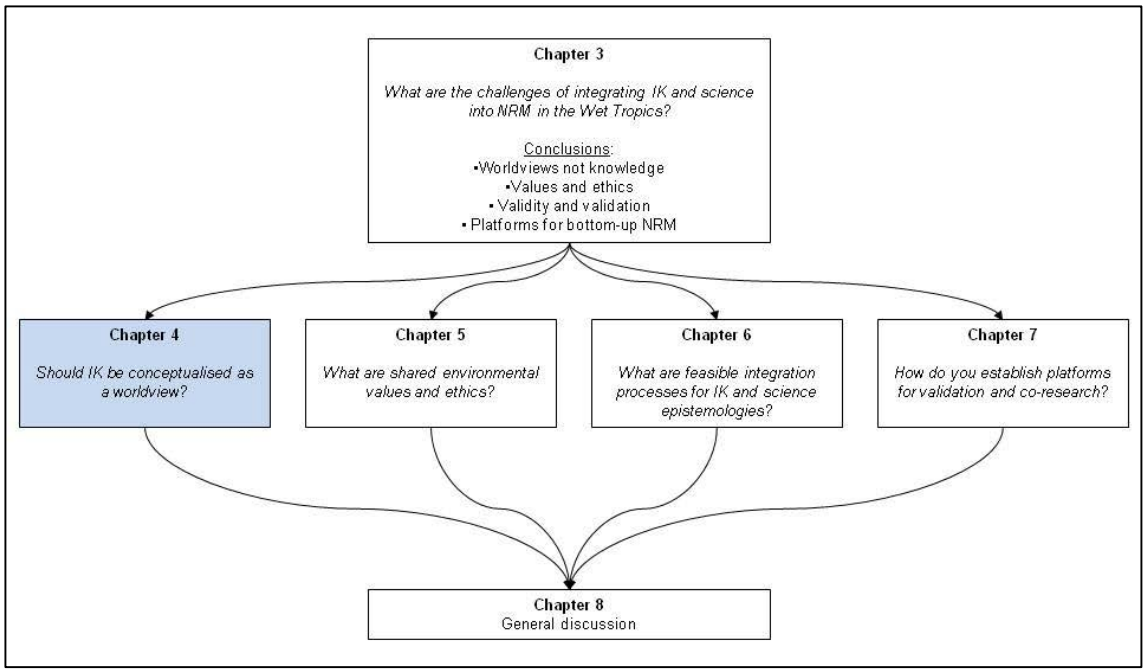
Figure 3.1. Thesis map with summary of results for Chapter 3 and general research questions for data chapters.

Chapter 4: Rewording the debate around indigenous knowledge: indigenous knowledge as a worldview and its potential contributions to the integral sustainable worldview.

Chapter 3 identified that indigenous knowledge and science are perceived as non-equivalent concepts in the Wet Tropics, and suggested an understanding of indigenous knowledge as a worldview. Chapter 4 further explores the relationship between concepts of indigenous knowledge and worldview and discusses some of the implications of looking at the issue of cross-cultural NRM from a worldview perspective. In doing so, Chapter 4 addresses the second research gap presented in Chapter 1. It also contributes to the need to further discuss some theoretical aspects of integration, the third research gap identified in Chapter 1.

Manuscript associated with this chapter:

Gratani, M. Rewording the debate around indigenous knowledge: indigenous knowledge as a worldview and its potential contributions to the integral sustainable worldview. Manuscript in review.



Abstract

In the field of cross-cultural natural resource management, relationships between worldview theory and concepts of indigenous knowledge have remained underexplored, despite the claim that "knowledge" is a term inadequate to convoy the richness of indigenous views of the natural world. In this chapter, based on a case study I conducted in the Wet Tropics of Queensland, I propose a reconceptualisation of indigenous knowledge as a worldview. I discuss several dimensions of the worldview represented by indigenous knowledge: ontology, explanation, prediction, axiology, praxeology and epistemology. I argue that shifting the focus from "knowledge" to "worldview" would facilitate a more holistic and equal representation of indigenous perspectives in modern environmental management.

4.1 Introduction

Dissatisfaction with the scientific *modus operandi* (Ingold, 1993; Banerjee, 2002; Mercer *et al.,* 2005; Allison & Hobbs, 2006; Hawke, 2012), coupled with increasing legal rights of indigenous societies worldwide to manage their estates, has produced interest in indigenous peoples' ecological knowledge and how it can inform sustainable and just natural resource management (NRM) (Bohensky & Maru, 2011; Nadasdy,

1999; Wohling, 2009; Foale *et al.,* 2011; Ens *et al.,* 2012a; Hill *et al.,* 2012; Moller, 2009a; Stephenson & Moller, 2009; Usher, 2000). Nevertheless, what indigenous knowledge is, if it exists, and how it relates in the social context of contemporary indigenous communities is still unclear (Nadasdy, 1999; Stephenson & Moller, 2009; Wohling, 2009). Dimensions of power and ideologies seem to be inherent to the debate but a focus on integrating *knowledge* does not account for them (Nadasdy, 1999; Moller *et al.,* 2009c).

Conceptualisations of IK have often referred to the concept of "worldview". For example, Folke states that worldview and cultural values are part of indigenous societies' knowledge systems (Folke *et al.*, 1998); Berkes identifies worldview as the most general level of analysis for IK (Berkes, 2012); Usher touches upon a "cultural based cosmology" as a framework to organise factual knowledge and environmental values in IK systems (Usher, 2000); in Houde's theorisation, values and cosmology are facets of IK (Houde, 2007); finally, Mazzocchi (2008) conceptualises IK as a "way of life", which provides models of how we came to be in the world, how individuals should conduct themselves in the world, and insights into the relationship human beings can establish with nature. Moreover, other indigenous and non-indigenous scholars point out how indigenous communities understand IK as a "way of life", of "being in the world" (Nadasdy, 1999; Royal, 2005; Aikenhead & Ogawa, 2007). As Keane summarises, IK is more akin to the concept of "a thought system that determines to a large extent the habitual way in which an individual copes with experience", and hence to a worldview (Keane, 2008).

Despite references to the concept of worldview when discussing IK, the literature on cross-cultural NRM has engaged with the worldview literature only to a limited extent, and IK is mostly approached as a collection of "data and information" (Nadasdy, 1999). IK should, however, have been modelled in a more holistic fashion to better serve collaborative NRM (Weiss *et al.,* 2012). Modelling IK is not only important from a semantic point of view, but also largely determines how IK is approached and ultimately used (Usher, 2000; Weiss *et al.,* 2012). There is an obvious link between the constructs people form in their minds, the way they see things, and their consequent actions. For example, adopting a utilitarian approach to the use of IK, disregarding the cultural framework underpinning it and approaching IK in a non-holistic way has been discussed as a barrier to its inclusion in NRM (Weiss *et al.*, 2012). These are issues of

great significance to Australian NRM given the growing Indigenous interest and increasing rights to manage Country (Weiss *et al.*, 2012).

In Chapter 3 I discussed how NRM practitioners and researchers working in the Wet Tropics hint at concepts of worldview when discussing IK and, in less measure, science. In this chapter I further investigate how IK can be modelled as a worldview and what contribution such a change in perspective could make to cross-cultural NRM in Australia and elsewhere. This chapter makes use of two data sources; the interviews used also for Chapter 3 and the published literature, as further detailed in the methods section.

Following, I provide a brief historical overview of how the concept of IK has emerged and evolved in the NRM literature, before introducing the literature on worldview.

4.2 Modelling Indigenous Knowledge

It could be said that interest in IK and its application to NRM was initiated three decades ago[6]. At that time, social anthropology had started to look at IK as a source of development strategies alternative to mainstream strategies (Pottier, 2003). The issue of indigenous land rights gained momentum (Ens *et al.*, 2015). Yet at the start of this process, it was assumed that if IK had anything to offer it was "because science could make use of it" (Pottier, 2003, pg.1). Hence, the approach to including IK in NRM was predominantly utilitarian. Data and information was extracted from IK and then fed into scientific research. With increasing recognition of indigenous land and human rights, collaborative partnerships were soon established between indigenous communities and mostly non-indigenous anthropologists, aimed at understanding IK more holistically and contrasting its exploitation (Pottier, 2003). Over time, the nature and scope of these partnerships evolved. They were broadened to include indigenous and non-indigenous researchers trained in Western scientific and decolonised research methodologies and fields of research beyond classical anthropology, such as NRM, planning, nature conservation and applied anthropology (Sillitoe, 1998; Sillitoe, 2007;

[6] Anthropological interest in indigenous knowledge goes back to the beginning of the 20th Century, however such early research was not concerned with applying IK to NRM, hence I do not hereby discuss such early literature.

Ens *et al.*, 2015).

Collaborative NRM partnerships involving indigenous and non-indigenous stakeholders have since gained respect in their capacity to inform development. However, there remain power imbalances between indigenous and non-indigenous people, which have hindered knowledge integration efforts. To address these power imbalances, indigenous people should be empowered and given higher levels of autonomy, rather than being pushed to embrace the materialistic positions typical of Western societies, which are emerging as unsustainable (Purcell & Akinji Onjoro, 2002). An alternative strategy is to mainstream indigenous worldview so that the positions of local and state government align with indigenous positions (Purcell & Akinji Onjoro, 2002).

Long-term partnerships have seeded numerous models of IK. Many have been published with the aim of making IK more intelligible to non-indigenous NRM researchers, practitioners and stakeholders. One such model classifies IK as incorporating four categories: factual/rational statement about the environment, how it works and explanatory inferences on why it works that way; factual knowledge about past and current use of the environment; value statement about how things should be and what actions are considered proper; and an underlying culturally based cosmology. The latter category is least articulated and hence least accessible. It is a framework by virtue of which people construct knowledge from fact, which Usher defines as the "knowledge system" (Usher, 2000). Usher resolves to focus discussion on the first category, the factual/rational statement about the environment and how it works, because this is the kind of IK that is more easily integrated with science and included in NRM (Usher, 2000).

An alternative model identifies six faces of IK: factual observations about the natural world, the face more compatible with the knowledge used by "resources management bureaucrats" (Houde, 2007, pg.5); management systems, a set of NRM practices that in Houde's vision focus on the sustainable use of resources; past and current land uses; historical knowledge transmitted through oral history; ethics and values about how things should be, to keep exploitation in check; culture and identity, since language and social relationships are often place based in indigenous cultures; and a cosmology, a face of IK which Houde, similarly to Usher, fails to clearly articulate, but which provides cohesion to all other faces (Houde, 2007). Notably, Houde outlines a list of

challenges and opportunities in including each of the six faces of IK, which I omit here for brevity but will return to in the discussion section.

For Berkes and colleagues, IK is a "knowledge-practice-belief complex ... a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes *et al.*, 2000). Considering the numerous facets of IK, including all of its aspects in NRM remains a challenge (Berkes, 2012).

Finally, the Anpernirrentye model prepared by Walsh and colleagues, which is directly informed by a knowledgeable indigenous Australian elder, conceptualised three main domains in IK: Country, People and the Dreaming. It also included 25 sub-domains, called "values" in the original publication (Walsh *et al.*, 2013). Values range from ceremonial rules and codes of conduct to more tangible aspects of IK as food sources and medicine (Walsh *et al.*, 201). Similarly to Usher, Houde and Berkes, Walsh and colleagues denounced that only a limited number of IK sub-domains are usually engaged in NRM projects (Walsh *et al.*, 2013).

By promoting a holistic approach to IK, the above described models aim to overcome the historical view of IK being a source of data and information. They expand the tokenistic inclusion of IK in NRM, capture the less tangible aspects of IK and render justice to dispossessed indigenous people worldwide. These processes assume that educating stakeholders about what IK is and what contributions it can make to NRM will increase the engagement of indigenous people and knowledge in NRM.

Collectively, these models discuss an increasing number of dimensions of IK, until the boundaries between concepts of "knowledge" and "worldview" blurs or disappears altogether, as suggested by Walsh *et al.* (2013), who discuss the Anpernirrentye model as both a model for IK and for the community worldview. Nevertheless, IK has been linked to worldview literature only to a limited extent, hence my interest in furthering the discussion around these themes.

4.3 Conceptual background

Worldview theories to date: a synopsis

Worldviews, derived from the German word *weltanschauung*, are conceptualised as collections of beliefs related to social values about life and the universe, which are held by an individual or group, and enable a comprehensive conceptualisation of the universe and humanity's relation to it. Worldviews are acquired and reinforced through social and cultural interactions initiated in childhood. Individuals learn, through the lens of socialised beliefs and values, "the way things are" and "should be" and this understanding pervades and influences most of their thinking and actions as adults. Most individuals are not aware of this process of socialisation, therefore they acquire beliefs and values unconsciously and uncritically (Olsen *et al.,* 1992). In addition to values, some worldviews provide practical instructions for a way of "being in the world" aligned with such values; all of them contain internal rules for producing valid representations of reality (Aerts *et al.,* 1994; Vidal, 2008). In summary, worldviews establish the culturally accepted definitions of social reality.

A review of the literature on worldview returned many articles that use the worldview concept, but only two analytical theories outline what the content of a worldview is. One theory takes a cultural anthropology approach (Kearney, 1984); the other is formulated by philosophers Apostel and Van der Veken (in Aerts *et al.,* 1994 and Vidal, 2008[7]).

In Kearney's conceptualisation, a worldview is an organised set of "presuppositions" about reality which determine ideas, beliefs and actions predicated on them logically and structurally compatible, so that the worldview is internally consistent. Worldviews have the fundamental task of providing individuals with conceptualisations of the "self", hence they are a source of identity and of the "non-self", which is everything in the

[7] I could not consult Apostel and Van der Veken's original reference because it is in Dutch, however Vidal (2008; pg. 1) clarifies that the work by D. Aerts *et al.* titled "World Views. From fragmentation to integration" (VUB Press, 1994) is the English translation of the original publication, titled "Wereldbeelden. Van fragmentering naar integratie" (DNB/Pelckmans, 1991). I use Vidal (2008) and Aerts *et al*. (1994) to source Apostel and Van der Veken's worldview model.

universe except for the self. "Self" and "non-self" are the most important categories of a worldview, around which all other categories are organised. Classifications are categories with which to organise the non-self, and usually include "society and nature", and sometimes also the category of "God, or God-like beings" (Kearney, 1984). Within these categories, objects are distinct in real and non-real. Worldviews also provide theories about Relationship and Causality between different categories. For example, the relationship between self and non-self can be harmonious, while the relationship between individual and nature may be dominant (Kearney, 1975; 1984). In Apostel and Van der Veken's model, "a worldview is a coherent collection of concepts and theorems that allows us to construct a global image of the world and to understand as many elements of our experience as possible" (Aerts *et al.,* 1994). *World* is intended as the totality in which we live and to which we can relate ourselves in a meaningful way, and hence include the natural and the social world (Aerts *et al.,* 1994; Vidal, 2008). According to this theory, a worldview aims to answer fundamental existential questions about reality, and by doing so it provides a model of the natural world (ontological), an explanation of how the world works (explanatory), predictions of future scenarios (futuristic), a guide for actions in the world (prescriptive), values and ethics to pursue desirable states (ethical), and methods for knowledge creation (epistemological) (Aerts *et al.,* 1994) (Table 4.1). For the purpose of establishing whether IK provides worldview content and can therefore be considered a worldview, I adopt Apostel and Van der Veken's model because it includes the ontological categories employed by Kearney, however it presents additional categories, therefore it is more comprehensive. I summarise Apostel and Van der Veken's theory in Table 4.1, where in the first and second columns I present the original worldview questions and models to answer them, as presented in Apostel and Van der Veken's original model. In the third column I explain the worldview content in terms more relevant to NRM, given the focus of my thesis, while in the fourth I list the typologies of worldview content (Table 4.1).

Table 4.1. Worldview content and dimensions as identified in Apostel and Van der Veken's model (modified from Vidal, 2008).

Existential question about reality	Philosophical discipline that attempts to answer the question, and theory provided	Worldview content	Worldview dimension
What is real?	Ontology, model of reality as a whole	Ontological model of the natural world in the present	Ontological
Where does it all come from?	Explanation, model of the past	Explanation of how the world work and of present and past events	Explanatory
Where are we going?	Prediction, model of the future	Prediction of future events	Futuristic
What is good and what is evil?	Axiology, theory of values	Values and ethics, also in relation to the environment	Ethical
How should we act?	Praxeology, theory of actions	Guide for action, also in form of NRM practices	Prescriptive
What is true and what is false?	Epistemology, theory of knowledge	Methods for knowledge creation and validation	Epistemological

Worldview theory relevance to NRM

A paper published by the journal *Futures* in 2011 explained the global ecological and financial crises in terms of a worldview crisis. The central thesis of this work was that the current integral worldview – the sum of all different worldviews held by different human societies – is not sustainable and is imbalanced towards materialistic and subjective approaches to quality of life (van Egmond & de Vries, 2011). Its authors proposed that different worldviews currently adopted by worldwide societies can be located along two axes, the vertical *materialistic-idealistic* axis and the horizontal *individual-collective* axis, based on the specific values and beliefs they promote (Figure 4.1).

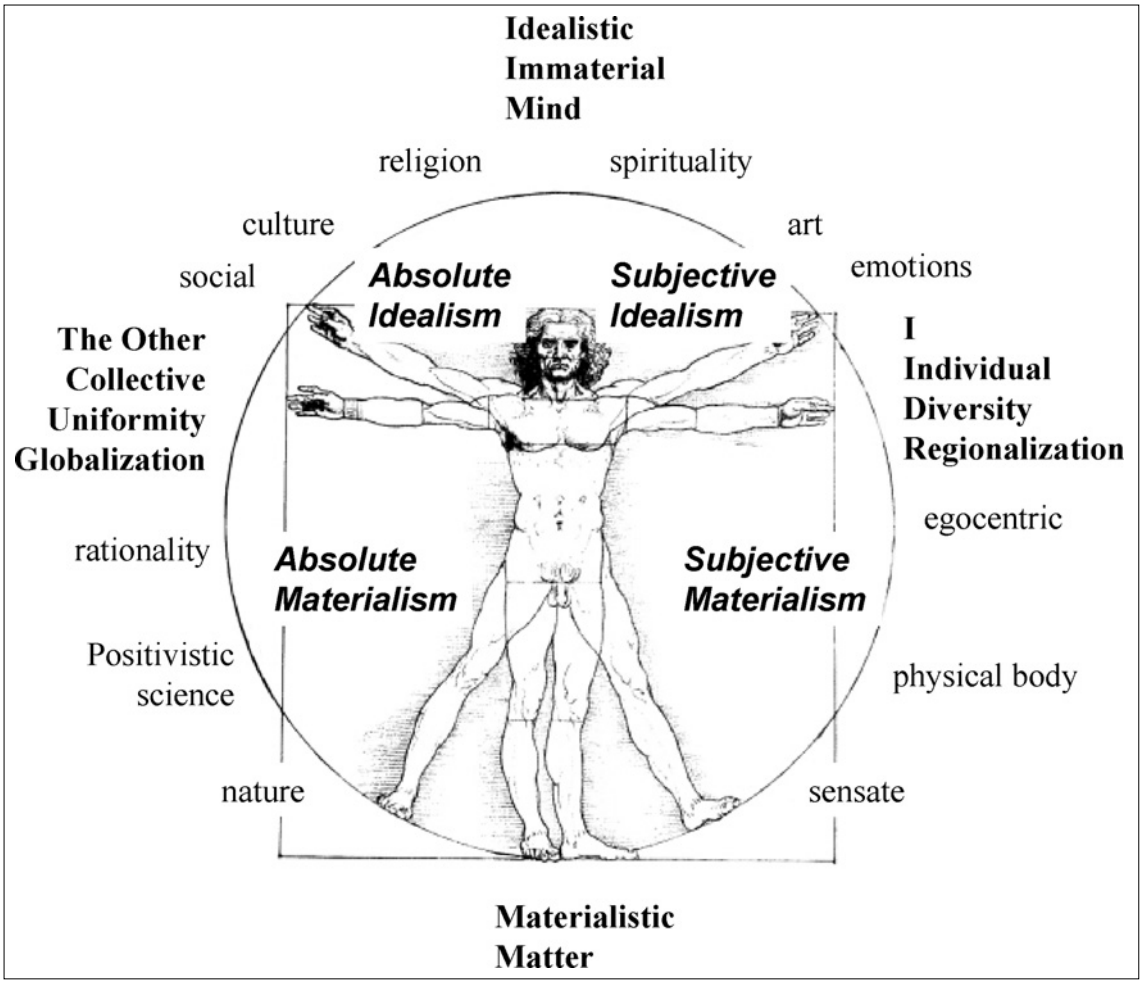


Figure 4.1. The integral worldview, as conceptualised by van Egmond and de Vries (2011).

Currently, the integral worldview is dominated by a materialistic worldview that promotes the existence of one universal absolute truth: that the world can be understood and managed according to scientific principles; and that science and technology can solve sustainability problems (Egmond & de Vries, 2011). This dominant worldview is grounded in egocentric values (van Egmond & de Vries, 2011). The authors discuss the imbalance towards such egocentric materialistic worldview as the root of our sustainability problems, which are dooming the global human society (van Egmond & de Vries, 2011).

To counteract this imbalance and avoid the collapse of the global human society, non-materialistic collective worldviews should be supported within the integral worldview (van Egmond & de Vries, 2011). For this to happen, a shift towards spiritual and eco-

centric values is needed. Only then will our social-ecological systems avoid collapse (van Egmond & de Vries, 2011). Perhaps IK could contribute to a more sustainable integral worldview, however if IK is a worldview still needs to be established, hence my attempt to verify if Apostel and Van der Veken's model of worldviews can fit IK.

4.4 Methods

This chapter relies on deductive theme analysis of interview transcripts from my research described in Chapter 3 and of published literature on IK in NRM. The first part of this chapter relies on the same sets of interviews as for Chapter 3. I refer the reader to that chapter for an outline of the methods for selection of project participants', recruitment and interviewing processes[8].

To verify if Apostel and Van der Veken's model of worldviews could explain how IK was discussed by research participants, I derived codes from Apostel and Van der Veken's worldview dimensions and reviewed interview transcripts to see if those themes were discussed for IK. Whenever I found that the worldview dimension as theorised by Apostel and Van der Veken's was discussed by participants for IK, I coded the corresponding paragraph under that theme (theme analysis through deductive coding. See Table 4.1 for a list of worldview dimensions used to codes themes discussed for IK). The theme/codes used in my analysis are therefore "ontological", "explanatory", "futuristic", "prescriptive", "ethical", and "epistemological".

Because my thesis focussed on environmental issues and conversations about NRM, I adapted Apostel and Van der Veken's model for structured interviews. For the ontological dimension, I searched interview transcripts for statements that would support an understanding of IK as a model of the natural world. Similarly, for the Explanatory and Futuristic dimensions, I searched transcripts for statements which

[8] To facilitate reading this thesis, I wish to restate that when interview extracts are presented, interviewees are identified in the text with a letter-numerical code. The first letters indicate *indigenous* (*I*) or *non-indigenous* (*NI*) interviewees, followed by *R* (researcher) or *EM* (environmental manager) and number. I interviewed five non-indigenous researchers (*NIR*), two indigenous researchers (*IR*), five non-indigenous environmental managers (*NIEM*) and four indigenous environmental managers (*IEM*).

demonstrated an understanding that IK is an embedded a model of how the natural world works in the present and will work in the future. For the theory of action, the theory of praxeology, I searched transcripts for statements that expressed an understanding of IK as including NRM practices on how to act in the environment. I characterise this dimension as "prescriptive" because it lays the rules for correct action in the world. I counter it with the ontological, explanatory and futuristic dimensions, which are mostly "descriptive" of the world in the present, past and future, respectively. For the ethical dimension, I searched transcripts for statements that suggested an understanding of IK as comprising ethical principles that guide attitudes and behaviours towards the environment. Finally, I searched interview transcripts for descriptions of IK that included methods for knowledge creation, the epistemological dimension of a worldview.

Systematic analysis of the literature

I conducted the same deductive theme analysis on a sample literature on cross-cultural NRM. In March 2014, I searched the literature for peer-reviewed journal articles that reported original research and contained the phrase "traditional ecological knowledge" (TEK) among their key words. I searched "TEK" because the term is more widely adopted in the international literature on cross-cultural NRM compared to *indigenous knowledge*. IK can be seen as a special case of TEK (WIPO, 2001), however in the literature the terms are commonly used synonymously (Sillitoe & Bicker, 2004).

The literature search was web-based and used the *SCOPUS* database, which operates on a wide multi-disciplinary platform (20,000 peer-reviewed journals from 5,000 international publishers). I focussed on articles published during the past decade (2004-2014) to detect current trend on how IK is discussed. The search returned 200 papers. Of these, I sampled 60 whose full text was accessible though my institution's subscriptions. Only those concerned with indigenous knowledge and communities were selected. Publications concerned with other forms of traditional or local knowledge were excluded. Moreover, IK papers were screened to select those which reported original research on cross-cultural NRM. I excluded review papers from the study. The final sample of papers totalled 29; fifteen percent of the initial search result. I then conducted a deductive analysis of the themes used in the papers to discuss IK and science, with codes derived from Apostel and Van der Veken's worldview dimensions.

The software *NVivo* supported the thematic analysis of the literature. Full references of the papers I reviewed are provided in Appendix 1.

During the coding process I allowed for the emergence of additional dimensions of IK that were not represented in Apostel and Van der Veken's model of worldviews; when additional themes emerged, I created new codes and, therefore, new typologies of worldview content.

4.5 Results and discussion

The theme analysis of interview transcripts revealed that when participants discussed IK, they employed each of the six worldview dimensions conceptualised by Apostel and Van der Veken. For example, interviewees discussed IK as a body of knowledge that contains a model of the natural world; explanations of how the natural world functions and how it has changed from the past, which usually emphasised the interactions between humans and non-humans and Country; and predictions about future events. In terms of the prescriptive worldview dimension, interviewees perceived IK as a detailed body of lore and customs which govern how resources should be managed, and speculated that such rules aimed to maintain sustainable resource use. Interviewees also discussed IK as including environmental values and an ethic of connectedness between humans and the environment. Finally, IK was discussed as created through the epistemological processes of attuning to the environment and putting one's observations into a more general context (Table 4.2).

Table 4.2. Themes raised by participants discussing indigenous knowledge and science, and illustrative quotes.

Worldview Dimension	Illustrative Quotes
Ontological	*"IK is the traditional owners' understanding of what they see around them, in the optic of their culture and past."* (NIEM5)
	"[IK is a] *spiritual understanding of the world that relates things to land management and how they look after the land."* (NIR3)
Explanatory	*"If you have healthy Country, then you have healthy people. If you don't have healthy people, then you don't have healthy Country. Once again it depends* [on] *the individuals; what they do in Country that potentially creates the problem."* (IEM1)
	"[In IK] *if you talk about an animal it is never just an animal but it is also a totem and it comes with its stories.* [We once] *had an old man saying that these animals are not here anymore because they don't do ceremonies anymore. If you consider that in fact if people are not on the land anymore and they don't do ceremonies anymore, and by ceremonies we don't just mean dancing and singing but also for example burning the land in a particular way, and hunting in a particular way that is all part of it. Than the practical implication of doing ceremonies and burning certain areas in a certain period of the year well that has a very ecological consequence for those species, and that might be the reason for those species to disappear, so he is in fact quite right, they are not doing ceremonies for that species anymore, they are not dancing, they are not singing and they are not burning anymore."* (NIR3)
Futuristic	*"They also applied that knowledge to do prediction of certain events. For example if some flowers are on trees it is clam time, and you find turtles would be mating and you find them on top of the water, and then they worked out how to use that knowledge."* (NIEM4)
	"Indigenous people were intimately connected with the environment, and their understanding of it comes from the human capacity for knowing, understanding and making predictions about the natural environment." (NIR1)
Prescriptive	*"I think it is a way to look after natural resources, for example [once] we got a stingray and that was given to one family, because that family has the knowledge for that thing, how to prepare it and how to cook it."* (IR2)
	[IK contains a] *very detailed systems of lore and custom. For example there was a law that even today says that pregnant women are not allowed to eat barramundi, why is that so? A lore and legislation that is there for a reason, because if we all eat them there wouldn't be any left. So that is the law that determine what you could do and what you couldn't do, and that was about sustainability."* (IEM4)
Ethical	*"Part of the IK system is not only the knowledge but the indigenous values that are associated with that."* (IEM4)
	"I think TEK is a huge body of holistic knowledge. If I think the way some elders have of learning and knowing and the connectedness, for them the wellbeing and the environment are connected, the people are part of it too." (NIEM1)
Epistemological	*"*[IK is created by] *looking and observing the forest, attune to see little things that happen and that change in the environment, and be able to get the big picture of what is happening in the environment."* (IEM2)

The theme analysis of the literature offered similar insights and suggests the six dimensions of worldview theorised by Apostel and Van der Veken account for most of the themes used to describe IK (Table 4.3). Overall, emphasis was on the descriptive dimensions of IK, with the vast majority of papers approaching IK as a collection of information or a data set and discussing it as an ontological model of the world, used to explain the past and, with much less emphasis, to enable predictions for the future. The epistemological dimension of IK was a theme well represented in the literature, while the ethical and prescriptive dimensions of IK were discussed but in fewer papers.

Two additional themes emerged from the literature: the cosmological dimension and the pedagogical dimension of IK. The cosmological dimension aimed to explain how the world was created. Ontological, explanatory and futuristic dimensions of IK are based on direct observations of the world, while the cosmological dimension suggests that a leap of faith should be endorsed. I maintain that the cosmological dimension is distinct from all others. Pedagogy did not easily fit within any of the six dimensions of a worldview as theorised by Apostel and Van der Veken, so I created an additional category for it, bringing the number of dimensions of IK to eight. Notably, only one of the reviewed papers employed all eight themes when discussing IK, by Turner & Berkes and published in 2006.

Table 4.3. Worldview dimensions used to discuss indigenous knowledge in the literature, together with percentage of papers discussing them.

Worldview Dimension (% papers that discussed it)	**Illustrative quotes**
Ontological – (80%)	"Canadian Inuit recognise six seasons based on natural phenomena associated with weather or animal movements. The two extra seasons cannot be readily translated into English, but can be *defined* as pre-fall and pre-summer. In the design of the TEK database, these two extra seasons were incorporated into the four-season structure, with pre-fall reclassified as fall and pre-summer reclassified as summer" (Lewis *et al.,* 2009).
Explanatory – (48%)	"Consultants emphasised that female weevils appear to be selective about where their eggs are deposited, with *R. palmarum* females preferring to deposit eggs where the inner palm tissues are exposed, while *R. barbirostris* females prefer the surface of trunks, close to internodal scars, and areas with few other eggs. Consultants believe that after mating, *R. palmarum* adults disperse to other cultivation sites in search of fresh palms, whereas many *R. barbirostris* weevils die, because the Jotı frequently find dead *R. barbirostris* adults at cultivation sites" (Choo *et al.,* 2009). "The Creator made all things one. All things are related and interconnected. All things are sacred. All things are therefore to be respected" (Turner & Berkes, 2006).
Futuristic – (27%)	"The TEK-based HIS [Habitat suitability index] models also had high predictive performance when evaluated with caribou location data" (Polfus *et al.*, 2013).
Prescriptive – (20%)	"All participants stressed the importance of harvesting only what was necessary and ensuring that they used every portion of the harvested culms where possible" (Kapa, 2010).
Ethical – (34%)	“The Dayak believe that natural resources, including forests, are important for human existence. That ‘‘land and people are interdependent’’ is the basic philosophy of the Dayak communities. Latitana, or forest land, is a concept of land use management related to many aspects of human life—religion, kinship, social and economy. Communities are aware of their dependence on their natural resources and the vital need to conserve. It is well recognised that degradation of resources can lead to serious negative consequences, mostly upon succeeding generations. *Simpukng* is an important part of Dayak culture" (Mulyoutami *et al.,* 2009).
Epistemological – (55%)	“The verity of this knowledge is not established by physical instruments, but reinforced through repeated observations over a long temporal scale that encompasses the immediate present” (Ignatowski & Rosales, 2013).

Worldview Dimension (% papers that discussed it)	Illustrative quotes
Pedagogical – (34%)	"During this training phase, young hunters are also taught to respect the woods by being mindful of other beings (animals, plants, spirits) that live there and conducting themselves in the woods as if they were in someone else's home. Some hunters are taught to give tobacco as a gift to the beings that reside in the woods before they enter to hunt (more discussion on tobacco use below). LDF[9] notions of respect for the woods also involve leaving the woods the way you found it by not littering" (Reo & Whyte, 2012).
Cosmological – (3%)	"The Creator made all things one. All things are related and interconnected. All things are sacred. All things are therefore to be respected" (Turner & Berkes, 2006).

The eight dimensions of IK as a worldview, derived by Apostel and Van der Veken's worldview model with the addition of the "cosmological" and the "pedagogical" domain, also explain previous models of IK, summarised in Table 4.4, with only Berkes and colleagues' model including all of the eight worldview dimensions I identified.

[9] The Lac du Flambeaou Band of Lake Superior Chippewa Indians.

Table 4.4. Dimensions of IK as identified by different IK models.

Worldview Dimension	Usher	Houde	Berkes et al.	Walsh et al.
Ontological	●	●	●	●
Explanatory	●	●	●	●
Futuristic		●	●	●
Prescriptive		●	●	●
Ethical	●	●	●	●
Epistemological			●	
Pedagogical			●	●
Cosmological	●	●	●	●

The eight dimensions of the indigenous worldview

The descriptive dimensions: Ontological, Explanatory and Futuristic model of the world and sense of self

My analysis of the perceptions of IK, and of the themes used to discuss it, confirmed a strong familiarity of NRM practitioners and researchers with IK as a description of the natural world and explanation of how it works. During my interviews, participants discussed IK as providing a model of the world and how it works, mediated by one's "culture", from which NRM practices descend. Interconnectedness was a theme commonly employed by interviewees when discussing the explanation of the world described in IK. Ceremonial and spiritual elements were recognised in IK systems as means of explanation of the reality, and causes of environmental issues. One particular interviewee suggested that there are no healthy people without healthy country. Another emphasised the practical environmental outcomes that can be generated by spiritual ceremonies that reinforce the connection between people and their country. Interviewees also recognised IK as source of predictions for the future, grounded in the understanding that the natural and social reality is interconnected.

Descriptive dimensions of IK were highly represented in the literature. The majority of the papers I reviewed discussed IK as providing a model of the real world and how it works, and attempted to reconcile this model with the scientific counterpart. Lewis and colleagues (2009) studied Nunavik knowledge of beluga whales during their

comparison of IK informed data with scientific data. Douterlungne and colleagues (2008) looked at applications of the knowledge of Lacandones, a Mayan community in Mexico, to scientifically validate it for its effectiveness against invasive plant species present in the area. Fraser and colleagues (2013) investigated the abundance and occurrence of species, population trends and conservation concerns held by first Canadians to monitor remote trout populations. Most authors gave emphasis to the descriptive facets of IK, which strengthen the vision of IK as a source of data and information. Other components of IK were less represented, such as the values given to species studied. Descriptive content of IK has been traditionally considered easy to extract and use in NRM, a point echoed by theorists of the IK models I present in Table 4.4. However, to consider IK as merely a source of data and information is risky if IK content is presented without adequate acknowledgement of other IK dimensions. Such an approach is unfair to indigenous societies, is overrated, and fosters utilitarian approaches to IK inclusion in NRM (Weiss *et al*., 2012).

Similarly to NRM experts from the Wet Tropics, the literature discussed IK as an enabler of predictions for the future. This worldview aspect of IK was discussed mostly in terms of indicators for monitoring the status of resources and for their harvest, exemplified by Lefale (2010), concerned with the possible application of IK derived indicators to monitor climate change, or in Polfus *et al.* (2013), where the focus is in understanding the capacity of IK to inform predictive models of the abundance of caribou according to different resource use scenarios. IK was, however, discussed for its capacity to enable predictions in a smaller number of papers, and often with the intent to feed it in statistic models, which again presents similar risks of misappropriation of the indigenous worldview futuristic content.

The prescriptive dimension: practices for NRM

Interviewees discussed rules for accessing and sharing resources as important components of IK. One participant spoke of a research project he conducted, during which a stingray was given to the family knowledge holder to appropriately prepare and cook it. Another speculated that lore and customs concerning resource management aimed to ensure sustainability. The prescriptive content of IK was clearly outlined by many interviewees, and was well represented in the literature, even if to a lesser extent than the descriptive dimensions. Usually prescriptions were discussed as means to

minimise overharvest of resources, or and only harvest what was needed, while minimising waste. Choo and colleagues (2009) discussed the Joti, indigenous people of the Amazon, who feared retribution should resources be misused. Peloquin and Berkes (2009) discussed Cree goose hunters, whose IK derived practices aimed to favour used species versus unwanted or invasive species. Douterlungne and colleages (2008) discussed how the Lacandones' IK of milpas management was applied to restore lands infested by braken ferns. Prescriptions aim to maintain a respectful relationship with the source of resources, where what is borrowed is somehow returned through rituals and spiritual practices. This is exemplified by Reo and White (2012), who described how Ojibwe deer hunters manage their land in a way that ensures the long term sustainability of deer as a way of reciprocating the gift of deer giving their life to feed them.

The ethical dimension: the guiding principles

The ethical content of IK was discussed in interviews and the literature as values, understood as principles of respect and reciprocity, and an environmental ethic of interconnectedness between land and people (see for examples interviewees' extracts presented in Table 4.2; Turner & Berkes, 2006; Peloquin & Berkes, 2009; Kapa, 2010; Ignatowski & Rosales, 2013; Reo & White, 2012; Shen *et al.*, 2012). The ethical content of IK was discussed by many interviewees and explored in more than a third of the reviewed papers, suggesting a perceived importance but also familiarity of researchers and practitioners with this type of IK content.

The epistemological dimension: how the IK/worldview is created

Fewer interviewees discussed IK as being created by specific epistemological processes compared to those who discussed the ethical and ontological content. The epistemological content of IK was largely represented in the literature review, with more than half of the papers touching on this topic. Turner and Berkes (2006) and Ignatowski and Rosales (2013) discussed indigenous epistemologies extensively. Turner and Berkes (2006) described "lessons from the past and from other places, perpetuated and strengthened through oral history and discourse; lessons from animals, learned through observation of migration and population cycles, predator effects, and social dynamics; monitoring resources and human effects on resources (positive and negative), building on experiences and expectations; observing changes in ecosystem

cycles and natural disturbance events; trial and error experimentation and incremental modification of habitats and populations" as methods to build ecological understanding of the natural world. Within indigenous societies, an acquired understanding is validated through repeated observations over a long temporal scale (Ignatowski & Rosales, 2013).

The pedagogical and the cosmological content of IK

The literature review I conducted suggested that IK also provides pedagogical and cosmological content. Both content types are not described as worldview dimensions in Apostel and Van der Veken's model. The cosmological content of IK has been extensively discussed in the literature and accrues to the beliefs/religious dimension of IK, the type of content that requires faith to be endorsed, and is deemed to be difficult to include in NRM.

IK is instead less often discussed as providing pedagogical content. Reo and White (2012) thoroughly describe how the Lac du Flambeau Band of Lake Superior Chippewa Indians (LDF) deer hunters are taught hunting related values, techniques and safety principles. For example, they are taught to be mindful while in the forest, to always know where they are and what they are there for. They learn how to show respect for the deer they hunt through prayer and tobacco offers, how to butcher their catch to avoid waste, and how to remain sober during the hunt to show respect for the deer and maintain their safety (see also Choo *et al.*, 2009 and Kapa 2010 for additional discussion on the IK pedagogical content). Their process of teaching gives evidence that IK provides instructions to perpetrate its own worldview content, a feature worldviews need for their own survival.

4.6 Conclusion

In this chapter I have demonstrated how IK and science are perceived to be non-equivalent in the Wet Tropics, and further investigated the dimensions of IK discussed during my interviews with indigenous participants and the literature. I found that the theme analyses of interview transcripts and that of the literature support an understanding of IK as worldview, with ontological, explanatory, futuristic, prescriptive, ethical, and epistemological dimensions consistent with the model of

worldview theorised by Apostel and Van der Veken (Aerts *et al.,* 1994; Vidal, 2008). In addition, I have identified cosmological and pedagogical content types of IK as worldview.

Van Egmond and de Vries (2011) advocate that present sustainability problems are mostly due to an imbalance in the current integral worldview towards a materialistic and individualistic view of life and the world; and that the balance should be restored by promoting less materialistic and less individualistic values and associated worldviews. IK offer the ecological worldview that may support the transition towards a more sustainable integral global worldview.

As for the integration of the indigenous worldview with the scientific perspective, I did not extend my analysis of the literature to explore if science can also be considered a worldview. Indeed, when contrasting indigenous perspectives on the world with non-indigenous ones, expressions like "western worldview", "western scientific worldview", "scientific worldview" and "colonial" or "dominant" worldview are used (Pierotti & Wildcat, 2000; Shizha, 2006; Mazzocchi, 2008; Irzik & Nola, 2009; Weiss et al., 2012; Van Opstal & Hugé, 2013). Moreover, Reeves (2013) observes that scientific theories "can be integrated to form a general vision of humans and our place in nature, one that excludes the existence of supernatural phenomena" and that this vision is the scientific worldview; the question of whether science "*is"* a worldview is, anyhow, still contentious (Reeves, 2013, p. 559).

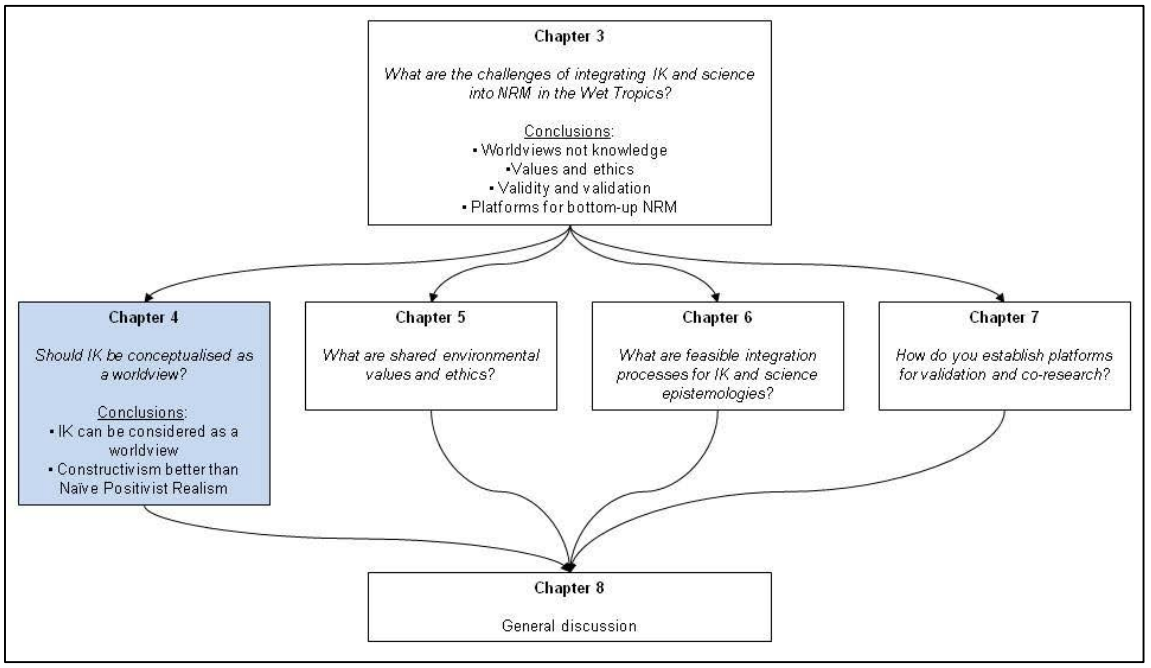
In my view, the term "knowledge" in IK is problematic. It has been observed before now that this term should be used with caution, thoroughly defined or abandoned altogether (Moller *et al.*, 2009). I have discussed IK as a worldview, therefore when promoting the inclusion of IK in NRM, IK should be approached holistically and all its dimensions considered in the integration process. In the following chapters I further discuss avenues for the inclusion of IK dimensions in NRM and for its integration with science where possible.

4.7 Chapter summary

We need to investigate how IK is conceptualised and communicated in cross-cultural NRM in the Wet Tropics as well as in the international literature.

The analyses presented in this chapter support a conceptualisation of IK that is broader than "knowledge system" and more akin to a worldview, and identifies eight types of worldview content that IK present.

In Chapter 5 I discuss one such "worldview content type", the axiological type, as well as the values and ethic that IK contains and how to promote them in Wet Tropics NRM.

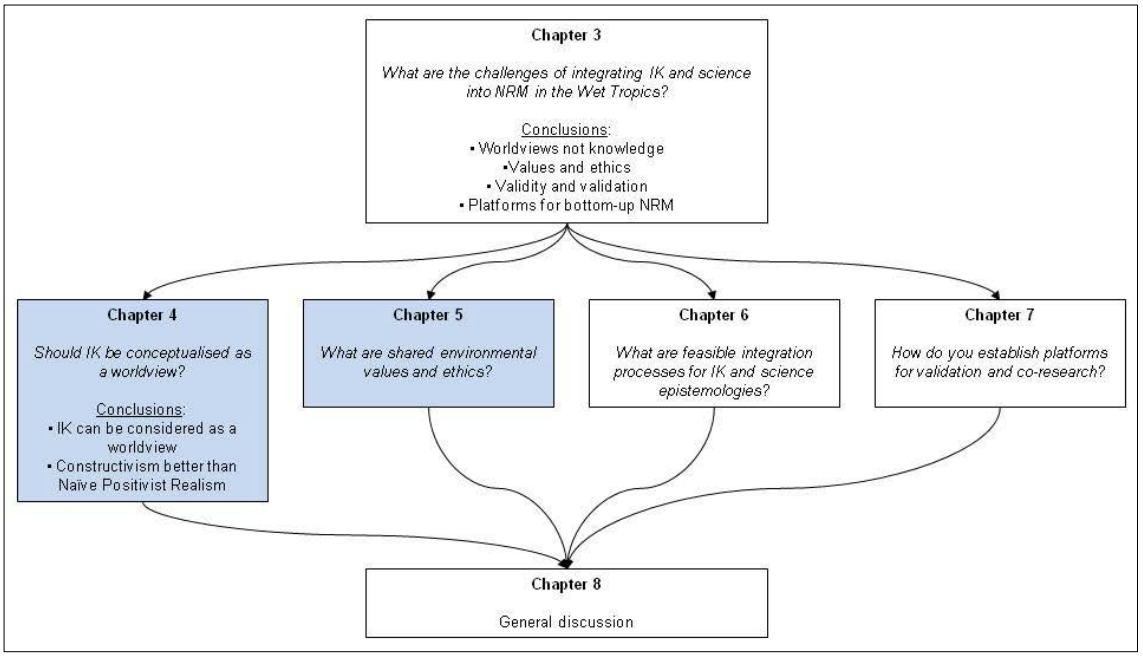


Chapter 5: Indigenous environmental values and ethics to inform sustainable water management: broadening understanding through a case study from the Wet Tropics of Queensland

In Chapter 3 I discussed a perception, within the Wet Tropics, that a shared set of personal and environmental values is necessary for local natural resource management to be participated in. As I discuss in Chapter 4, ethics and values are important part of the worldview indigenous knowledge. In this chapter I investigate the environmental values and ethic held by a community of Traditional Owners of the Wet Tropics, and I discuss them in the context of Schwartz theory of humanitarian values. I conclude that indigenous values and ethic could support sustainability in my study area by re-introducing in NRM a feeling of reverence for the environment that is currently lost. This is the first of three data chapters that rely on the collaborative ethnographic case study I conducted with the Malanbarra and Dulabed Yidinji.

Manuscript associated with this chapter:

Gratani, M., S.G., Sutton, J.R., Butler, E.L. Bohensky & S. Foale. In review. Indigenous environmental values and ethics to inform sustainable water management: broadening understanding through a case study from the Wet Tropics of Queensland.



Abstract

The claim that in natural resource management (NRM) a change from anthropocentric values and ethics to eco-centric ones is necessary to achieving sustainability leads to the search for eco-centric models of relationship with the environment. Indigenous cultures can provide such models; hence there is the need for multicultural societies to further include their values in NRM. However, Australia's current understanding of indigenous environmental values and ethics is limited and their inclusion in cross-cultural NRM is unsatisfactory. In this chapter I investigate the environmental values and ethic placed on freshwater of the Wet Tropics by a community of Indigenous Australians. I use Schwartz's theory[10] of humanitarian values to frame my analysis and discussion of the contribution these values and ethics can make to sustainable NRM. I found the participant community holds biospheric values and an eco-centric ethic; restoring these values and ethic in NRM could contribute to sustainability. The case study I present also suggests Schwartz's framework for environmental values and ethics is applicable to the indigenous community who took part in the project. I therefore argue that Schwartz's theory of humanitarian values should be used as a unifying framework to integrate indigenous and non-indigenous values to inform sustainable NRM.

[10] See Schwartz (1994).

5.1 Introduction

The way societies approach natural resource management (NRM) is a reflection of their values, ethic and how they define and measure quality of life. Historically, "western" societies have been associated with egoistic values, anthropocentric ethic and understanding of quality of life based on materialism. Such perspectives have allowed for natural resources to be irresponsibly exploited, provided the right technology was available and cost-effective (Merchant, 1992). A materialistic approach to NRM is increasingly recognised as unsustainable and a change in values and ethics towards more sustainable ones is advocated (van Egmond & de Vries, 2011). Furthermore, universalist / biospheric values and eco-centric environmental ethics are being increasingly correlated with pro-environmental behaviours (Stern, 1994; Schultz & Zelezny, 1998; Clark *et al.*, 2003; Garling *et al.*, 2003; Teel *et al.*, 2007; Axsen & Kurani, 2013). Consequently, incorporating eco-centric values and ethics into NRM policy and practice could promote sustainability.

Indigenous cultures may represent sources of environmental values and ethics alternative to dominant materialistic ones. A number of authors have argued that historically indigenous cultures were underpinned by eco-centric values and ethics and holistic, non-materialistic worldviews (Ingold, 1993; Banerjee, 2002; Mercer *et al.*, 2005; Hawke, 2012). Recent research indicates many indigenous societies worldwide still hold such eco-centric values and ethics despite globalisation and the consequent erosion of their traditions (Kelbessa, 2005; Michell, 2005; Snodgrass *et al.*, 2007; White, 2010; Voeller, 2011; Hawke, 2012; Royal, 2012); hence one could argue that by developing a common set of values and a shared ethic to inform NRM that reflects indigenous ones, a more sustainable approach to NRM can be promoted. NRM that is inclusive of indigenous environmental values can also enable environmental justice and the survivorship of cultural minorities, which are at risk of cultural assimilation by mainstream capitalistic societies (Razak, 2003).

In Australia, and similarly in other settled countries, the contribution indigenous environmental values and ethic can make to sustainability thinking is under-researched and hindered by the current approach to environmental values and NRM research. Mostly, environmental values are conceptualised as biophysical attributes of the environment, such as landscape features and formations, and sites, processes and

properties such as endangered species and biodiversity. This conceptualisation permeates much of the literature on modern NRM and conservation (Bentrupperbäumer *et al.*, 2006). When environmental values are conceptualised in biophysical terms they are consequently associated with places and tangible aspects of the landscape. As a consequence, intangible values and the ethic associated with the environment remain overlooked to the detriment of the holistic indigenous worldviews (Jackson, 2006; Jackson *et al.*, 2005; Langton, 2011; Maclean & Bana Yaralji Bubu Inc., 2011; Ross, 1996; Smith *et al.*, 2003; Toussaint *et al.*, 2005; Trigger & Mulcock, 2005). This limits the potential contribution of indigenous societies and their environmental values to sustainability thinking.

To overcome the conceptualisation of environmental values as biophysical attributes of the environment, it has been proposed that environmental values should be considered as humanitarian values, and therefore as "individual and shared community or societal beliefs about the significance, importance and wellbeing of the natural environment, and how the natural world should be viewed and treated by humans" (Reser & Bentrupperbäumer, 2005, p.141; Jackson *et al.,* 2005; Jackson 2006; Bentrupperbäumer *et al.*, 2006). As such, environmental values are ethical principles that guide individual and societal decisions about the environment (Bentrupperbäumer *et al.*, 2006; Reser & Bentrupperbäumer, 2005). To date, however, none of the available studies on indigenous environmental values, in Australian contexts, has discussed them from this perspective (see for example Barber & Jackson, 2011; Goode *et al.,* 2003; Grice *et al.*, 2012; Larrakia, 2008; Maclean & Bana Yaralji Bubu Inc., 2011; Venn & Quiggin, 2006). Moreover, while the need to develop an integrative set of values and shared ethics that reflect indigenous and wider community perspectives and interests has been acknowledged, it is not clear how these shared values and ethics could be achieved (Jackson, 2005; 2006). This chapter aims to further this understanding.

5.2 Conceptual background: defining environmental ethic, values and associated constructs – insights from philosophy, psychology and social sciences

Values, and subset environmental values, are related to the concept of beliefs. Beliefs are understandings about the state of the world that are typically considered *facts* to those who hold them, since individuals are usually unaware their understanding of the world is socially and culturally constructed (Olsen *et al.*, 1992). Values are a special set of beliefs about what is good and evil, right and wrong, beautiful and harmonious, or not (Vidal, 2008).

In 1987, Schwartz and Bilsky proposed a definition which encompasses much of the work preceding them (Dietz *et al.*, 2005): values are beliefs about desirable end states or behaviours transcend specific situations and guide selection or evaluation of behaviours and events. Hence, values are guiding principles which provide individuals with motivations to identify goals and criteria to guide actions and achieve them (Schwartz, 1994). This definition resonates with the work of Reser and Bentrupperbäumer, who argue environmental values are beliefs held by individuals and societies about the significance, importance and wellbeing of the natural environment that inform how humans should treat the natural world (Reser & Bentrupperbäumer, 2005). Over the past three decades Schwartz's work has influenced research in environmental values and his theory of universal humanitarian values has been validated in more than eighty countries. I therefore adopt Schwartz's theory of humanitarian values as theoretical framework for my study on the grounds that it has been validated worldwide.

In his theory of universal humanitarian values, Schwartz (1994) argues there are 56 universal values that can be found consistently across cultures (Table 5.1). These values guide individuals' actions to satisfy biological needs as well as the requirements for smooth social interactions and group survival. Based on similarities of the goal they support, these 56 values can be grouped into ten value-types (Table 5.2) conceptualised by Schwartz: power, achievement, hedonism, stimulation, self-direction, universalism, benevolence, tradition, conformity and security. These ten value types form a continuum, in a circular structure, since each value type shares emphases with adjacent

ones. Hence, values that express opposing motivations are on opposite sides of the circle. This allows the orientation of value-types along four axes which Schwartz names self-enhancement, conservation, self-transcendence and openness to change. The four axes are therefore "value orientations". Later, Schwartz and his commentators redefined the self-enhancement, conservation and self-transcendence value orientations as egoistic, traditional and biospheric or altruistic value orientations to avoid confusion with similar terms used in different NRM contexts (Dietz *et al.*, 2005; Schwartz, 1994; Stern & Dietz, 1994). I too adopt the redefined values in my thesis (Figure 5.1).

Table 5.1. Humanitarian universal values, as conceptualised by Schwartz (adapted from Struch & Schwartz, 2002).

Schwartz's Humanitarian Values	
1. Equality (equal opportunity for all)	29. A world of beauty (beauty of nature and the arts)
2. Inner harmony (at peace with myself)	30. Social justice (correcting injustice, care for the weak)
3. Social power (control over others, dominance)	31. Independent (self-reliant, self-sufficient)
4. Pleasure (gratification of desires)	32. Moderate (avoiding extremes of feeling and action)
5. Freedom (freedom of action and thought)	33. Loyal (faithful to my friends, group)
6. A spiritual life (emphasis on spiritual not material matters)	34. Ambitious (hard-working, aspiring)
7. Sense of belonging (feeling that others care about me)	35. Broadminded (tolerant of different ideas and beliefs)
8. Social order (stability of society)	36. Humble (modest, self-effacing)
9. An exciting life (stimulating experiences)	37. Daring (seeking adventure, risk)
10. Meaning in life (a purpose in life)	38. Protecting the environment (preserving nature)
11. Politeness (courtesy, good manners)	39. Influential (having an impact on people and events)
12. Wealth (material possessions, money)	40. Honoring of parents and elders (showing respect)
13. National security (protection of my nation from enemies)	41. Choosing own goals (selecting own purposes)
14. Self-respect (belief in one's own worth)	42. Healthy (not being sick physically or mentally)
15. Reciprocation of favors (avoidance of indebtedness)	43. Capable (competent, effective, efficient)
16. Creativity (uniqueness, imagination)	44. Accepting my portion in life (submitting to life's circumstances)
17. A world at peace (free of war and conflict)	45. Honest (genuine, sincere)
18. Respect for tradition (preservation of time-honored customs)	46. Preserving my public image (protecting my "face")
19. Mature love (deep emotional and spiritual intimacy)	47. Obedient (dutiful, meeting obligations)
20. Self-discipline (self-restraint, resistance to temptation)	48. Intelligent (logical, thinking)
21. Detachment (from worldly concerns)	49. Helpful (working for the welfare of others)
22. Family security (safety for loved ones)	50. Enjoying life (enjoying food, sex, leisure, etc.)
23. Social recognition (respect, approval by others)	51. Devout (holding to religious faith and belief)
24. Unity with nature (fitting into nature)	52. Responsible (dependable, reliable)
25. A varied life (filled with challenge, novelty, and change)	53. Curious (interested in everything, exploring)
26. Wisdom (a mature understanding of life)	54. Forgiving (willing to pardon others)
27. Authority (the right to lead or command)	55. Successful (achieving goals)
28. True friendship (close, supportive friends)	56. Clean (neat, tidy)

Table 5.2. Value types as defined by Schwartz (1994).

Definition of value type		Exemplary values
Power	Social status and prestige, control or dominance over people and resources	Social power, authority, wealth
Achievement	Personal success through demonstrating competence according to social standards	Successful, capable, ambitious
Hedonism	Pleasure and sensuous gratification for oneself	Pleasure, Enjoying life
Stimulation	Excitement, novelty, and challenge in life	Daring, varied life, exciting life
Self-direction	Independent thought and action-choosing, creating, exploring	Creativity, curious, freedom
Universalism	Understanding, appreciation, tolerance, and protection for the welfare of *all* people and for nature	Broad-minded, social justice, equality, protecting the environment
Benevolence	Preservation and enhancement of the welfare of people with whom one is in frequent personal contact	Helpful, honest, forgiving
Tradition	Respect, commitment, and acceptance of the customs and ideas that traditional culture or religion provide	Humble, devout, accepting my portion in life
Conformity	Restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms	Politeness, obedient, honouring parents and Elders
Security	Safety, harmony, and stability of society, of relationships, and of self	National security, Social order, clean

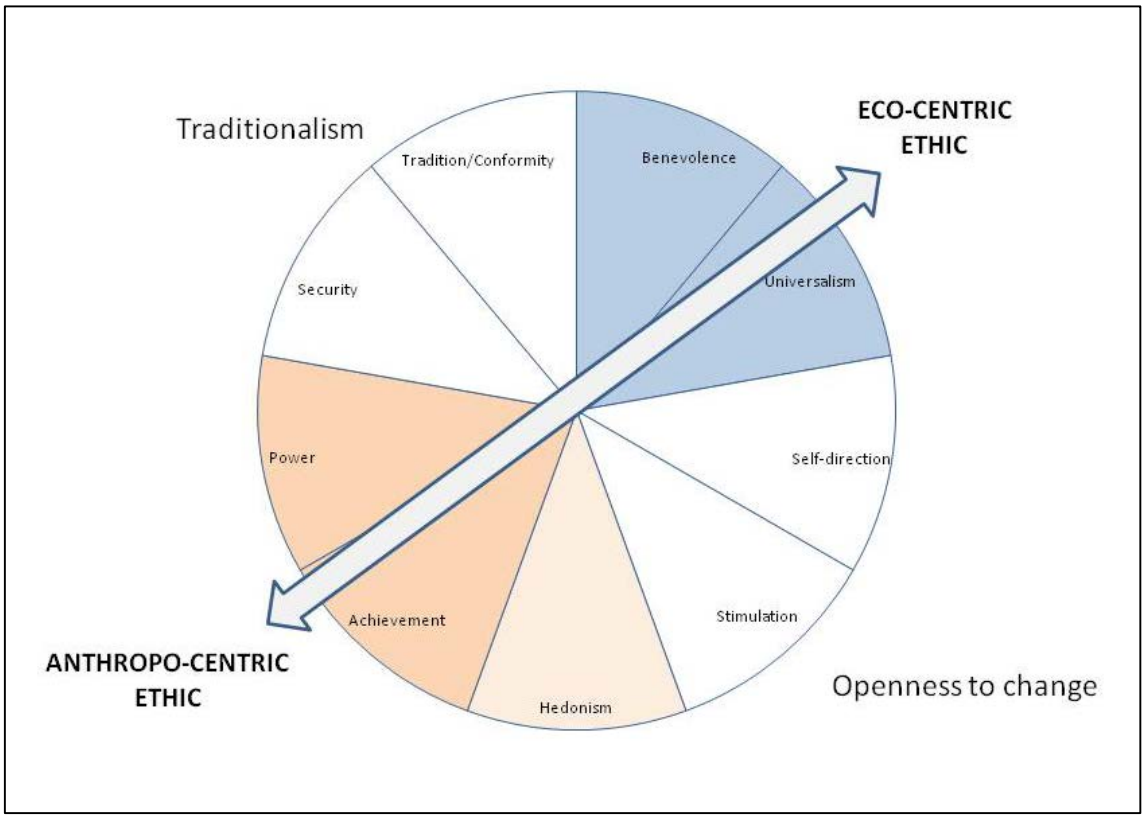


Figure 5.1. Value orientations, modified from Schwartz (1994).

The concept of value orientation as elaborated by Schwartz and his commentators parallels that of environmental ethic introduced by Merchant in 1992. Similarly to value orientations, environmental ethics are theories grounded in environmental values that guide attitudes and behaviours towards the environment. Environmental ethics "link theory and practice, translate thoughts into actions, worldviews into movements, ideas into behaviours" (Merchant, 1992, pg. 62). Therefore, they are key to understanding how sustainable a culture is likely to behave. Values and ethics alone cannot mandate pro-environment and sustainable behaviours: behaviours are ultimately constrained by individuals' needs and capabilities, which can be accrued to social, cultural and economic external factors (Dietz *et al.*, 2005; Schwartz, 1994; Stern, 2000; van Egmond & de Vries, 2011; Sutton & Tobin, 2011). Nevertheless, other external factors being equal, it is individuals' values and ethics that enable or prevent the adoption of sustainable behaviours.

Environmental ethics are usually discussed as "anthropocentric" versus "eco-centric". Anthropocentric ethics are grounded in the assumption that humanity enjoys special

rights to the environment, and do not accommodate rights and needs of the environment and of other species. Such anthropocentric ethics have been historically associated with the mechanistic scientific and capitalistic worldview, referred to also as western worldview, which arose in the seventeenth century. Environmentally, anthropocentric ethics enable individuals to extract and use natural resources to enhance their own lives, the limitation being the consent of other members of neighbor societies (Merchant, 1992).

The counterparts to anthropocentric ethics are eco-centric ethics. Eco-centric ethics arose to internalise externalities derived from development and exploitation of natural resources. These ethics are grounded in the belief that intrinsic values and rights are associated with all sentient and non-sentient beings. Ecocentric ethics maintain that balance of nature, unity, stability, diversity and harmony of ecosystems and the survival of living and non-living beings are overarching goals that should guide humans' actions toward the environment. Aldo Leopold is considered the father of the modern eco-centric ethic: according to Leopold (1966, p. 262), an "action is right when it tends to preserve the integrity, beauty and stability of the biotic community. It is wrong if it tends otherwise". Ecocentric ethics have been associated with holistic worldviews; where everything is interconnected, the whole is greater than the sum of the parts, knowledge is context-dependent and humans and nature are part of the same organic system (Merchant, 1992). Indigenous traditions worldwide have been discussed as holding ecocentric environmental ethics and holistic worldviews (Hawke, 2012; Kelbessa, 2005; Michell, 2005; Royal, 2012; Snodgrass *et al.*, 2007; Voeller, 2011; White, 2010), and a higher representation of such ethics have been advocated as a means to achieve sustainability (van Egmond & de Vries, 2011).

In this chapter I use Schwartz's humanitarian values model to frame my understanding of the environmental values held by a community of Indigenous Australians. Improving this understanding emerged as a need to further the inclusion of IK in NRM in the Wet Tropics (Chapter 3). Moreover, having suggested in Chapter 4 that ethical dimensions of worldviews should be integrated for just collaborative NRM, I hereby tackle the task of developing avenues for this to happen: understanding the values and ethics that the Traditional Owners of the Wet Tropics hold is the first step to create paths to their integration in NRM. I contribute to this understanding through my work with the Malanbarra and Dulabed Yidinji community. In my work, I relate the community's

environmental values to conceptualisations of value orientations and environmental ethics, as theorised by Schwartz and his commentators, to better outline the contribution indigenous values can make to sustainability in modern NRM.

In this context this chapter addresses the following research questions:

a. What are the indigenous values placed on the environment?
b. Can these indigenous environmental values be understood as humanitarian values?
c. What is the indigenous environmental ethic that we can infer from these values?
d. What contribution can such values and ethics make to sustainable NRM?

I explore these research questions through the ethnographic case study I conducted in collaboration with the Malanbarra and Dulabed Yidinji community of the Wet Tropics of Queensland, in Australia.

5.3 Methods

Study area

The present chapter, together with Chapters 6 and 7 are based on an ethnographic case study I conducted in collaboration with the community of traditional owners of the Malanbarra and Dulabed Yidinji, traditional owners of the Goldsborough Valley. In Chapter 2 I described the community, their involvement and their interest in my thesis project because of its overlapping with their own research agenda.

My study area is the Malanbarra and Dulabed Yidinji Native Title determination area, which lies in the Russell-Mulgrave catchment, as previously described (Chapter 2).

Choice of participants and interviewing process

The Malanbarra and Dulabed Yidinji community resides in territory that extends from the Atherton Tableland to the west, to Innisfail to the south, Cairns to the north and Gordonvale to the east. The community can be defined as a Native Title community, a community brought together by Native Title interests (Davies, 2003), and includes numerous individuals with different histories of connection to Country, and more or less prolonged periods of relocation away from it. By virtue of its diversity, the community

may be seen as fairly representative of the indigenous population of the Wet Tropics, and this may entitle me to a certain degree of generalisation of our conclusion. Nevertheless, participants of my project accrue to 0.1% of the overall indigenous population of the Wet Tropics.

Following community engagement and the signing of a research agreement, the community's Prescribed Body Corporate (PBC) directors for the Malanbarra and Dulabed Yidinji provided a list of members who were interested in taking part in the project. Twenty community members were interviewed. Overall, 25% of the PBC adult registered members took part in the project, each a member of the community interested and active in the management of their Native Title area. In recruiting participants, I aimed for a sample gender and age balance to capture diverse perspectives existing in the community.

Interviews were informal, semi-structured, and essentially took the form of relaxed, amicable conversations with indigenous project participants held at a location chosen by them. I used a pre-set list of questions to guide interviewees (Table 5.3), however referred to it only loosely and encouraged project participants to talk freely about their connection with the environment, what they considered important in it, the reasons why it was important to them, and the nature of activities they conduct in the environment. Conversations usually had a focus on the river and surrounding rainforests, the main features of the community's estate. As is the nature of semi-structured interviewing, the depth and scope of discussions varied depending on the degree of connection between participants and the study area, as well as their expertise and interests. Most of the interviews lasted 1-1.5 hours.

Data analysis

I transcribed interviews and coded transcripts inductively for theme analysis. During inductive coding, in the first phase – the open coding process – themes were allowed to emerge spontaneously from the words of participants (inductive coding). In a second phase – the theoretical coding – I collapsed the open codes into overarching categories, which I use as main points for discussion in this chapter. I used this inductive theme analysis to answer the first research question. Inductive theme analysis enabled me to ground my understanding in the words of participants and provided rich narratives

which I used to illustrate this understanding.

To answer the second research question (if these indigenous environmental values can be understood as humanitarian values) I coded interview transcripts deductively. I applied the 56 universal values identified by Schwartz (1994) as codes, and searched interview transcripts to determine if and how participants discussed them. In this type of analysis, Schwartz's values are therefore retrofit to the semi-structured interviews I conducted with the Malanbarra and Dulabed Yidinji.

To answer the third research question (what indigenous environmental ethic we can infer from these values) I used Schwartz's model of value-orientation to infer the value orientation as emerged from project interviews. Finally, to answer the fourth research question, I discussed results from the first three research questions in terms of what contribution the values and ethic expressed by the participant community can make to modern NRM in terms of sustainability. The results of my analyses were presented to community leaders in 2013, who endorsed my understanding of their environmental values and ethic.

The quotes extracted from interview transcripts and used in this chapter are identified only with two letters (TO), followed by a progressive number, to ensure personal anonymity.

Table 5.3. Pre-set list of questions used to guide semi-structured interviews.

1.	How long have you been living in this area?
2.	Can you tell me if your family has a specific area of responsibility?
3.	What does it mean/used to mean for the management of Country?
4.	Did you use to spend lot of time along the river as a kid?
5.	Do you spend time on Country now?
6.	What did you use to do while being there/what do you do while on Country?
7.	Do you take children when you go to the river and what activities do you do with them?
8.	During your lifetime how has Country changed? Did these changes affect your lifestyle?
9.	Is there anything you are prevented from doing on Country?
10.	Are ceremonies still conducted on Country?
11.	Is the language still practiced in the community?
12.	Are language names still given to children?
13.	Do you still use traditional food from the river and the forest?
14.	Does the community have a totem?
15.	Can you list some of the reasons why the river is important to you?
16.	Can you think of any place along the river that is particularly important for you?
17.	What is the reason for that?

5.4 Results and discussion

Indigenous values for the environment

The importance of protecting the environment for its connection with the people

A central theme that emerged from the interviews was participants' concern for the need to *"protect the environment"*. Interviewees highlighted the importance of respecting the environment and preserving its life-giving force for present and future generations. Some portrayed the river system, especially the river, its central feature, as a living being and referred to it as *"him"* rather than *it*, similar to observations in previous analogous research (Jackson *et al.*, 2005; Maclean & Bana Yaralji Bubu Inc., 2011). The river system has his own rights, and all human beings and especially traditional owners, owe him respect. The river gives life to the people, plants and animals living beside it, a concept also observed in studies by Grice *et al.* (2012), Maclean and Bana Yaralji Bubu Inc. (2011), and Toussaint *et al.* (2005). Participants described the river

system and country in general as almost a super organism, to which plants, animals and the human communities who dwell on him belong. In the holistic vision of participants all components of the system are interconnected and can be mutually affected by changes, even those which occur farther away. One participant referred to the existence of karma for the river and country in general, in addition to karma existing for people, implying Country, the river and the people are interconnected and rules of reciprocity apply. The river and his physical attributes were also described as an integral part of the same circle of life of animal, plants and people. For example, participants referred to the fact they were animals, rocks or water in "the dreaming", and from there they became human beings (see also Toussaint *et al.,* 2005).

Most participants suggested if the river is left untouched or used with respect, he has the ability to support the current plant, animal and human populations that depend on him. However, participants complained this ability has been impinged by post-colonial misuses and over-uses of the river, also recently highlighted in research on the general health of streams of the Wet Tropics (Tsatsaros *et al.*, 2013). Hence, now the river needs to be *"left alone"* so that he can heal himself. Participants often referred to the increasing need of a growing population, which demands water for "*wrong uses*", as a reason of great fear for the pressure it puts on the capacity of the river to support the system thriving around him. There exists a fear that water may be used unsustainably, a concern recorded in similar case studies, such as the Daly River (Jackson *et al.*, 2005). The core value of preserving the life-giving force of the river informed and still informs traditional management responsibilities and rules for Country, which aim to "*not take too much*" and "*preserve for future generation*". The persistence of traditional rules for sustainable use and sharing of aquatic resources has been also recorded in indigenous water values related research by Jackson *et al.* (2005, 2012), Maclean and Bana Yaralji Bubu Inc. (2011) and Toussaint *et al.* (2005).

The teaching from ancestors and the respect for traditions

Interviewees often spoke of the need to respect traditions and the teachings of ancestors, and to obey the precepts passed down from ancestors through the generations. Participants highlighted the importance of song, dance, ceremonies and stories for the transmission of knowledge to youth and the celebrations of connection to Country. Participants reported that song, dance and ceremonies are nowadays carried out only

sporadically, though some of the younger participants also expressed interest in the cultural restoration of those traditions. On the other hand, storytelling on Country is still widely practiced and stories play an important role in the transmission of environmental knowledge and ethical and social norms, similar to what has been observed previously (Jackson *et al.*, 2005; Toussaint *et al.*, 2005). For example one story tells of the Mulgrave River being created by the rainbow snake, which escaped a storm in Lake Eacham. The story could be seen as encoded hydrologic knowledge of the connection between local surface and groundwater bodies, even if the understanding it reflects is not underpinned by scientific evidence. Another story tells of a cassowary that died while kicking his legs in different directions. The way the kicks were directed inspired rules for sharing of resources, and hence the story seems to encode ethical and social norms on how to use river resources. Many stories tell of supernatural events, some of which happen when the rule "*do not take too much*" is broken, or when generally something wrong is said or done on Country. Such stories keep in place cultural and social norms for using river resources sustainably. Often, punishments are said to be inflicted on disobeyers by the spirits of ancestors, who are still looking after Country.

Storytelling takes place during visits to Country, usually while community members enjoy other leisure and subsistence activities. Historically purported walkabouts were traditionally conducted, where elders used to take young members away for a few days and walk and camp in the rainforest along the river, all the while telling stories and showing Country, and hence passing down the cultural knowledge of it. Participants said walking and staying on Country is still the preferred way to educate youth. Currently, "cultural camps" serve this purpose. Held during school holidays, the camps offer the additional benefit of being open to non-indigenous children, who can learn at least a part of the indigenous knowledge of Country. Despite this, many project participants suggested a lack of time to walk on Country was a limitation to the way Country is currently enjoyed and knowledge transferred to youth. Lack of time was discussed as a consequence of Traditional Owners having mainstream jobs to attend, as well as living away from Country, which is now protected in by national park status or else the private property of non-TO landlords. Other limitations offered included the overgrowth of rainforest across tracks and patches traditionally managed with fire, which impedes walking, and limited access to Country due to current land tenure and

competing use of the area, for example by tourists. Walkabouts and cultural trips are well known as the main way of sharing knowledge within indigenous traditions (Jackson *et al.*, 2005; Maclean & Bana Yaralji Bubu Inc., 2011; Toussaint *et al.*, 2005). Moreover, during my project participants pointed out that walking on Country is the preferred methodology for collaborative research on the ecological and social components of Country: one elder who took part in the project, and who was also acting as spokesperson for a group of male elders dwelling outside the study area, referred many times to the need for elders to take researchers on Country to show them their vision of it, and to better connect to Country and recall knowledge stored in their memory. The importance of such walking narratives is increasingly recognised in collaborative research on indigenous matters (Maclean & Bana Yaralji Bubu Inc., 2011; Robinson & Wallington, 2012).

Unity and self-identification with nature

Participants often described their intimate feeling of unity with nature and need for nurturing, celebrating and communicating their identity which ultimately they saw as grounded in their relationship with the environment. Most participants reported that their identity comes from the river and their language name connects them to the river as well as other features of the landscape. Many of the language names referred to during interviews were intimately related with water, water cycle, species living in or around the river, and activities within the river. For example, one language name is *Jullud*, referring to the stick used to pull eels out of the water, while another is *Burrun*, meaning the green frog that *"passes out when the rain is coming"*. Language names were traditionally given to children by some of the elders, who observed the children's nature and temper and choose a name for them. A participant also added that, before giving the language name, elders would wait for a vision that would *"send the story"*, describing how that specific person came to be human and hence what her language name should be. Some participants further elaborated their identity comes from the river because they once were *in* the river and that *"all incidents"* that brought them to be born as humans happened in the river. One participant identified with the river, saying there was no difference between him and the river, between the water in the river and the blood in his veins. Moreover, a personal totem is associated with the language name and the totem promotes a specific connection of the individual with a place, a feature or the landscape or a species inhabiting it. Community members have special

caring responsibility for their totems, as observed in similar research with different communities (Jackson *et al.*, 2005; Maclean & Bana Yaralji Bubu Inc., 2011; Toussaint *et al.*, 2005).

The sense of identity which stems from the river is also developed through the association of the entire cycle of life of individuals with specific cultural and special places on Country. Participants spoke of historical birth places under trees or in the water, especially in rapids, even if they are not presently used. Instead, after the birth of a baby, they bury the placenta on Country to seal the association of one person to her own land. Language names can associate individuals with specific places. For example, *Bundil* and *Budil* are the two tips of a local mountain that serves as clan boundary. They are also the language names of two young individuals in the community. Other special places are those where historical community events took place, such as corroborees or massacre places, and places that function as clan boundaries and as such regulate groups' relationships and resource access in the community. In some places stories are believed to be "guarded" by the spirits of ancestors. Burial sites are kept in great regard, visited regularly, and often used to reconnect with ancestors and seek their advice on special matters. Moreover, burial along the river is still practiced by the community, even if sporadically, and one participant reflected that she was happy to have the option of being buried on Country. Finally, "sacred places" are places where harvest and access to outsiders should be forbidden; these places are considered by participants as very beautiful and pristine but currently threatened by unregulated tourism.

In the opinion of participants, frequent visits to Country, spending time on Country, enjoying leisure on Country through use and non-use activities (fishing, swimming, camping, bird-watching) and living on or close to Country represent not only opportunities to reconnect with Country and with cultural practices of land and water management, as observed in much of the previous research (Grice *et al.*, 2012; Jackson *et al.*, 2005; Maclean & Bana Yaralji Bubu Inc., 2011; Morgan *et al.*, 2004; Toussaint *et al.*, 2001), but are also a way to reaffirm a long-term connection to Country among the wider society. One participant also explained how his artworks describe that connection, also observed by Toussaint and colleagues (2001).

Place attachment emerged as a solid basis, even today, for participants' sense of

identity. Some participants discussed their frustration because current practices of giving language names have changed, which means some people in the community are unable to obtain a language name. This appears to be due to ancient practices no longer being carried out, and new protocols have not been clearly outlined and accepted by the community. Many participants also expressed their frustration due to unaccompanied locals and tourists accessing cultural and special places without following the cultural protocol associated with those places, risking disrespect or ruining places of significance to the community by, for example, inadvertently trampling on burial sites or harvesting resources in sacred places.

Health and wellbeing associated with the river and surrounding rainforest

Most participants discussed the importance of having a physically and mentally healthy lifestyle. Many health problems were ascribed to a contemporary lifestyle and to poor diet that should, in the words of one participant, *"contain a lot more bush tuckers"*. By contrast, living off resources of the river system and using traditional remedies from the bush were indicated as possible solutions. One participant recalled he treated his long-term symptoms of diabetes by living on Country, eating fish and bush tuckers, and using traditional medicine. His declarations are corroborate with existing scientific literature which has, during the last thirty years, explored how the health of Australian Aborigines with chronic diabetes improves when resuming traditional practices of hunting and gathering, due to both the physical exercise associated with those practices and the wellbeing coming from the fulfilment of "Caring for Country" responsibility, central to Aboriginal worldview (O'Dea, 1991). Soaking in water in specific healing places or in the river was referred to as the preferred treatment for a number of minor ailments, such as sores and limb pains, while soaking in specific places, where small fish pick and clean dead skin was considered helpful in particular with skin sores. Health values of rivers and the potential for traditional medical remedies to be used today remain under-researched in Australia, possibly due to concerns for the protection of intellectual property rights.

Connection with the environment was discussed as a source of mental health and wellbeing. Some project participants referred to healing properties of locally caught fish which, when cooked in traditional ways, was used to alleviate the symptoms of minor illness and as a comfort food during recovery from surgery and confinement in

hospital. In addition, the social and spiritual dimensions of wellbeing were said to be enhanced through the relationship with Country. This relationship is nurtured by spending time on Country, for example while enjoying recreational social activities, also observed in the literature (Jackson *et al.,* 2005; Maclean & Bana Yaralji Bubu Inc., 2011; Toussaint *et al.,* 2005), and by respecting and venerating the ancestors who looked after Country in the past, and still do. In summary, for the study's participants, physical, mental and spiritual wellbeing were important holistically, and were maintained through consumption of natural resources and through recreational and spiritual dimensions of their relationship with the environment.

The economic value of the environment

Participants considered the environment as a provider of opportunities for environmentally and culturally sustainable livelihoods while Caring for Country, which in the opinion of some participants would confer a sense of freedom and independence. Most participants said the river and its resources support the community. Many use river resources for subsistence and they regularly extract fish, prawns and freshwater crayfish. Snakes, turtles, witchetty grubs and honey ants are also harvested but only sporadically or for transmission of cultural practices to youth. Determining the monetary value of subsistence use of the river was beyond the scope of this project, but other studies elsewhere in Australia have suggested it is high, especially for indigenous subsistence fisheries and for people relying on welfare payments (Busilacchi *et al.*, 2013; Jackson *et al.*, 2012, 2005; Maclean & Bana Yaralji Bubu Inc., 2011; Maclean & Robinson, 2011; Toussaint *et al.*, 2001, 2005, 2001). Furthermore, the river and its surroundings were considered to be economically valuable for the potential to create wages-based job opportunities, which participants identified as mainly ranger positions to undertake cultural and environmental monitoring and restoration along waterways, as observed by Grice and colleagues (2012).

In addition to the customary river based economy, participants identified river-based non-customary endeavours with the potential to provide future livelihoods for the community. Examples include cultural tourism and aquaculture for food production and river restoration, as well as marketing bush tucker and medicines. The potential for such indigenous economies has been identified and thoroughly discussed in other water-related research, especially the work of Altman and Jordan (2008), but also Grice *et al.*

(2012), Jackson *et al.* (2012), Maclean and Bana Yaralji Bubu Inc. (2011) and Morgan *et al.* (2004). It is increasingly acknowledged that economic values for freshwaters should inform water allocation flows (Jackson *et al.,* 2005; Maclean and Bana Yaralji Bubu Inc, 2011; Morgan *et al.,* 2004). Pursuing a river-based sustainable livelihood, especially if it involves spending time on Country, also represents an opportunity to reconnect with Country, and the health and social benefits associated with it have been widely documented in the literature (Burgess *et al.*, 2008; Johnston *et al.*, 2007; Weir, 2008). In the opinion of one participant, working on Country provides a way to achieve social recognition; through Indigenous Rangers the wider community would understand that Indigenous Australians are "*still there, we are not gone!*"

Indigenous environmental values and the link with Schwartz's humanitarian values

The deductive theme analysis I conducted on interview transcripts revealed that overall, when talking about the environment and their relationship with it, project participants verbalised seventeen of the universal values defined by Schwartz (1994; Schwartz *et al.*, 2012; Table 5.3).

Table 5.4. Schwartz's values as verbalised by project participants. For brevity, only quotes to illustrate values with three or more entries are reproduced.

Value	Illustrative quote
Respect for traditions	*"All our ancestors, all our children, we take them to the river, always, and no matter where they live they will always come back to that area. Before my sister died she got her daughter to bring her up here, just to have a look at this area, all the way up here and back, she had to come and see the Pyramid. It doesn't matter where we are, we will always go, take the kids to the river, our ancestors always lived by the river, which we can't do without. And that's why we need to fix it all up, we need to fix our river up because it's all gone to ruin."* (TO23)
Protecting the environment	*"Oh well, I just wanted to tell you, the big problem here is that we still haven't had a proper burning. Our country hasn't been burnt, so that new plants and animals can come out. But it hasn't been burnt for 10 to 15 years now. My dad used to burn, wet tropics would know it was him when they saw the smoke. He used to burn only Mum's and his – not sure about mum and his – area, and they wouldn't burn in the rainforest, but in the open forest so the new grass and wallabies and possums could come out."* (TO11)
Honoring parents and elders	*"Spending time on Country is important to me even because you can hear the ancestors, if you go to meeting ground you can feel and hear them."* (TO15)
Unity with nature	*"*[The river,] *it's like the blood in my veins! That's my food, everything comes from there, my life ... that water, it's me! When you start messing things around you then start messing with us! And we start feeling sick and one wonder 'What's going on?', and this is where* [it] *all starts, but you know ... that is like the blood in my veins! It's very, very important to me and my people."* (TO7)
Healthy	*"This place here, I used to take my older cousin and she had a swollen ankle with blood and everything, so I brought her here and I sat her over there and by the time we left everything was gone, the water is also healing for us. She told me I cannot come down, so I told her I'd better pick you up and so by the time we left all was good."* (TO23)
Independent	*"I envision a centre that is self-sufficient, without having* […] *to depend on grants. We should make it self-sufficient, with camp sites for tourists and fee that they pay, so we can keep* [the site] *clean. In the Goldsborough Valley at the moment there are lots of tourists who go there camping and rafting, but they leave a lot of rubbish behind, cans and broken bottles, and we don't have a way to monitor people who go in and out, so we should have a gate to count people and ask visitors, non-local visitors, for a fee."* (TO1)

Value	Illustrative quote
Obedient	*"I feel a very strong presence of ancestors, I really believe you need to watch out what you say and do, because if you do the wrong thing* […] *I still believe you get punished. I truly believe that! The presence of spirits is very strong"* (TO3)
Enjoying life	*"*[Along the river we used to] *mainly swim and the main diet was fish, because during the day all men used to go spearfishing, it was like a competition, with spearguns, and they always got back with a lot of big fish, they used to get silver breams, and big ones, kake breams, black bream, jew fish, and they would get also eels and turtles."* (TO11)
Spiritual life	*"You know sometimes we sit here* [along the river,] *talk and say 'can you think that we walk where our ancestors walked this place, all way here, and they see their descending walking here?' We feel their presence here."* (TO24)

The values most represented – three or more people spoke about them – were *respect for tradition*, *protecting the environment*, *honoring of parents and elders*, *unity with nature*, *healthy*, *obedient*, *independent*, *enjoying life* and *a spiritual life*. Values also mentioned, but by two or less participants, were *inner harmony*, *freedom*, *social order*, *creativity*, *social recognition*, *social power*, *self-discipline* and *choosing own goals*. The values verbalised by participants are summarised in Figure 5.2, where the original terms used by Schwartz are maintained.

The following remarks may be necessary to fully frame participants' intentions. Firstly, the value *protecting the environment* was always verbalised in association with notions of being on Country, looking after it, using its resources sustainably, burning, and applying other measures of traditional NRM. These activities were also discussed as providing a great deal of wellbeing, as discussed in previous research (Sangha *et al.*, 2011). Participants did not show a preservationist approach to nature, with the exception of sacred places. Secondarily, participants verbalised the importance of "belonging to Country", and a feeling that they belong to Country, and "hence the country cares for me"; I interpreted this as an expression of Schwartz's value *unity with nature*. One participant talked about "reciprocation of favours" towards the environment, rather than towards other people, as discussed by Schwartz; I interpreted this as an expression of Schwartz's value *protecting the environment*.

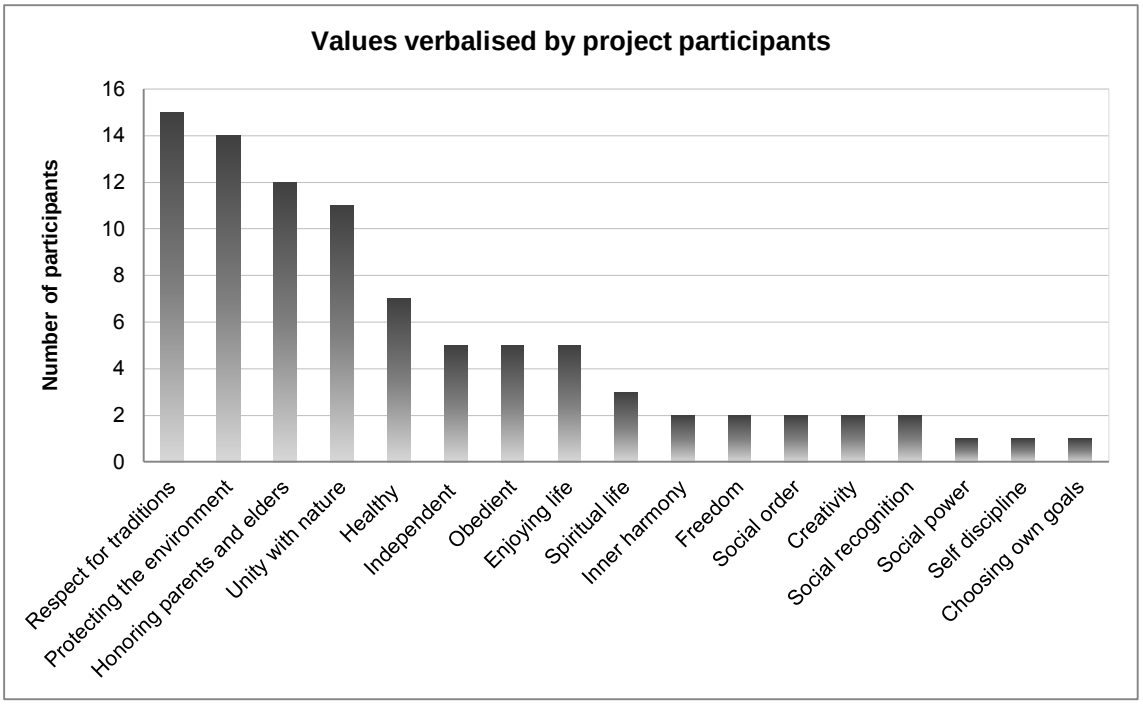


Figure 5.2. Most common values verbalised by project participants, as defined by Schwartz (1994).

The indigenous environmental ethic inferred from humanitarian values and its contribution to natural resource management

In comparing the values expressed by project participants with value types describe by Schwartz, I found the values types most represented in the case study were t*radition/conformity*, *universalism*, *self-direction*, *security*, *hedonism*, *power* and *benevolence* (see Tables 5.1 and 5.2 for summaries of Schwartz's work). It follows then that the main value types to emerge from my analysis were *universalism* and *tradition* (Figure 5.3).

According to Schwartz, universalism is an expression of self-transcendence value orientation (Schwartz, 1994). This value orientation has been discussed in the literature as an eco-centric environmental ethic (Dietz *et al.*, 2005; Merchant, 1992; Stern & Dietz, 1994). Universalism has also been observed as positively correlated with pro-environmental behaviours (Axsen & Kurani, 2013; Clark *et al.*, 2003; Garling *et al.*, 2003; Schultz & Zelezny, 1998; Teel *et al.*, 2007). Tradition, on the other hand, has not been strongly correlated with a particular environmental ethic (Dietz *et al.*, 2005).

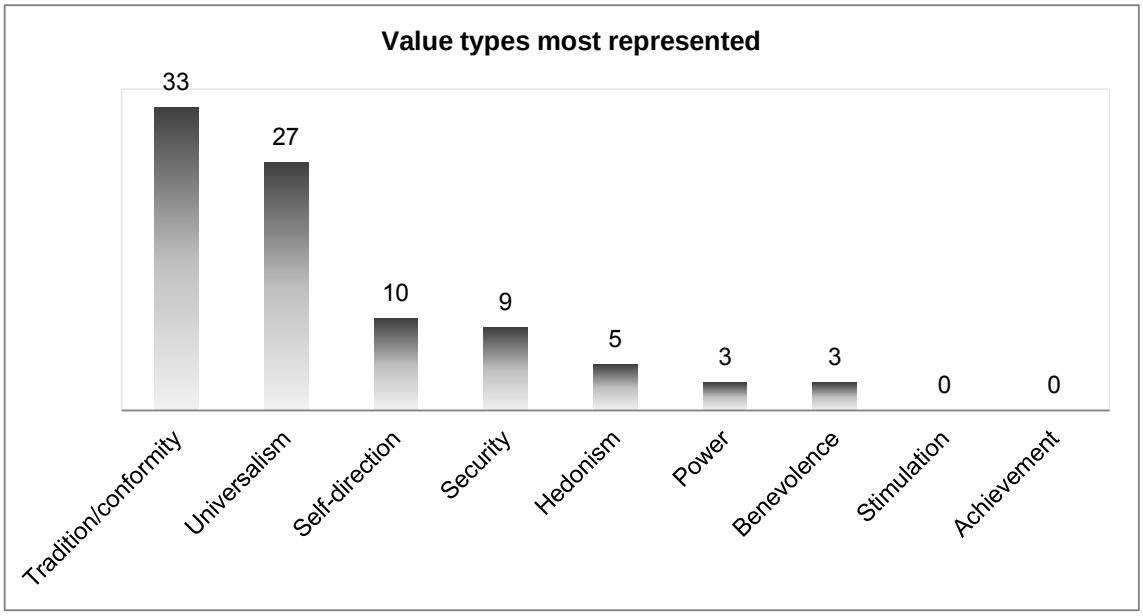


Figure 5.3. Value types most represented in my sample.

My results suggest the participant community holds an eco-centric environmental ethic, centered on the concept of sustainable use of the environment and its resources, where human beings are an integral part of the natural world and hence subject to the same natural rules that apply to plants, animals and unanimated features of the landscape. Economic benefits are still very important within this eco-centric environmental ethic, but need to be extracted from the environment in a sustainable fashion.

This environmental ethic appeared, in my case study, to be associated with a worldview where the relation between human beings and the natural world is one of respect, gratitude, acknowledgement of dependence, and interconnectedness with animals, plants and other environmental features. My results are similar to observations of many other indigenous traditions worldwide (Hawke, 2012; Kelbessa, 2005; Michell, 2005; Royal, 2012; Snodgrass *et al.,* 2007; Voeller, 2011; White, 2010).

Eco-centric ethics have been associated with pro-environment behaviours and environmentalism given the right circumstances and absence of impediments to the implementation of these behaviours (Axsen, 2013; Clark, 2003; Garling, 2003; Schultz, 1998; Teel, 2007). Moreover, the adoption of eco-centric ethics and biospheric-universalistic values is discussed as pathways to sustainability (Axsen, 2013; Banerjee, 2002; Clark *et al.*, 2003; Garling *et al.*, 2003; Hawke, 2012; Ingold, 1993; Mercer *et al.*,

2005; Schultz & Zelezny, 1998; Teel *et al.*, 2007; van Egmond & de Vries, 2011). Intrinsic and biospheric environmental values are increasingly observed in populations around the globe, changing attitudes towards the environment of entire societies (Callanan, 2010; Kopnina, 2012) and this increasing support could lead to eco-centric ethics gaining their way in legislation and policies. Water values are also changing within Australian society (Jackson *et al.*, 2008), and in the opinion of some authors the restoration of the Indigenous Australians' water ethic would support humanity's journey towards sustainability (Hawke, 2012). My case study aligns with these claims, and provides evidence to suggest the participant community holds an eco-centric ethic which is the foundation of sustainable behaviours when broader economic and social contexts are enabling.

In many international fora, indigenous societies worldwide claim their environmental values and ethics are more sustainable than those associated with "western" capitalism, and their worldviews and ethics should be used as the foundation of more sustainable models of resource management and development (see, for example, the *United Nations Permanent Forum on Indigenous Issues*, the *Convention on Biological Diversity*, the *UNESCO Universal Declaration on Cultural Diversity*, the *International Summit on Indigenous Environmental Philosophy* and the *Declaration of the Rights of the Peoples and the Earth*). Central arguments to these claims suggest indigenous worldviews and associated values and ethics promote an understanding of the human condition in terms of kinship and interdependence with other sentient and non-sentient elements of ecosystems. In this view, human actions should be aimed at the maintenance of balance within the natural world, whose limits in terms of capacity to provide must be respected for development to be sustainable (Royal, 2005, 2009, 2012). These arguments were reflected in project participants' statements, in which they showed overall support for the quality of life provided through harmony with the environment, and acknowledged humankind's dependence on it, rather than materialistic possessions that derive from environmental exploitation. Indigenous environmental values and ethics hence support sustainability by promoting reverence towards the environment instead of its commodification.

Advocacy for a better representation of indigenous values and ethics in NRM has been countered by speculative arguments that Aboriginal management practices have contributed to resource over-exploitation and wildlife extinction (discussed in Bowman,

1998; Wroe *et al.*, 2004). According to such arguments, indigenous environmental management and philosophies have often resulted in practices as unsustainable as those based on western worldviews and anthropocentric ethics. Despite this line of thought, much of the current research appears to be supportive of indigenous approaches to NRM as a way to increase sustainability (see, for example, the already cited Hawke, 2012; Kelbessa, 2005; Michell, 2005; Royal, 2012; Snodgrass *et al.*, 2007; Voeller, 2011; White, 2010). In summary, it appears modern indigenous cultures have much to contribute in terms of promoting sustainability though the restoration of eco-centric ethics for NRM. Indeed, a balanced approach would see indigenous propositions integrated with non-indigenous and scientific ones, so that NRM is an expression of shared and mutually validated values and ethics that serve the goal of sustainability.

5.5 Conclusions

Overall, my results support the usefulness of the Schwartz framework for interpreting indigenous environmental values of the Malanbarra and Dulabed Yidinji. Schwartz's theory of values and value orientations has been validated so far in over eighty countries and across cultures (Schwartz *et al.,* 2012), and is increasingly informing enquiries into the psychology and social aspects of adopting pro-environment and sustainable behaviours (Axsen & Kurani, 2013; Clark *et al.*, 2003; Garling *et al.*, 2003; Schultz & Zelezny, 1998; Stern, 1994; Teel, 2007). As such, Schwartz's theory represents a powerful platform on which to build the integrative set of values and ethics that multicultural societies need.

Furthermore, Schwartz's model can also be used to understand how pro-environment a culture potentially is, based on the values it holds, and to identify which values prevent the adoption of sustainable behaviours within that culture. Indeed, Schwartz's cross-cultural relevance indicates Schwartz's theory could provide the integrative framework to identify the shared set of values to inform inclusive NRM in the Wet Tropics. I argue that this theory should be used to frame further research in the field of indigenous environmental values and ethics, in order to promote a model for co-research that brings different perspectives together and that avoids cultural relativism.

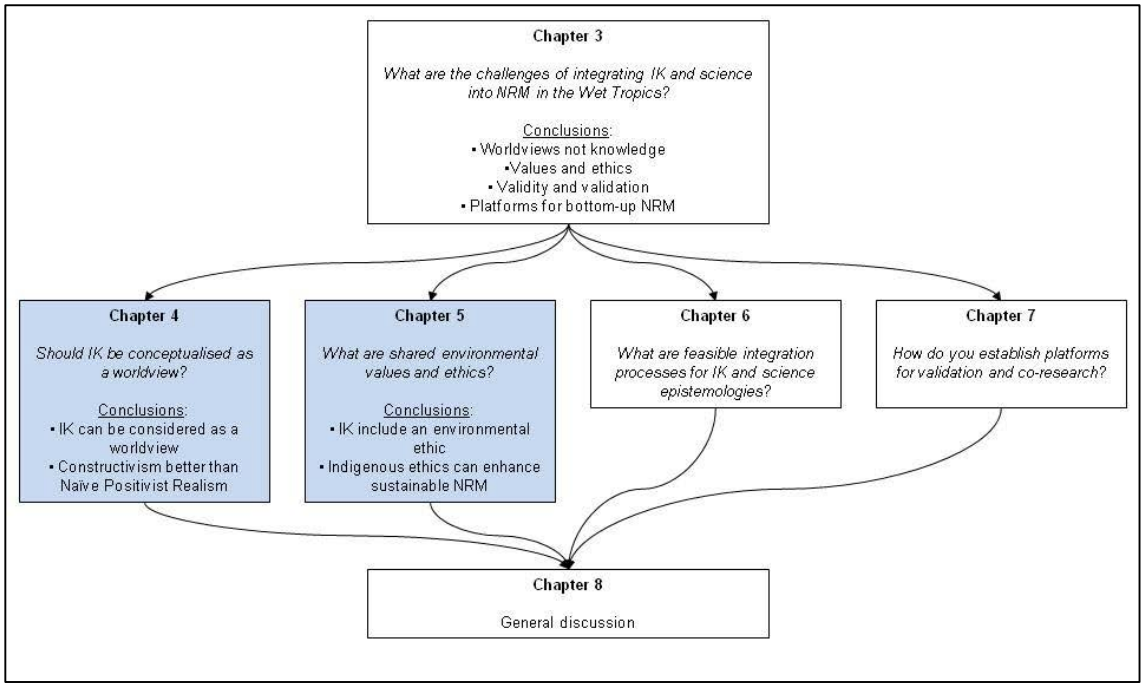
Values, ethics and worldviews should be articulated as explicitly as possible to enable

societies and their leaders to acknowledge them and include them in policy making about sustainability (van Egmond & de Vries, 2011).

5.6 Chapter summary

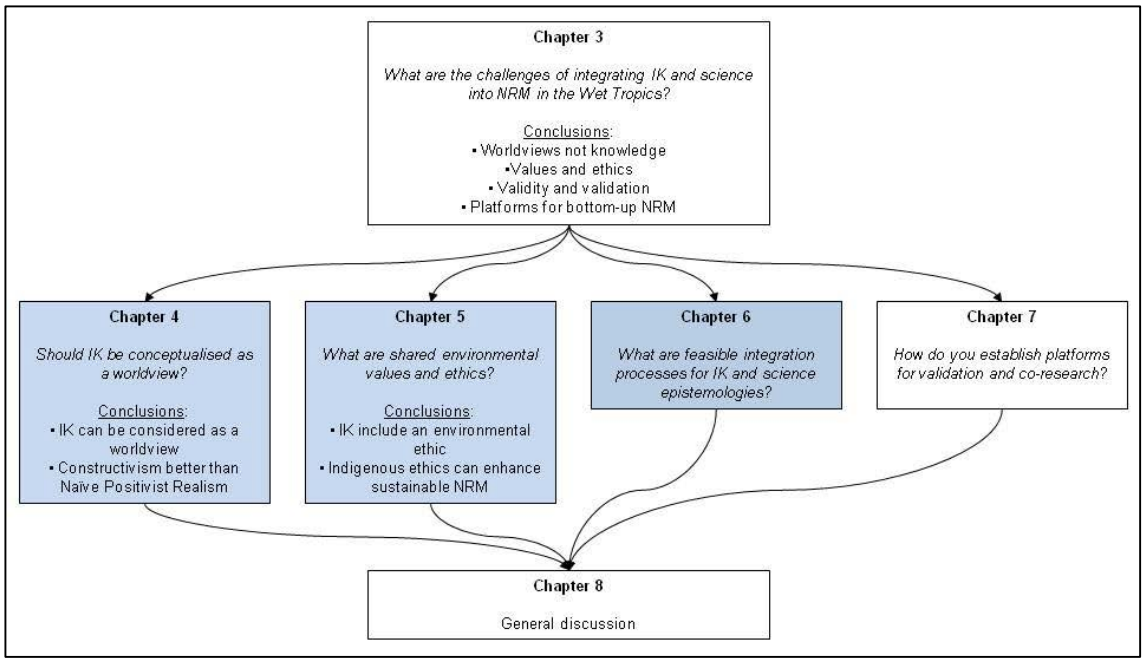
In this chapter I have discussed the environmental values and ethic held by a community of Wet Tropics traditional owners. I found that their values and ethic are eco-centric, and the literature maintains that restoring them would improve the sustainability of NRM.

In Chapter 6 I look at avenues to promote such values in Wet Tropics NRM.



Chapter 6: IK derived environmental monitoring systems as avenue for integration of epistemologies and worldviews

Chapter 3 highlighted the need to better understand the epistemological foundation of IK in the Wet Tropics, and possible paths of knowledge co-generation within the IK and scientific domains. In this chapter I investigate what are feasible integration processes for indigenous and scientific epistemologies. I focus on using IK derived monitoring systems as avenues for integration of epistemologies and worldviews. This is the second of three data chapters to stem from my collaboration with a community of traditional owners of the Wet Tropics, the Malanbarra and Dulabed Yidinji.



Abstract

The present chapter has a twofold aim. Firstly, it fulfils the need of the participant community for the development of a tool to empower them to negotiate NRM within their estates that is more inclusive of their values. In the first part of the chapter I describe my collaboration with the Malanbarra and Dulabed Yidinji in developing a criteria and indicator monitoring system that supports the community in promoting their priorities for NRM and restoration in the area. Secondly, this chapter discusses the potential of IK derived monitoring systems in promoting the integration of different views around NRM. In this context, in the second part of this chapter I further develop the theme of integration of epistemology as path for integrating worldviews. I initially introduce a summary of epistemological processes for worldview integration, grounded in the literature. I then contextualise the design of IK/science derived monitoring system for the environment as an avenue for the integration of some of these epistemological processes. I conclude that collaborative environmental monitoring and join hypothesis testing represent viable avenues to promote mutual understanding and integration of different worldviews.

6.1 Introduction

Epistemology is the study of methodologies for the production of true statements about the natural world (Aerts *et al.*, 1994; Irzik & Nola, 2009; Vidal, 2008). Epistemology is also defined as the study of processes for knowledge production and validation (Russell, 2010). The concept of knowledge, as already discussed in the previous chapters, is far from being univocally defined, and while in the western science domain knowledge is often understood as collection of information (Ackoff, 1989; Nadasdy, 1999), knowledge has also been discussed as a way of life, a way of being in the world and a worldview (Aikenhead & Ogawa, 2007; Berkes, 2012; Folke *et al.*, 1998; Hikuroa *et al.*, 2010; Houde, 2007; Keane, 2008; Mazzocchi, 2008; Royal, 2005; Usher, 2000). In Chapter 4 I argued that, to promote the inclusion of indigenous perspectives in NRM, a focus on integrating worldviews should be implemented. I also proposed how integration of worldviews could be achieved through integration of their different dimensions, epistemology among them. In this chapter I explore the question, "What are feasible processes for integration of indigenous and scientific epistemologies?"

To answer this question, I first present the work I conducted with the Malanbarra and Dulabed Yidinji people, which aimed to develop an IK derived environmental monitoring system to empower them in negotiating NRM that is more inclusive of their priorities and values in their traditional estates. I then present a review of the literature on knowledge production and on integration of indigenous knowledge and science in NRM, with a focus on epistemological issues[11]. From the literature, I extract an analytical framework that clarifies what is the role of epistemology and which are the processes involved in the creation of knowledge. I then use this model to contextualise the work conducted with the participant community for its potential for integration of different epistemologies, and ultimately of worldviews.

[11] For the nature of the themes treated, and so the production of valid knowledge about the natural world, and for the length of time humanity has been concerned with it – thousands of years – a comprehensive review of the literature on the argument is virtually impossible and surely beyond the scope of this chapter, hence my literature review is only partial.

6.2 Part 1: The development of an IK derived monitoring system for the environmental quality of the Malanbarra and Dulabed Yidinji traditional estate

Waterways and surrounding riparian habitats have always been central to Australian Aboriginal culture for the cultural and spiritual values they embody. Indigenous Australians' connection to waterways is intertwined with their very sense of identity, with present and past existence of land and water on country, with social and cultural rules for stewardship of the land and associated water bodies (Toussaint *et al.*, 2005). The connection that traditional owners have with their waters is deep, spiritual and sentimental. They feel they belong to their waters and this spiritual attachment should find its way into natural resource and water management (see for example Langton 2002, 2006; Rose, 2004; Jackson 2005; Jackson *et al.*, 2012; Trigger & Mulcock, 2005, Goode, 2003).

Inequities that remain embedded in current Australian water management should be addressed to achieve social justice (Howitt, 2001; MacLean, 2007; Durette, 2008; Tan, 2009), Native Title rights (Armstrong, 2008) and economic gains (Altman, 2008, assisted by Branchut). Indeed our knowledge of Aboriginal values for rivers and water is incomplete and biased towards Northern Australia (Jackson & Morrison, 2007) and there is still little development of paths for the inclusion of indigenous values in water management decision making process (Jackson, 2005; Jackson & Morrison, 2007). One of the reasons for this may be the difficulty of translating and integrating the holistic worldview Aboriginal values (Adam & Kneeshaw, 2008).

In context, other than water management, the preparation of criteria and indicator frameworks based on indigenous values and knowledge has represented a valuable medium within which social values merge with scientific knowledge of environmental conditions to monitor and influence trends in management (Adam & Kneeshaw, 2008). Nevertheless, water management frameworks developed to guide preparation of criteria and indicators tend to keep environmental, social and economic capitals as distinct. In doing so, we perpetrate a reductionist approach to water management (Darnault, 2008). Such criteria and indicator frameworks do not favour integration of the holistic views of

traditional custodians to the management of the environment and its waterways. The development of IK-based criteria and indicators for water management that are respectful to indigenous holistic views of NRM is therefore to a creative and ground breaking endeavour. Here, I describe my attempt to develop such innovative criteria and indicators for water management while conducting a case study with a community of Australian traditional custodians. My exploration aimed to, 1) understand indigenous values and ethic for water and for the environment in general, discussed in Chapter 5, and 2) identify a values and IK-based monitoring system that could support the inclusion of the local indigenous worldview into NRM planning for the area.

Methods: interviews and participant observations during collaborative field work

Between 2009 and 2012 I conducted interviews and/or collaborative field trips with 24 members of the Malanbarra and Dulabed Yidinji community to identify how they value the environment. Interviews were informal and mostly conducted while walking or spending time on Country. Frequent visits to Country, which I hereby refer to as "collaborative field work", were necessary for key participants to recall their knowledge correctly and for me to gain a better understanding of their vision of the environment. For me, as well as the community involved, spending time on Country was also a way to show respect for the cultural protocol, because that is the way knowledge of Country is traditionally produced and transferred. Field trips were also the source of participant observations I conducted during the project. When visiting Country was not possible, interviews were conducted at a location chosen by the participants.

During my work, it emerged that the community had its own system of indicators for monitoring environmental conditions. So that I could address the community's research agenda, and their interest in the condition of their traditional estate and post-colonial land use change (see Chapter 2 for more on the community research agenda), I organise indicators adopted by community members in a "criteria and indicators framework", to be used by community members as a monitoring tool. As part of my work, I conducted purported interviews and collaborative field trips with seven key informants from the

Royee family[12].

Field trips were conducted at ten study sites selected by key participants. The chosen sites were examples of "good" and "bad" environmental conditions, according to participants. The sites were accessible to non-Malanbarra people and could be surveyed within the time and budget limits of the project. In addition to these reasons and to respect the community's cultural protocol for the area – which requires outsiders to be introduced to Country by the legitimate traditional owners – it was necessary to involve traditional owners in the project and that they be willing to accompany me. I do not report hereby the location of the study sites to maintain cultural confidentiality.

I asked key participants the questions, "What do you *look at* in the environment to say that country is sick or healthy, and why?" and "Why is this important to look at?" In their responses, participants reported indicators, and conditions and/or processes these indicators were considered to be associated with. Participants were asked to provide one main reason why an indicator was important, as well as any secondary reasons. I ascribed each indicator to one or more associated criteria.

I then developed a scoring sheet with a numerical value – from 1 to 5 – associated with a qualitative assessment of the indicator, with 1 being *poor quality* and 5 being *good quality*. Each score was explained in words on the scoring sheet so that participants could attach a meaning to the number. For example, the indicator "State of burial site" was scored based on how the site was exposed and disturbed, while the indicator "Spawning sites for Gula Gula" was scored based on the number of remaining spawning sites (Table 6.1). The scoring sheet was then trialled in the study sites by key participants. The score provided for the different sites was then averaged to provide a single number expression of the status of that site.

[12] As explained in Chapter 2, due to their late involvement in the project, field trips did not include other families.

Table 6.1. Extract of the scoring sheet used by key participants to score indicators at the study sites.

Indicator	Score 1	Score 2	Score 3	Score 4	Score 5
State of burial site	Site exposed and highly disturbed	Site exposed and disturbed	Site exposed and slightly disturbed	Site exposed but not disturbed	Site not protected and access restricted
Number of spawning sites of Gula Gula	No longer present	Present but in decline	Decreased but now stable	Decreased but now increasing	Present at historical level

Results and discussion

I found that project participants employed numerous "indicators" to monitor the status of cultural and spiritual places, traditionally used resources, including iconic species like interbred dingoes and cassowaries[13], biophysical characteristics of the environment, such as water quality and quantity and vegetation coverage, and the level of pressure from human activities impacting in the area. Overall I collated a set of 40 indicators that are monitored by project participants.

When participants discussed why indicators were important to consider, I was able to relate those indicators to six main processes operating in the environment and valued by the community, which I hereby term *criteria* according to Adam and Kneeshaw (2008). Indicators and criteria discussed by project participants are summarised in Table 6.2.

[13] Cassowaries are nowadays gone from the study area, however participants requested to retain the indicator to express their disappointment with the loss of this important cultural species.

Table 6.2. Indicators and criteria monitored by participants of the Wet Tropics case study.

Content has been removed
at the author's request

While each indicator was ascribed to the relevant criteria on the basis of its core reason of importance referred by participants, there was considerable overlap between indicators and criteria. For example:

- One indicator, the plant Lomandra, was listed for two criteria: cultural and traditional resources;
- Three indicators, cherry tree, freshwater crayfish and freshwater shrimps, which were used mainly to monitor the "status of traditional resources" were said to have a secondary role in monitoring water quantity, water quality and erosion;
- Three indicators, gar fish, water nuts and mites under stones, were listed mainly as being related to water quality but also represented traditional resources or were directly used to identify potable water;
- Three of the most biophysical indicators, river bank erosion, riverbed conditions and cassowaries, were said to have cultural and traditional resources implications, e.g. riverbank erosion threatens burial sites along the river, while deterioration of the riverbed increases turbidity, which in turn threatens fish populations.

Indicators for monitoring water quality – of great importance to the community – were numerous. Water quality is paramount for the sustainability of the river system and its enjoyment through direct and indirect water use, such as drinking and swimming. One example of water quality related indicators is *Murigi*, the larvae of aquatic insects found beneath submerged stones in the river. Key community participants lift river stones to check for the presence of Murigi to decide if water is safe for drinking. Thus, the presence of Murigi is an indicator of good water quality. Similarly, the garfish, *Arramphus sclerolepis*, once abundant in the Mulgrave, was considered an indicator of good water quality and its disappearance in recent times is associated with water quality deterioration.

Project participants also discussed "pressure indicators". The main reasons of concern for pressure on the environment stemming from human activities were the introduction and spread of invasive species, unregulated tourism and 4x4 driving, and upstream land use change for its potential to increase sediment, spread invasive plants and discharge chemicals downstream, especially during flooding events.

Observing the natural world and monitoring indicators were part of spending time on

Country or on dedicated "walkabouts", which was referred as the traditional education method as well as the preferred method for sharing knowledge with researchers:

> *"Just being there near the river is important to me, look at it and notice the changes, for example near the fisheries is the place where a lot of us used to camp, but now this is changed so much you know."* (TO11)

> *"Another thing that has changed are walking tracks, walking now is impossible, we used to walk there with granddad, and he would show us all sites, sacred sites and trees and so on, but now it is not possible anymore ... now I have no brothers to go with!"* (TO10)

In averaging scores for the ten study sites we found that two sites, Budu Maju and Yet Foy, scored poorly, while four, Fisheries, Gulun, Jibbalan and Wotchull/Kearney's scored average, and three, Japan, Miura Maraji and Mankul Women's place were considered in good condition.

It was not possible to score the Fishery Bridge Women's place because the women of the community had not been there for decades prior to our field trip. Visitation had stopped due to the site being most easily accessed only through private property, and otherwise difficult to reach. Local traditional owners prefer not to request passage through the private property because they do not feel welcome. This situation supports claims that Australian traditional owners are losing their indigenous knowledge and worldview because they are prevented from accessing their culturally significant sites in the current post-colonial land tenure system.

Table 6.3. Scores attributed to study sites by key participants.

Study Site No.	Site Name	Score
1	Budu Maju	1.8
2	Fisheries	3.0
3	Gulun	2.9
4	Japan	3.4
5	Jibbalan	2.9
6	Miura Maraji	4.1
7	Wotchull/Kearney's	3.0
8	Yet Foy	2.6
9	Mankul Women's place	3.4
10	Fishery Bridge Women's place	N/A

Conclusion

My exploration of the IK derived monitoring system held and applied by community members unveiled a vast array of criteria and indicators used by the Malanbarra and Dulabed Yidinji to monitor the parameters of the environment they consider valuable. This confirms that the use of indicators to monitor environmental conditions around values typical of indigenous societies (Berkes *et al.*, 2000; Garcia & Lescuyer, 2008; Heaslip, 2008).

Some of the indicators used paralleled those used in scientific water and riparian habitat monitoring systems, as in the case of Murigi. Other indicators, even if not currently used in scientific monitoring systems, "make sense" from a scientific perspective, such as the case of the garfish, which feeds by sight and whose disappearance can indeed be explained by an increase of water turbidity due to increased runoff and riverbank erosion (Richard Pearson, pers. comm.).

Community members felt empowered when they had in their hand a tool they could understand, and which reflected their values, understanding of the environment and priorities for NRM. Some community members approached local NRM government

agencies to explain their criteria and indicators framework and scoring system, and asked for them to be included in the environmental monitoring of the area. They also used it to pursue grant funding. My hope is that one day our work will bear some practical gain for the participant community; however this kind of outcome requires commitment well beyond the duration and resources of a PhD thesis.

My case study supports the notion that environmental monitoring is a customary activity as much as a Western scientific one (Heaslip, 2008); data collected and the type and scale of environmental impacts looked upon may be different in the two traditions (Heaslip, 2008) and their comparison can be enriching, even if challenging. Developing environmental monitoring tools that encompass IK derived criteria and indicators, together with science informed criteria, which can be managed by Traditional Owners – as described by Ens *et al.* (2012b) – may represent a powerful way to integrate data collection processes, the different epistemologies they derive from and ultimately the worldviews they represent.

6.3 Part 2: Monitoring systems as avenues for integration of different epistemologies

What people know certainly takes a good deal of space in their mind. Ackoff (1989) formulated a classification of the content of human mind, which was consequently modified by Bellinger *et al.* (2006). This classification organised the content of the human mind into data, information, knowledge and wisdom[14]. According to this model, data are symbols that represent the property of objects, events and their environments, and they are the product of observation, where to observe is to sense (Ackoff, 1989). "Information is data that have been given meaning by way of relational connection", which can be useful but does not have to be: for example "it is raining" is a datum, while "the temperature dropped 15 degrees, and then it started raining" is information. Information answers "who", "what", "where" and "when" questions (Bellinger *et al.*, 2006). Knowledge, on the other hand, is a "collection of information" that enables us to account for "patterns", to transform information in "instructions" and, in general, to make predictions; knowledge answers "how" questions, in fact knowledge is also

[14] I hereby leave wisdom aside, since my focus is on "knowledge" integration.

referred to as "know-how" (Ackoff, 1989; Bellinger *et al.,* 2006). The statement "if the humidity is very high and the temperature drops substantially, the atmosphere is often unlikely to be able to hold the moisture, so it rains", is an example of knowledge (Bellinger *et al*., 2006, p.3). Much of the "scientific knowledge" available is similar to these sorts of statements; hence scientific knowledge can be described as a collection of information produced through scientific accepted method(s). Ackoff, as well as Bellinger *et al.*, disagree on what "understanding" is, if it is a separate type of content of the human mind or if it is a dimension that underlies the passage between one level and another, in the meaning that from data by increasing the understanding of reality we gain knowledge.

Knowledge, conceptualised as a collection of information, is usually adopted in western scientific societies, however it has been considered too narrow (Nadasdy, 1999). Alternatively, scholars have defined knowledge more broadly and from different perspectives. Arendt, for example, theorises that there is no true knowledge unless "conceptual change" is achieved, and so the knower embraces new information, believes it is good, and therefore decides it is worth retaining, and uses it in future problem solving. This process of "embracing" is different to rationally "understanding" a concept, and indeed Arendt points out how a concept can be fully and rationally understood, but still rejected if not "believed" (Arendt, 1978). Knowledge as conceptual change is therefore knowledge from the knower's perspective that does not exist *per se*, beyond the person knowing. Knowledge beyond the individual and her cultural context is not knowledge anymore; it is dead knowledge, or more accurately, an ex-situ information system (Van Opstal & Hugé, 2013). Arendt's perspective adds metaphysical layers to the concept of "knowledge", which then acquires definers related to personal and societal beliefs and values, in addition to rational definers.

The theory of the social production of knowledge argues that knowledge is acquired through acceptance of new information that fits in the internal pre-existing knowledge of the individual, and in her value system; in other words within her worldview. By contrast, if the new information upsets too much the pre-existing worldview, the new information is rejected (Berger & Luckmann, 1966). Within this theory, Diemers (1999) modelled a three-step transformational process which explains how an individual who encounters information more or less consciously decides whether it is worth retaining as part of her established knowledge. The steps are: (1) "comprehension",

whereby the individual understands the new information, which requires the information to be expressed in a familiar language; (2) “contextualisation”, whereby the individual tries to make sense of the new information by relating it to her pre-existing knowledge or worldview; and (3) “valuation”, whereby the new information is valued as useful for application, and is then retained and established as new knowledge. Notably, these processes do not necessarily occur while individuals are consciously aware of them.

When the works of Arendt and Diemers are integrated with the model of the content of human mind formulated by Ackoff and Bellinger, “understanding” can be conceptualised as intermediate between information and knowledge. As such, achieving “understanding” requires the rational comprehension and contextualisation of new information. Advancement from understanding to knowledge requires, in addition to rational processes, metaphysical ones, and recurrence to individual and societal values and beliefs. The model of processes involved in knowledge creation, as derived from integration of Arendt, Diemers, Ackoff and Bellinger’s work, is shown in Figure 5.1, which model also implies that value-free scientific enquiries can at best achieve “understanding”, while to achieve “knowledge” the involvement of personal values and beliefs is necessary.

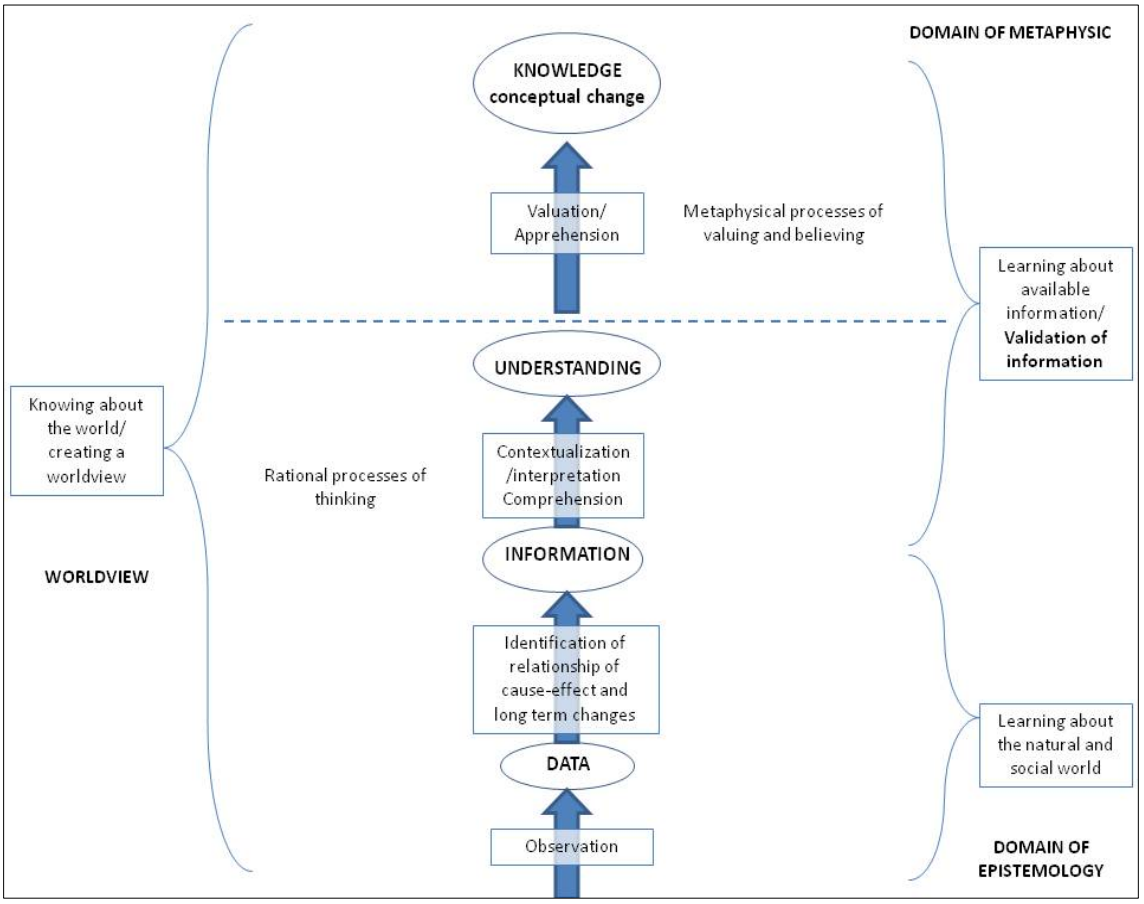


Figure 6.1. Epistemological process involved in the creation of data and information, and in its validation to produce understanding and ultimately knowledge as conceptual change. Here, square shapes represent "processes" and rounded shapes represent "outputs".

When relating the concepts of data, information, understanding and knowledge as conceptual change to Apostel's model of a worldview, discussed in Chapter 4, we could align:

- Data and information to the ontological dimension of a worldview, since they provide a model for the natural world in the present;
- Understanding of the explanatory dimension of a worldview, since it provides explanations for how the world work; and
- Knowledge as conceptual change to the dimensions of ethical, prescriptive and futuristic dimensions of a worldview, because it enables choices on what is desirable for the present and future, and how we will act to achieve a desirable status.

It follows then, collectively, that the processes which go from *understanding* to

knowledge as conceptual change are the processes which enable "knowing the world" and how to live in it; ultimately these processes enable the creation of a worldview. On the other hand, the model shows how only some of these processes, those which pertain to "learning about the natural and social world" are rational and hence are in the domain of epistemology, while processes that enable the achievement of knowledge as conceptual change require the involvement of values and beliefs, and therefore belong to the domain of metaphysic. Such processes are involved in "learning information available" through its validation (more on this point in Chapter 6).

The role of values and beliefs in the production of knowledge has been extensively theorised and debated by authors such as Popper (1959), Kuhn (1970), Berger and Luckman (1966) and Chalmers (1976). The perspective which emphasises the role of values and beliefs, and in general of cultural and social aspects in the knowledge creation process, has become known as the constructivist perspective. Constructivism acknowledges that, since the majority of constructs we use to enable reasoning are socially and culturally constructed, the resulting knowledge will be culturally and socially constructed (Russell, 2010), and this also applies to scientific knowledge. Hence, even if only one reality exists, constructivism resolves that there are multiple possible designs of a system of enquiry, all of which are conducive to culturally and socially mediated constructions of reality. These constructions of reality all present a degree of validity and contain some truth. According to constructivism, however, there is no universal truth, since there will always be a gap between our imperfect ways of knowing and the world itself (Cobern, 1989, 1991 and 1993; Russell, 2010). Hence, knowledge is always partial, imperfect and transient (Brown *et al.*, 2010), in addition to socially constructed. Constructivism is often attacked on the ground that it implies relativism. Many authors have, however, counteracted this criticism by arguing that constructivism surely allows for plurality of views on reality and for respect of culturally diverse epistemologies – epistemological relativism – but not necessarily embrace absolute relativism, nor does it imply that "everything goes" (see for example Boudon, 2005; Johnson, 2007; Proctor, 1998; Prasad, 2007; Davis, 2008; Gough, 2004).

Constructivism has been traditionally contrasted to the "exact science" tradition which, as summarised by Weiss and others (2012), is grounded in two perspectives, the positivistic reductionist and the logic-deductive. The positivistic reductionist perspective argues that true knowledge about natural processes can be achieved by

reducing them to physical, physiological or chemical events that can be measured. The logic-deductive approach emphasises the role of hypothesis testing through the use of empirical data in the production of true knowledge. The positivistic logic-deductive approach to knowledge creation was traditionally grounded in the tenet that only one true knowledge is possible because there is only one reality, and this true knowledge can be achieved through "scientific methods". This belief can result in the negation of the existence of anything outside and beyond what is scientifically observable and testable, known as scientism (Lyver *et al.*, 2009). The endorsement of a certain degree of epistemological pluralism and therefore of constructivism is a pre-requisite to attempts to respectfully integrate different knowledges and worldviews available for natural resource management.

Epistemological processes to integrate indigenous and non-indigenous worldviews

Since in this chapter I discuss integrating epistemologies, from now on I will focus only on epistemological processes aimed at producing understanding as they are summarised in Figure 6.1.

Scientific epistemology endorses a limited number of methods as valid processes for understanding the natural world. These methods may differ in different disciplines but they all have in common emphasis on hypothesis testing and/or the ability to make predictions about the system studied. Most of the scientific methods aim to test hypotheses of possible causes of natural phenomena for their predictive power, and rejecting them if they generate false predictions (Crawford, 2009). The results of scientific enquiries require validation through the consideration of evidence and reason within a social process of critical deliberation, which ultimately rests on sharing information and openly criticising and debating it (Russell, 2010). Strict rules are enforced on what represents valid evidence to accept or reject hypotheses and to validate results for them to be qualified as "scientific" knowledge; usually such strict rules emphasise repeatability and quantification (Gilchrist & Mallory, 2007; Berkes, 2009; Brown, 2010).

In indigenous cultures, some of the accepted processes for achieving valid understanding parallel scientific ones. Such processes include the collection of

qualitative data on natural phenomena over long periods of time through the observation of specific and locally developed indicators (Berkes, 2009). Such observation should be conducted, according to some indigenous precepts, through the human body instead of through technological devices, so to achieve intimacy and immediacy with the natural world (Royal, 2012). Data collected from different observers are then validated and integrated to provide explanations of changes in ecological processes over time and space, usually in terms of cause-effect relationships (Usher, 2000; Berkes, 2009). Nevertheless, some other processes are non-scientific. For example, in some indigenous contexts it is supported that understanding of natural phenomena can be acquired through access to spiritual spheres of reality via meditation, fasting and rituals, which activates the spiritual authority of the knowledge seeker (Royal, 2012). Similarly, it is believed understanding can also be achieved through revelation sent by spiritual beings during dreams (Berkes, 2012). The knowledge and understanding gained through such methods is, however, still subject to validation through socialisation and therefore against other community members' knowledge, and against bequeathed teachings of ancestors (Houde, 2007; Crawford *et al*, 2010; Royal, 2012). In this sense this knowledge is non-scientific, but not unscientific. Validated knowledge is then used to make predictions which are tested through observations also in indigenous systems and cultures (Crawford *et al*, 2010; Berkes, 2012).

Royal (2005, 2009, 2012) discusses methodologies for knowledge creation in Māori traditional culture, and lists some distinctive processes typical of the creation of indigenous knowledge (Royal 2012, p. 13):

- Knowledge resides in the body, "in bodied" knowing – authority is built in a person of knowledge as they become a vessel or the embodiment of knowledge.
- The pursuit of knowledge concerns the progressive revelation of depth and understanding about the world, rather than the construction of new knowledge as one constructs an object.
- Knowing (the world) is equivalent to identification with the world – humankind is a product of the earth and we dwell (or ought to dwell) in a kinship relationship with the earth. The world is to be known and understood through relationship.
- Indigenous knowledge is a "heritage inspired" knowledge system which speaks of the wisdom of the ancestors.

- The purpose of the knowledge-creation process is to activate the spiritual authority of the knowledge seeker, the powers of the individual. It is important to recognise that these "powers" are the qualities and energies of the natural world and the goal is to allow these qualities to flow through the person. Thus, the person becomes one with the natural world.
- The venue, place and location of the knowledge-creation process are important. Spaces and places are not "neutral", absent of qualities and energies. The topic of discussion ought to be synergistic with the location and vice-versa.
- The time of the knowledge-creation process needs to be appropriately set. indigenous knowledge making is conscious of the natural rhythms of the universe of the way day and night interact, for example, or the way in which energy flows naturally in a person throughout a day. Attention is paid to the appropriate date in the lunar calendar and time of day or night.
- The process for the selection of topic is set by the leaders of the knowledge- creation. They consider the needs of the day, the capacity of knowledge-creation participants to address the question, relevance to community interests, and more.
- Much use is made of narrativised knowledge. This kind of knowledge is available to the group (pre-existing stories and narratives of the deeds of ancestors and myth heroes within which contain ideas and perspectives relevant to the topic at hand).
- Identification with the subject – one has the authority to speak not because one is "right", but because of connection and relationship to the topic. Traditionally, this was achieved through the use of genealogy.
- Memory is not just about knowledge of previous events, but also conscious awareness and the awakening of the conscious mind. Memory is about being consciously aware of connection and relationship between things.
- Encounters with the world through the apparatus of the body rather than through technology. There is immediacy and an intimacy with the natural environment. New rituals are required to "unclothe" ourselves from the energies of urban and artificial environments to which we have become accustomed.
- Use is made of meditation and fasting practices whereby inspiration and new ideas are actively sought. Hence, while much development might take place in a group, individuals may also be dispatched into the wilderness to seek understanding.

Royal's perspective is unique in that it is emic, the perspective of an indigenous scholar

explaining an indigenous epistemology to indigenous and non-indigenous audiences. Royal's argument is that indigenous epistemologies are distinct from scientific ones essentially by virtue of their use of non-rational – but not irrational – processes of knowledge creation, such as dream, emotion, spirit, intuition and epiphanies, which are valued along with rational ones, and by the fact that the knowledge seeker places himself *in* the natural world rather than outside it. In this thesis I endorse his stance[15].

To summarise the findings of the literature review I presented so far, processes of knowledge creation inherent to both indigenous and scientific epistemologies are as summarised in Table 6.4.

It follows that, to integrate indigenous and scientific epistemologies, we need to act on: data collection, inference of cause-effect relationships and long-time trend, and comprehension and contextualisation that enable understanding from available information. Following, I describe how I took a closer look at the Malanbarra and Dulabed Yidinji community to identify their processes for data collection and information production to identify avenues for their integration with scientific epistemological processes.

[15] If the particular traits of the knowledge creation process, as identified by Royal, suffice to identify an indigenous epistemological domain distinct from the scientific one, it is not the object of this chapter. Nor is it the question, if such claims of epistemological distinctiveness are fuelled by a political motivation to create an indigenous identity and worldview distinct from the western scientific ones and legitimated by its own methods. The stance I adopt in this chapter, and overall in this thesis, is that if indigenous societies worldwide advocate their epistemological independence from the constraints of the scientific methods, their claims need to be taken seriously, perhaps regardless of their motivation, in order to respect their rights to self-determination. It is on this ground that I assume there are two distinct epistemologies, the indigenous and the scientific, that need to be integrated for the production of understanding and knowledge to guide natural resource management.

Table 6.4. Epistemological processes as emerged from the literature review and project participant interviews.

Epistemological processes		
1. Collection of data	**2. From data to information**	**3. From information to understanding**
1a. Observation of nature through qualitative indicators and quantitative indicators, assessed through the senses or measured through technology	2a. Infer of cause-effect relationships, through observation in one's lifetime and through comparison with knowledge transmitted 2b. Infer of cause-effect relationships through hypotheses testing (e.g. experiments) 2c. Revelation – intuition – dreaming as a way to feel the natural world in addition to seeing 2d. Meditation and fasting	3a. Comprehension and contextualisation – applied to information coming from own or other knowledge systems

Methods: interviews coding and participant observations

During my case study I interviewed numerous Malanbarra and Dulabed Yidinji community members and conducted collaborative field trips. During these activities I also kept a diary of my participant observations.

I searched both interviews and my diary for evidence that the community members applied the epistemological processes presented in Table 6.4.

Results and discussion: Avenues available for integration of indigenous and scientific epistemological processes

The epistemological processes adopted by Malanbarra and Dulabed Yidinji participants mediated by my own understanding are presented in Table 6.5, together with illustrative quotes extracted from participants' interviews.

During my case study with the Malanbarra and Dulabed Yidinji, I did not observe some

of the epistemological processes identified in Table 6.4. For example, in regard to the use of hypothesis testing, I was not able to directly observe independent hypotheses testing by community members. I did, however, have the chance to scientifically test an indigenous knowledge derived hypothesis regarding certain vines that were traditionally used in the community as fishing poisons and their effect on the invasive fish Tilapia (as further discussed in Chapter 7). On that occasion I was told by one of the project participants that an elder (and project participant) was running some preliminary independent experiments in the forest to make sure the plant worked before running the official experiments in the laboratory. During the laboratory experiment, I noticed indigenous co-researchers were comfortable with the overall procedure of scientific hypothesis testing. Further, on another occasion, the same elder informed me that he maintains nurseries of native plants in the rainforest, conducts small scale revegetation on a personal basis, and that before planting he tests which species work better in different conditions. To conclude, even if I did not have the chance to directly observe independent hypotheses testing by community members, it seems reasonable to think that testing hypotheses is a process regularly used in the participant community as a way of producing information and understanding about the natural world.

Table 6.2. Epistemological processes observed during the case study.

Epistemological processes	Illustrative quotes
1. Collection of data	
1a. Observation of nature through qualitative and quantitative indicators, monitored through senses rather than through technological devices	*"*[To monitor medicinal plants] *you go through them and you count what you have got there. Even along the side of the river bank we have got nursing plants, and we can count them, we know what's growing in that area, we know how many."* (TO7)
2. From data to information	
2a. Infer of cause-effect relationships and long-time trends, through observation in one's lifetime and through comparison with knowledge transmitted	*"… my dad used to say that that was the cause for destroying the fish, the mill."* (TO11) *"Well over the years remember way back when I was a kid the river had its natural form and shape that it needed to support that fish, that population of fish that was there at that time, but now that you don't have that shape and all that I reckon the fish cannot breed anymore."* (TO7)

Integrating the production of information from data: inferring cause-effect relationships and long-time trends

My observations of project participants suggest the data collected by the Malanbarra and Dulabed Yidinji through indicators informed by their worldview were then used to infer cause-effect relationships and long-time trends by comparing the current status of the environment with previous assessments conducted during one's lifetime, and with knowledge transmitted by ancestors (Table 6.5). Within communities, often few individuals – usually elders – act as repositories of bequeathed knowledge; such individuals possess a nuanced understanding of natural phenomena that span different spatial and temporal scales, and have a developed perception of causal factors of environmental changes and how these factors can interact. Elders' expertise is superior to that of common community members and is useful in complementing scientific understanding (Chalmers & Fabricius, 2007; Berkes, 2012; Moller *et al.,* 2004; Ziembiki *et al.,* 2013). Including knowledgeable elders in providing natural resource management advice to government and research organisations is, therefore, an avenue for integrating indigenous processes of inferring cause-effect relationships and long-

term trends with non-indigenous ones.

During my case study I had the opportunity to work with some knowledgeable elders from the Malanbarra and Dulabed Yidinji community. They were recognised unanimously by other community members as "those with the knowledge" and, therefore, had the authority to speak on behalf of Country. Despite such recognition, some younger and more vocal individuals often challenged elders' authority for political reasons. I also observed that often these more vocal individuals, despite being much less knowledgeable, were those who end up being "consulted" by government agencies as community representatives, likely because they are more visible and more aligned with western lifestyles, and thus "easier" to interact with (Muller, 2014).

Sub-optimal leadership transfer to youth has, however, been recognised as a problem of internal governance for some indigenous communities[16]. In some case studies, knowledgeable elders have been awarded honorary university degrees in recognition of their expertise (Peta Standley, pers. comm.). This recognition may serve the twofold purpose of reinforcing elders' leadership within communities, and serving as contacts for stakeholders and government organisations to provide expertise about specific topics within the community, even if a thorough discussion about engagement with other community leaders should still take place, for cultural protocols to be respected (Ziembicki *et al.,* 2013).

Joint hypothesis setting and testing is another viable path for co-production of information (as I further discuss in chapter 7), especially for inferring cause-effect relationships.

6.4 Conclusions

In this chapter I discussed some of the epistemological processes of knowledge production that I observed during my case study and in particular the processes of data collection that the community employs. I also presented an IK-derived set of qualitative criteria and indicators that the community is now using to negotiate a higher inclusion in

[16] http://governance.reconciliation.org.au

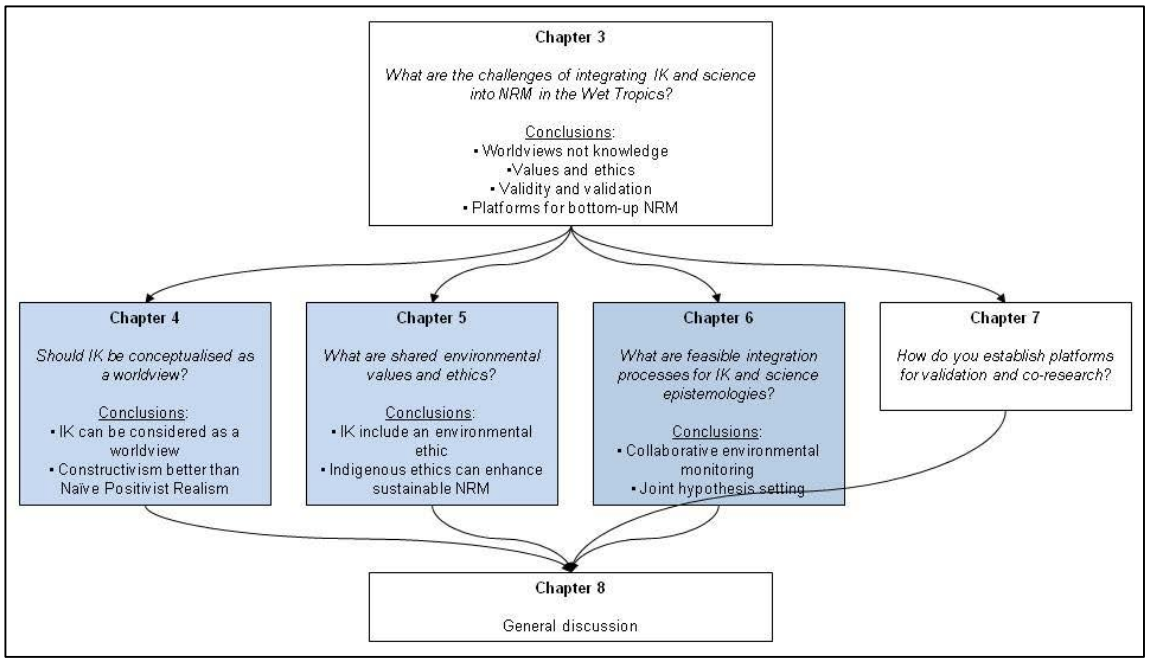
their estate NRM.

It should be noted that the criteria and indicators monitored by the community are an expression of the values they place on their Country. It follows then, that by implementing the community criteria and indicators for environmental monitoring and by prioritising NRM decisions that restore the health of such indicators the community values and worldviews will be supported in NRM.

6.5 Chapter summary

In this chapter I have discussed avenues to convey the values, ethic and ultimately the worldview of the community who participated in my project. The preparation of an indigenous worldview informed criteria and indicators framework for environmental monitoring and for the prioritisation of NRM decisions in the area emerged as an efficient and valuable path.

Collaborative environmental monitoring, together with joint hypothesis testing, have also emerged as avenues for integrating epistemological processes coming from different worldview. In the next chapter I continue the discussion on how to promote mutual understanding between stakeholder holding different worldviews and knowledge in the Wet Tropics.

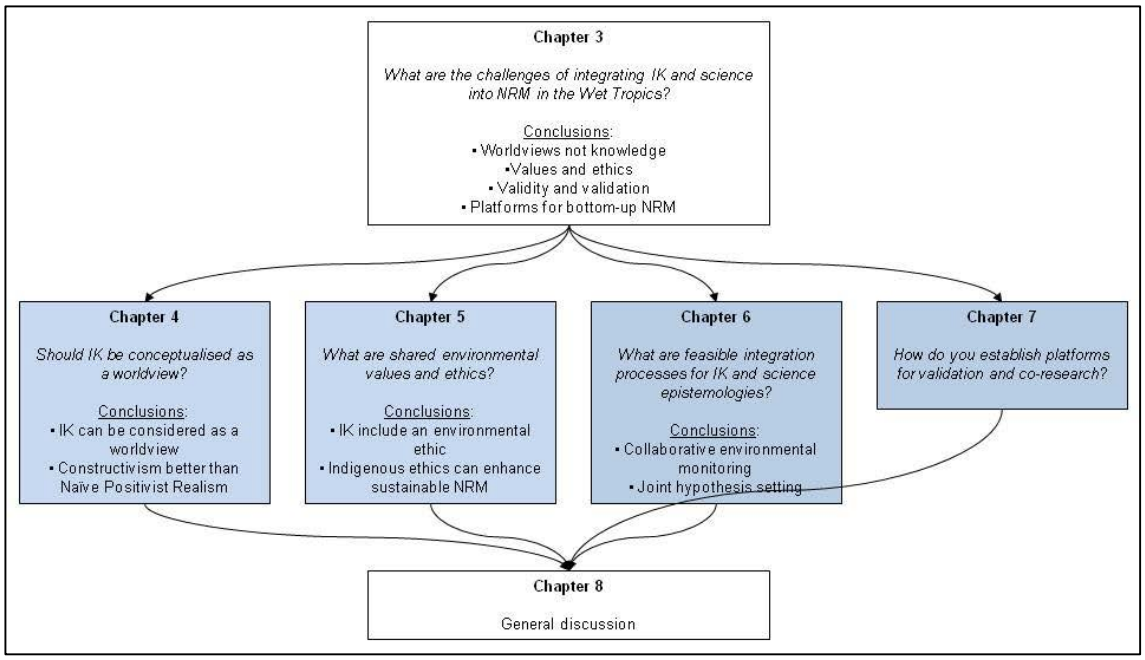

Chapter 3
What are the challenges of integrating IK and science into NRM in the Wet Tropics?
Conclusions:
• Worldviews not knowledge
•Values and ethics
• Validity and validation
• Platforms for bottom-up NRM
Chapter 4
Should IK be conceptualised as a worldview?
Conclusions:
• IK can be considered as a worldview
• Constructivism better than Naïve Positivist Realism
Chapter 5
What are shared environmental values and ethics?
Conclusions:
• IK include an environmental ethic
• Indigenous ethics can enhance sustainable NRM
Chapter 6
What are feasible integration processes for IK and science epistemologies?
Conclusions:
• Collaborative environmental monitoring
• Joint hypothesis setting
Chapter 7
How do you establish platforms for validation and co-research?
Chapter 8
General discussion

Chapter 7: Is validation of indigenous ecological knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management

Chapter 3 hinted to a perceived need for indigenous knowledge to be validated prior to its inclusion in the Wet Tropics natural resource management and for the creation of platforms for collaboration around this issue. In this chapter I further analyse the concept of validation to ascertain if it is perceived as disrespectful by involved Traditional Owners. I also propose a platform for collaboration between stakeholders around issues of knowledge validity and validation. This is the last of three data chapters that rely on collaboration with a community of traditional owners of the Wet Tropics, the Malanbarra and Dulabed Yidinji.

Manuscript associated with this chapter:

Gratani, M., J. R. A. Butler, F. Royee, P. Valentine, D. Burrows, W. I. Canendo & A. S. Anderson. 2011. Is validation of indigenous ecological knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management from the Wet Tropics, Australia. *Ecology and Society* 16(3): 25.



Abstract

Despite the growing recognition of the contribution indigenous knowledge can make to contemporary "western" science-based natural resource management, integration of the two knowledge systems has yet not reached its full potential in Australia. One explanation could be an implicit requirement for indigenous knowledge to be validated by western scientific knowledge, which has stalled its application and perpetuated the primacy of scientific knowledge over indigenous knowledge. Consequently, there is little experience of indigenous knowledge validation, indigenous peoples' perspectives of the process, and no formal frameworks to achieve mutual and equitable validation of both indigenous knowledge and scientific knowledge. In this chapter I assess the opportunities and limitations of validation processes using a case study of traditional fishing poisons for invasive fish management in the Wet Tropics World Heritage Area of Australia. The study was conducted within a co-research approach with the Aboriginal holders of the indigenous knowledge, who are among the paper's authors, and science-based biologists. In joint laboratory trials we demonstrated that fishing poisons are effective at immobilising invasive tilapia. Retrospective interviews with indigenous co-researchers showed they did not find the experience of validation disrespectful, but instead empowering and necessary for their indigenous knowledge to be understood and appreciated by scientists, and included in natural resource

management. Based on our experiences and knowledge of socialisation theory, here I present a framework for potential future design of collaborative validation processes to support integration of indigenous worldviews in natural resource management, and the acceptance of scientific knowledge within indigenous communities in Australia.

7.1 Introduction

Turnbull (2009, p. 2) states, "if there is to be a future for us all, it depends on treating the planet and the totality of its environmental and cultural resources as a commons to be shared and sustained. Recent re-conceptualisations of the commons consider them as complex adaptive systems whose sustainability and resilience depends upon diversity and interactive feedback between autonomous and distributed agents (Ostrom, 1999). This raises the question that if the commons are also considered to include the diversity of knowledges, then how can they be productively shared and allowed to interact?" This is an important issue for Australia, where Cork (2009, p.64) suggests "humans have dampened the processes of disturbances on both the natural and human-made environments, causing loss of diversity of form and function among non-human species and loss of diversity in thought, skills and outlook among humans". Hence, there remains a challenge to both recognise and respect diverse knowledge systems, while simultaneously allowing the "healthy disturbance" of established epistemologies to promote diversity of thought and resilience of social-ecological systems.

In Australia, natural resource management (NRM) based on western scientific knowledge (SK) has been imposed through colonialism over a landscape that had previously been managed by systems of indigenous knowledge (IK; Ross & Pickering, 2002), which reflects indigenous worldviews. Although the situation is changing, IK in Australia plays a limited role in NRM (Carter & Hill, 2007), and western scientific epistemology maintains intellectual primacy over indigenous ones (Nursey-Bray, 2009). This might be because, as summarised by Stephenson and Moller (2009: 142), "when control and decision making authority rests ... with government management agencies, negotiation needs to occur and new institutions must be created to ensure indigenous groups have a substantive role in environmental management". There is also a general expectation that IK must first be validated against science to be valued and adopted, and this may stall negotiation of a role for IK in the co-management of natural resources

(Nakashima & Roué, 2002). As a consequence, even though Australian federal and state government policies encourage the inclusion of IEK in NRM; integration through local NRM plans has not achieved its recognised potential.

The Oxford Dictionary[17] defines validation as, "to check or prove the validity or accuracy of" or "to demonstrate or support the truth or value of". That the validity of one knowledge system must be confirmed by another raises issues over the equity of such an approach. The risk is that the superiority currently held by SK is perpetuated if validation of IK is achieved by either adopting SK as the standard against which IK must be measured, or by accepting only scientific evidence to support IK (Shiva, 2000). Many authors suggest the primacy of SK is justified by the positive record of science in empirical, real-world problem solving (Dickison, 2009), and therefore IK should be validated against SK (Gilchrist *et al.,* 2005; Gilchrist & Mallory, 2007). However, others warn against the unilateral validation of IK by SK, because it might be disempowering and disrespectful for local communities (Brook & McLachlan, 2005).

For others, however, indigenous knowledge systems require no validation by western knowledge systems because they have proved their validity by supporting communities for thousands of years (Michell, 2005). Indigenous peoples also adopt their own IK as the benchmark against which to validate other knowledge systems. As Williams (2009: 168) notes, "indigenous people worldwide ... commonly believe that their traditional knowledge is superior to scientific knowledge because it is meaningful to them and it works". Hence, the relative positions of knowledge holders toward alternative knowledge systems may further inhibit the dialogue necessary for the integration of SK and IK in NRM. Consequently, there is a need to develop spaces where holders of different knowledge systems can develop a respectful and equitable dialogue on how to mutually validate and integrate their knowledge for effective NRM (Davidson-Hunt & O'Flaherty, 2007; Robson *et al.,* 2009).

In this chapter I tackle the issues, (a) the perceived need for validation when integrating IK and SK, (b) what validation is, and (c) how validation can support integration of IK and SK, with a case study that tested traditional fishing poisons for the control of tilapia, invasive fish that are spreading through the rivers of the Wet Tropics of Queensland,

[17] Oxford Online Dictionary: http://www.oxforddictionaries.com

Australia.

Fishing poisons are toxic plants which affect fish, but not the people that consume the fish. They continue to be used in traditional societies across the world, especially in developing countries (Neuwinger, 2004). There is widespread interest in adopting fishing poisons in modern pest management because they are effective on many aquatic pest species, and are usually less expensive (Bagalwa & Chifundera, 2007), and perceived as more environmentally friendly than chemical pesticides (Ramanujam & Ratha, 1980). Scientific validation has previously played a role in assessing the effect of traditional fishing poisons on target pest species (Ramanujam & Ratha, 1980; Ibrahim *et al.,* 2000; Luitgards-Moura *et al.,* 2002; Kalita *et al.,* 2007) and non-target species (Wei *et al.,* 2002; Singh & Singh, 2005; Bagalwa & Chifundera, 2007) in Africa, India, South America and China. However, none of these studies evaluated the validation process in terms of learning, equity, and respect. Furthermore, scientific validation of traditional fishing poisons for invasive fish has never, to our knowledge, been undertaken in a collaborative fashion in Australia.

The work described in this chapter was initiated by some of the elders of the Malanbarra and Dulabed Yidinji community, who sought to have their knowledge validated in scientific terms; they hoped it raise awareness of IK among the non-indigenous community as well as governmental agencies, and of its potential to contribute to contemporary NRM. The scientific validation hereby described was conducted by a mixed team of indigenous and non-indigenous researchers. The team's ultimate aim was to promote the integration of IK and SK to improve local NRM, and to explore potential linked livelihood opportunities for the indigenous community. However, during the project a number of different perspectives of the validation process emerged and this provided an opportunity to reflect on our experience. Hence, the research questions I address in this chapter are, (1) what are the characteristics of the validation process, and (2) is validation of IK by SK intrinsically a disrespectful process?

I retrospectively interviewed indigenous team members who took part in the validation process and related themes that emerged from our discussion to the published literature on validation processes and knowledge production. At present there is no framework in Australia for governments and their environmental agencies to validate IK prior to its adoption in NRM.

At the time of writing I could only find one published example of a framework for the validation of IK, in which ethno-pharmacopeias were validated in ethno-veterinary practice. Within this framework Lans and colleagues (2007) accepted reviews of similar IK applied elsewhere and published validation of similar plants as non-experimental evidence, but acknowledged that this was inferior to scientific validation. Hence, based on my findings I also developed a framework for the potential future design of collaborative validation processes and knowledge integration in Australian NRM.

7.2 Methods

Study area

The study was carried out with the collaboration of some of the elders from the Malanbarra and Dulabed Yidinji community, traditional owners of the Mulgrave River valley in the Wet Tropics World Heritage Area of Queensland (Figure 1.3). Malanbarra means "people of the stony river bed" (Nungabana, 1996), and as previously discussed, the community has a traditional and ongoing dependence on and cultural knowledge of the Wet Tropics rainforest and the Mulgrave River (Sangha *et al.,* 2011). As traditional owners, the Malanbarra are involved in the co-management of the World Heritage Area surrounding the Mulgrave River, but they are not satisfied with their role. They consider decisions made by the Queensland and Australian government agencies responsible for NRM based on western scientific paradigms are disconnected from their aspirations and do not respect their cultural values or IK. The elders involved in this project sought to explore the potential for their IK to contribute to management of the Mulgrave River, as well as control of tilapia through the integration of IK and SK.

Tilapia species' tolerance for a wide range of environmental conditions and their reproductive strategy enables them to be highly successful colonisers, and severe declines of native fish species have been related to their presence in Colombia, Nicaragua, Madagascar and Nevada (Canonico *et al.,* 2005). In Australia two species of tilapia, *Tilapia mariae* and *Oreochromis mossambicus* have been introduced as ornamental species. They are established in Queensland (Webb, 2003; Lintermans, 2004), where they are listed as noxious species, and considerable resources are devoted

to managing their spread (QFS, 2001). As previously mentioned in Chapter 1, *T. mariae* has established self-sustaining populations in the Mulgrave River (Webb, 2007; Burrows, 2009).

Piscicides and mechanical removal are both methods adopted by NRM agencies for controlling tilapia in Queensland (Ovenden, 1998). Rotenone is most commonly used because of its low toxicity for non-target animals, rapid decomposition in the environment, and relatively low cost. Despite these advantages the use of rotenone is controversial because of its side effects on non-target species and the toxicity of solvents used in its preparation (Ling, 2002). Hence, indigenous fishing poisons are a possible alternative source of environmentally friendly bioactive molecules.

The presence of tilapia in the Mulgrave River therefore presented an opportunity to test the traditional fishing poisons used by the Malanbarra and Dulabed Yidinji as a possible alternative tool for their control. In collaboration with elder co-researchers, I developed an experimental procedure to scientifically validate the efficacy of Malanbarra fishing poisons for tilapia.

Community engagement

Engagement with the Malanbarra and Dulabed Yidinji community throughout the study was set within a culturally appropriate co-research framework designed for the region (Cullen *et al.,* 2008; Cullen-Unsworth *et al.,* 2010). The team who conducted the validation described in this chapter consisted of two male Malanbarra and Dulabed Yidinji elders, me and my supervisors, who are non-indigenous scientists from James Cook University, the CSIRO and the Australian Centre for Tropical Freshwater Research (ACTFR). In addition, an indigenous cultural broker helped me in the field during the initial phase of community engagement.

Elder co-researchers provided their free and prior informed consent for all phases of the project. It was agreed the identity of the two plants traditionally used as fish poisons remained the intellectual property of the community and should be considered confidential. I have named them “W” (white) and “R” (red), referring to the colour of their sap.

Samples of each plant were collected by the elders during participatory field trips in the

study area. Plants were prepared by cutting a 30-50 cm section from the basal stem and storing it in a plastic bag in a refrigerator. In the laboratory the elders pulverised the plant sections using a pestle and mortar to produce a paste of woody material and sap. The mixture was then added to laboratory tap water (86% oxygen saturation, 24-28°C, filtered to eliminate chlorine) to achieve a mother solution. The solution was then diluted to achieve two concentrations typically used in the field for both W and R, equivalent to 1.8 g/l (low concentration) and 3.8 g/l (high concentration).

Laboratory tests

A pilot experiment was conducted in April 2009, and the research study was conducted during three experimental sessions in May, July and December 2009. Overall, we tested 48 individual *O. mossambicus* tilapia of 12-14 cm total length in multifactorial tank experiments at the ACTFR. Each was placed in an individual plastic basket, and four batches of 12 fish were treated in a 250 litre experimental tank. Low and high concentrations of W and R were added to the tank water, with one treatment per batch of fish. A stopwatch was used to measure the onset of response in each fish ("onset time") in seconds. Immediately after each fish showed the onset of effects, and having recorded the onset time, a team member removed the fish and allowed it to recover in an adjacent clean water tank. Three control fish were kept in plastic baskets in clean water for the entire duration of each treatment. Mean onset times for fish in each batch were compared using t-tests.

Reflections on the validation process

The indigenous co-researchers' reflections on the validation process were derived from retrospective semi-structured interviews (after Bernard, 2006). I undertook the interviews once the tank experiments were completed in December 2009. Interviews were video and/or audio recorded, and covered the following topics:

a. Whether and why indigenous co-researchers supported the validation process;
b. Whether they felt disrespected by the process; and
c. Their suggestions for a future IK validation framework

7.3 Results and discussion

Laboratory tests

Fish that were exposed to the treatments showed obvious effects; fished used as controls did not show any change in behaviour. Symptoms differed for the two plants: W induced agitation, spasmodic breathing and immobilisation, while R induced paralysis. Symptoms observed in the laboratory conformed with reported stunning and reversible effects observed by indigenous co-researchers who traditionally applied the two fish poisons in the Mulgrave River. Mean onset time for W was significantly greater for the low concentration treatment when compared with the high concentration treatment (t-test, $t = 2.96$, $p < 0.05$). Mean onset time for R was significantly greater for the low concentration treatment when compared with the high concentration treatment (t-test, $t = 2.93$, $p < 0.05$). Mean onset time for the low concentration R treatment was significantly less than that for the same concentration of W ($t = 3.82$, $p < 0.05$). Similarly, mean onset time for the high concentration R treatment was significantly less than that for the same concentration of W ($t = 6.17$, $p < 0.05$). Results are summarised in Table 6.1.

Table 7.1. Mean onset time for the two treatment concentrations of W and R applied to the tilapia, *O. mossambicus*.

	Onset time (seconds)			
	Low concentration (1.8 g/l)		High concentration (3.8 g/l)	
Plant	**Mean**	**SE**	**Mean**	**SE**
W	625.0	91.5	345.0	23.5
R	262.5	25.1	180.0	12.8

Results summarised in Table 7.1 demonstrate that W and R were highly effective when applied to *O. mossambicus.* Different active chemical components are usually responsible for the bioactivity of fish toxicants, but their isolation and characterisation requires complex chemical analysis (Ibrahim *et al.,* 2000). To protect the intellectual

property of the community, I did not investigate the biochemistry of W and R. However, my observations reflect the published literature on typical observed effects of saponins, alkaloids and rotenone/rotenoids. Plant W induced respiratory stress, fish became agitated and their breathing became spasmodic. Similar symptoms were observed when *T.nilotica, O. machrochi* and *Haplochromis* spp. were tested with *Maesa lanceolata,* a saponin plant used for traditional fishing in the Congo (Bagalwa & Chifundera, 2007). Climbing perch, *Anabas testudineus,* exhibited similar symptoms when exposed to saponins of *Quillaja saponaria* (Roy & Munshi, 1989). Roy and Munshi (1989) ascribe such respiratory stress to the impact of saponins on fishes' respiratory epithelia, whereas Wickens (2001) attributes it to the alteration of water tension whereby uptake of oxygen from water is impossible. Although extended exposure to saponins can be lethal (Bagalwa & Chifundera, 2007), I observed only temporary effects, perhaps because in our experiment the fish were removed and revived after the onset of symptoms.

Plant R induced muscle paralysis, typical of toxic alkaloids (Wickens, 2001), which are active chemical components of the families Loganiaceae, Solanaceae and Umbelliferae, all of which contain species of toxic plants used as fishing poisons worldwide by indigenous cultures (Singh & Singh, 2005). Alkaloids disrupt the calcium homeostasis of the cell and induce depolarisation in neurons, and are used by some reef sponges of the genus *Agelas* to deter predatory fish (Bickmeyer *et al.,* 2004). Muscular paralysis is also induced by rotenone and rotenoids; isoflavonoids that occur in different genera of tropical Leguminosae (Luitgards-Moura *et al.,* 2002). My laboratory test results suggest the effect of the two plants W and R is dose-dependent; this was also observed by Bagalwa and Chifundera (2007), who tested saponin extracts of *M. lanceolata* on *T. nilotica*, and by Ibrahim and colleagues (2000) for rotenone plants tested on *T. nilotica*. The experiments also indicate that plant R affected fish more quickly than plant W.

Reflections on the validation process

Interview extracts are provided in the following sections in italics, with text in plain font inserted to help contextualise them. A suffix is used to univocally identify the co-researcher (Co) cited.

a. Whether and why indigenous co-researchers supported the validation process

Indigenous co-researchers supported the validation process because they believed results from the experiments proved the legitimacy of their IK to scientists and government environmental agencies. As such the results built confidence among the elders about their own knowledge, and empowered them in negotiations about their involvement in the co-management of their traditional estates:

> *"Well, the experiment put us out there, it did ... brought it right to the point that yes this thing* [the plants that affected tilapia] *does work ... otherwise I do believe that this thing a lot of our people would have kept this quiet and would have said 'No, we are not going to put this thing out there', or otherwise 'maybe the older people don't agree', whereas we have spoken with our elder and we said 'Well look, you know, somebody has to take the initiative and do this and prove to other people that it can be done and that we can help other people with this. It can be done; we can eradicate this fish* [tilapia]*'."* (Co1)

Co-researchers also supported the scientific validation of their IK as a tool to gain the attention of government agencies and non-indigenous communities. In their opinion, the validation experiment gave evidence to support the integration of their IK in the established NRM system. Elders claimed many scientists and government agencies believe only data collected in a scientific fashion can support sound NRM. They supported the scrutiny of their knowledge in scientific terms to challenge the inertia of established environmental practices, as also noted by Huntington (2000) in Canadian First Nation communities. However, elders also believed that overall the mainstream SK system still does not recognise alternative knowledge systems and their holders, also observed by Shiva (2000) and Denzin and colleagues (2008) in North America and India. Consequently, elders continue to demand more equitable involvement of their IK

in current NRM:

> *"Without it* [the experiment] *they* [government agencies] *wouldn't believe you for starters, I don't believe they would, you could tell them about it and unless it's actually shown to them and they can actually see this thing for themselves as what they did during that experiment, I don't believe they would. They tend to do things their own way more times than often, but they haven't got anything else that will do this job* [the effect plants have on tilapia]*"* (Co1)

> *"The western society doesn't really want to take on board our indigenous knowledge and respect our values and how we do business on Country, and how we are as one with nature, and we live and we breathe Country, you know, we can read Country and I knew this experiment would work as we have a similar plant up home, where I come from in the Tablelands, but it was just good to get it out there* [through the experiment] *and get it into the scientists' ears to let them know that this can happen and it's just a stronger voice for us traditional owners so that we can get the things rolling because we're sick of being put behind all the time, you know we need to be working together instead of one up front and one behind."* (Co2)

> *"*[With the experiment we gained] *more attention now than what we did in the past, because it was so hard to, government bodies would never listen to you, they would say 'yeah, yeah, yeah' but it was all falling out here* [out of their ears]*, nothing was remaining in here* [in their head]*, you know, because when we come back to this thing again, then we are going through the whole process again and reinventing the wheel if you like."* (Co1)

b. Whether indigenous co-researchers felt disrespected by the validation process

Indigenous co-researchers did not indicate they were dissatisfied or had been disrespected by the validation process. Rather, they emphasised the importance of appropriate engagement and the adoption of a collaborative approach for the successful running of the experiment. The acknowledgement of elders' expertise and their involvement in all phases of the research project is strongly advocated by indigenous

and non-indigenous scholars as conferring legitimacy and validity to research projects on indigenous matters (Cadet-James, 2001). Therefore, I engaged Malanbarra and Dulabed Yidinji elders in a collaborative research approach that allowed the time necessary to develop mutual understanding, trust, and a positive relationship. Indeed, the process was time-consuming, which may partly explain why government agencies often do not engage appropriate community members in planning activities, as also observed by Denzin and colleagues (2008).

However, it was crucial for the process of validation to be perceived by the elders as respectful:

> *"Usually when scientists come and want to do studies they don't come and see the traditional owners or see the main people like the elders, who are the decision makers. They usually just see anyone and by that they don't really get the 110% out of that project or whatever they are doing because they're not seeing the proper people. Even though they are seeing the people that belong to Country but* [it might be they] *see a younger generation, where they don't have much of an idea only hear what a couple of people have said and then try and add that together. But really to get the best benefit out of it* [you have] *to come and see the elders, because it is coming from them* [who are the people to whom the knowledge] *has been passed down to."* (Co2)

> *"*[In this project I saw] *western and indigenous knowledge together. Scientists respecting and appreciating traditional knowledge and ways, earning trust, value and respect not just one hit wonder come in and fly out again but earning that trust, well becoming a friend like we have over the last year and a half, at the start it was a bit edgy but since you come up and then you started being a part of a bigger picture with the traditional owners they accepted you because they trusted you and just working with scientists and that and telling them that we do have ways that date back for 40,000 years that we need to put on the table for you to understand with your western ways."* (Co2)

Indeed, the involvement of elders was essential for recording accurate Malanbarra and

Dulabed Yidinji knowledge of fishing poisons, as was also observed by Chalmers and Fabricius (2007) in their study of land cover change within the Nqabara community of South Africa, and by Gilchrist and colleagues (2005) for knowledge of migratory birds held by the Inuktitut of the Eastern Arctic. My study therefore further corroborates the prerequisite for collaborative approaches if positive integration of IK and SK is to be achieved (Cullen *et al.,* 2008; Moller *et al.,* 2009c; Cullen-Unsworth *et al.,* 2010; Mercer *et al.,* 2010).

c. Indigenous co-researchers' suggestions for a future IK validation framework

Indigenous co-researchers found the discussion about developing a framework for future IK validation challenging because they were not familiar with the language relating to frameworks and conceptual models. Therefore the question was rephrased in terms more familiar to them, and they were asked what they would do if they had a similar plant to propose for a different application. Elders suggested they would apply scientific validation in the same way:

> *"*[If I had another plant to use for another application] *I would bring* [people to be convinced] *back out to the Country, talk to them about this thing and then show them, give them a bit of an experiment so we'll show you that it actually does work."* (Co1)

Toward a framework for knowledge validation

I found parallels between our experience of the validation process and the theory of knowledge socialisation (Berger & Luckmann, 1966). The theory proposes that when processing new information, individuals and institutions attempt to internalise the information into existing knowledge. Diemers (1999) modelled a three-step transformational process whereby an individual who encounters information decides if it is worth retaining as part of their established knowledge: (1) "comprehension", whereby the individual needs to understand the new information and hence it has to be expressed in a known language; (2) "contextualisation", whereby the individual tries to make sense of the new information by relating it to his/her pre-existing knowledge or benchmark; and (3) "valuation", whereby the new information is valued as useful for application, and is then retained and established as new knowledge (Figure 7.1).

However, if new information clashes with pre-existing knowledge or is considered not useful, it is rejected. I suggest the IK validation exercise followed a similar transformational process, whereby the efficacy of fish poisons was new information that the co-research team jointly passed through the comprehension, contextualisation and valuation steps. Based on this parallel I adapted Diemer's (1999) model to create a cross-cultural validation framework (Figure 7.2).

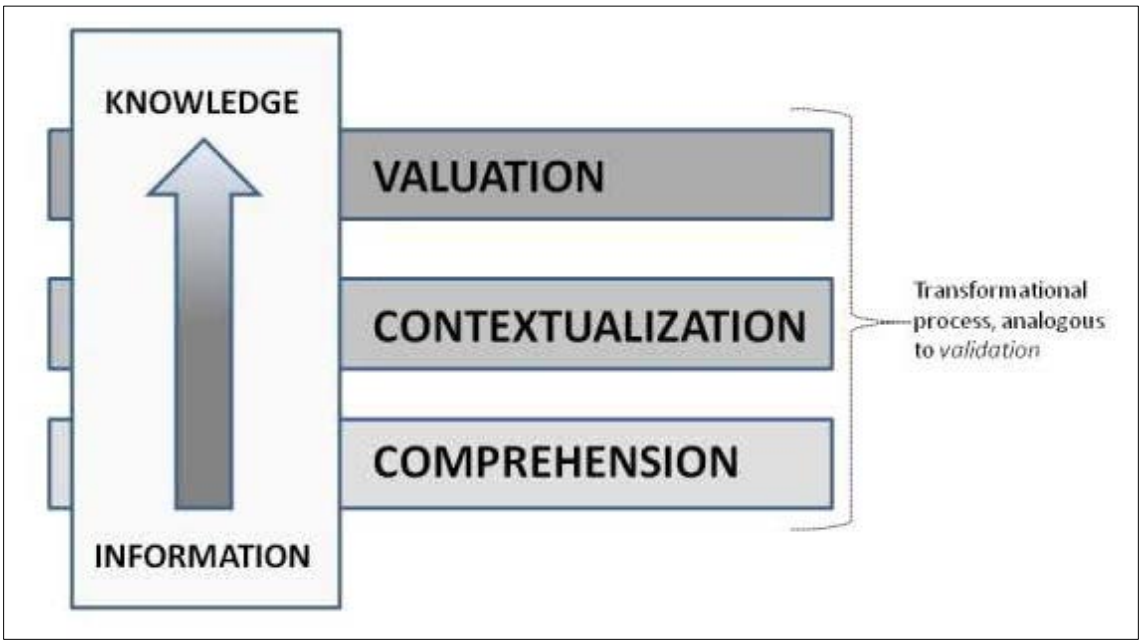


Figure 7.1. The three-step transformational process of knowledge production from new information, modified from Diemers (1999).

In tackling this topic, my initial assumption is that IK and SK are two different domains of knowledge with a similar underlying process of knowledge production through socialisation. In both cultures the quality of new knowledge is checked by a panel of experts; through the peer review process in the western knowledge system and through endorsement by councils of elders in IK systems. In my opinion, the key difference between indigenous and non-indigenous knowledge systems is that knowledge produced on either side of the cultural divide can reflect different social values and can be encoded in different forms, such as scientific publications in western societies, and story, ritual or history in indigenous societies.

In the framework I developed (Figure 7.2) five categories of IK and SK information are given equal weight for the production of validated knowledge: (1) historical observation in both western and indigenous societies, including written or oral; (2) published literature; (3) experimental data; (4) similar IK used in other indigenous cultures; and (5) folklore developed to maintain IK. Each category is evaluated by a collaborative and cross-cultural "validation team" composed of indigenous elders, western scientists and NRM managers. The team is analogous to the "communities of learning" defined by Robson and others (2009) and "place-based learning communities" proposed by Davidson-Hunt and O'Flaherty (2007) to facilitate convergence of IK and SK.

To achieve collaborative validation, the team must proceed through the three steps of Diemer's (1999) transformational process of knowledge production:

1. Mutual comprehension, by presenting information in a language and medium intelligible to all team members;
2. Cross-cultural contextualisation, by finding analogies within each team member's pre-existing knowledge system, which is supported by the mutual comprehension achieved in the first step; and
3. Respectful valuation, by valuing information against a common values framework representing all of the team members involved.

If all three steps are successfully achieved, the information can be considered collaboratively validated knowledge and can then be included in NRM planning documents and made available for application (Figure 7.2), subject to the local institutional context and process. However, if one of the three steps fails, the information remains confined to the knowledge system that produced it and cannot be classified as validated knowledge. In that case, the process can be started again following appropriate reflection on the cause of the failure.

It should be noted, however, that there are alternative processes for the co-production of knowledge not represented in my framework. For example, in my framework I did not explicitly consider joint hypothesis formulation and data collection (Moller *et al.,* 2009b; Chapter 6), or how appropriate institutions are established within which power is shared and adaptive learning can occur (Davidson-Hunt & O'Flaherty, 2007; Robson *et*

al., 2009). Such processes may vary in Australian environmental planning, potentially presenting differing prospects for knowledge integration (Hill *et al*., 2012), and therefore validation exercises. Instead, my framework focuses on the process of collaborative validation of information that has been independently produced within one or other knowledge systems, rather than the enabling institutional environment. It should also be highlighted that knowledge holders in the two systems can independently access and utilise information produced by the other system (Figure 7.2).

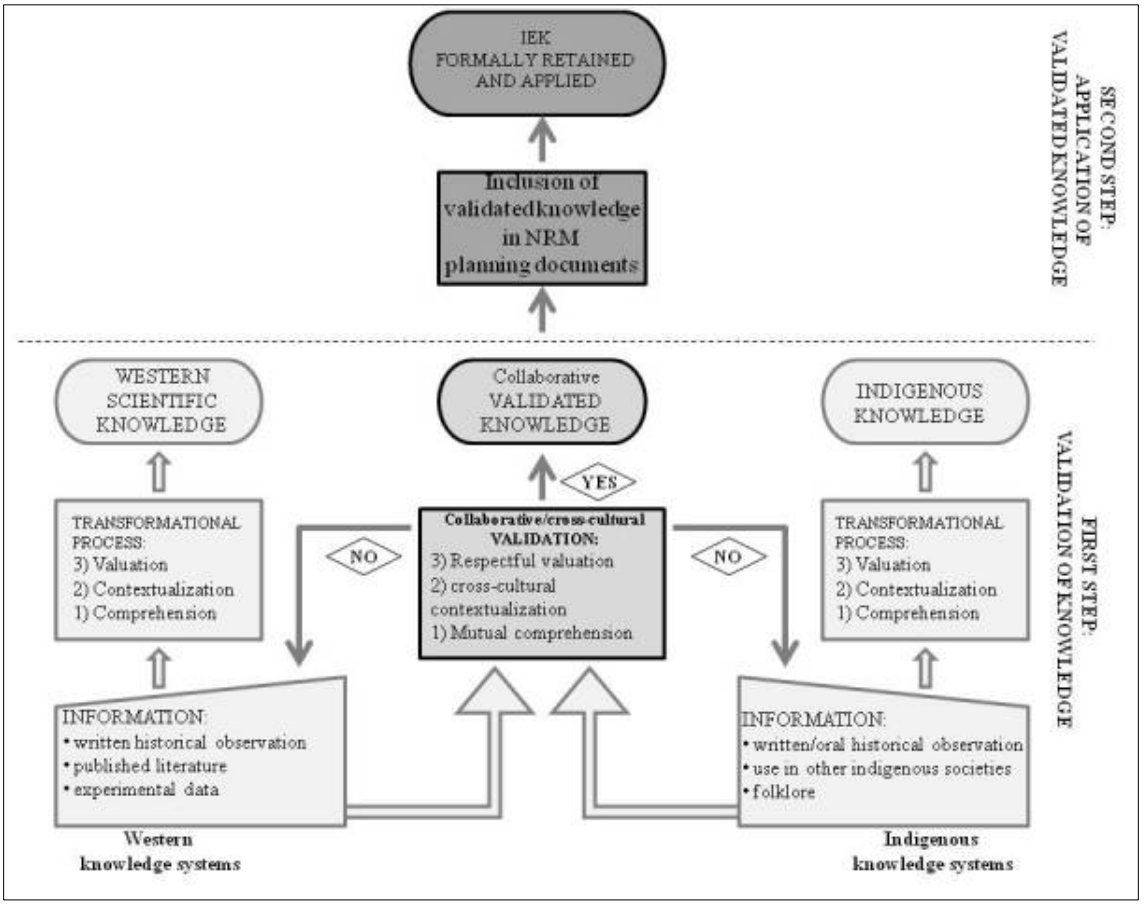


Figure 7.2. A framework for collaborative validation of indigenous ecological knowledge (IK). Here, trapezoid shapes represent "inputs" to processes, squares represent "processes" and rounded shapes represent "outputs". Dashed arrows represent potential independent accessing of information by western and indigenous knowledge systems outside a collaborative validation process.

Implications for the adoption of collaborative validation in natural resource management

Both Berkes and Moller and their colleagues (2000 and 2009, respectively) suggest the integration of SK and IEK should occur at the level of "process" rather than of "content" to avoid the appropriation of information from one knowledge system by another. I support this view and propose that integration can be equitably achieved through adapting the transformational process within knowledge socialisation. The framework I developed and hereby discussed proposes a collaborative, cross-cultural approach to support the mutual validation of knowledge systems and, consequently, knowledge integration through process.

To date the assumption that information from IK systems and worldviews should be tested against SK before being adopted may have presented a major obstacle to their application in NRM. Scientific experimental validation is time consuming, expensive, and may be disrespectful of indigenous cultures when not conducted in a collaborative fashion. In addition, cultural and spiritual components of IK systems are usually disregarded by western knowledge systems (Casimirri, 2003). This is particularly likely if validation is carried out by scientists and/or government agencies unilaterally, with little or no involvement of legitimate holders of IK. In this case the validation of IK weakens IK systems and cultures (Casimirri, 2003; Turnbull, 2009), and is often unsuccessful because without considering the social and spiritual dimension of IK systems it fails to harmonise incompatible worldviews (Casimirri, 2003; Brook & McLachlan, 2005; Aikenhead & Ogawa, 2007). The adoption of the framework I developed by Australian environmental agencies would enable indigenous communities to actively participate in the validation process as an equal partner, and enable them to present their own information without risking disempowerment and disrespect.

From what has been discussed so far, I suggest validation is not an intrinsically disrespectful process. Instead, it can be seen as a fundamental human process of internalising new information within an established knowledge system. This already occurs within indigenous and non-indigenous people and institutions, and I advocate that it should be extended to the integration of IK and SK, rather than being avoided on the grounds that integration may be disrespectful to IK. However, in promoting this approach I am not advocating that IK should always be validated by SK, or vice-versa;

rather, I propose that cross-cultural validation exercises must consider all knowledge domains as equal to achieve an equitable and mutually respectful process. In advocating my framework I am sharing the pragmatic attitude of my indigenous co-researchers, who embraced validation as a way to challenge the current worldview in Australian NRM. However, I am aware that power dynamics implicit in different co-management contexts within which validation and knowledge integration take place will have a major influence on the nature of the process and its outcomes (Newman & Moller 2005; Moller *et al.,* 2009a).

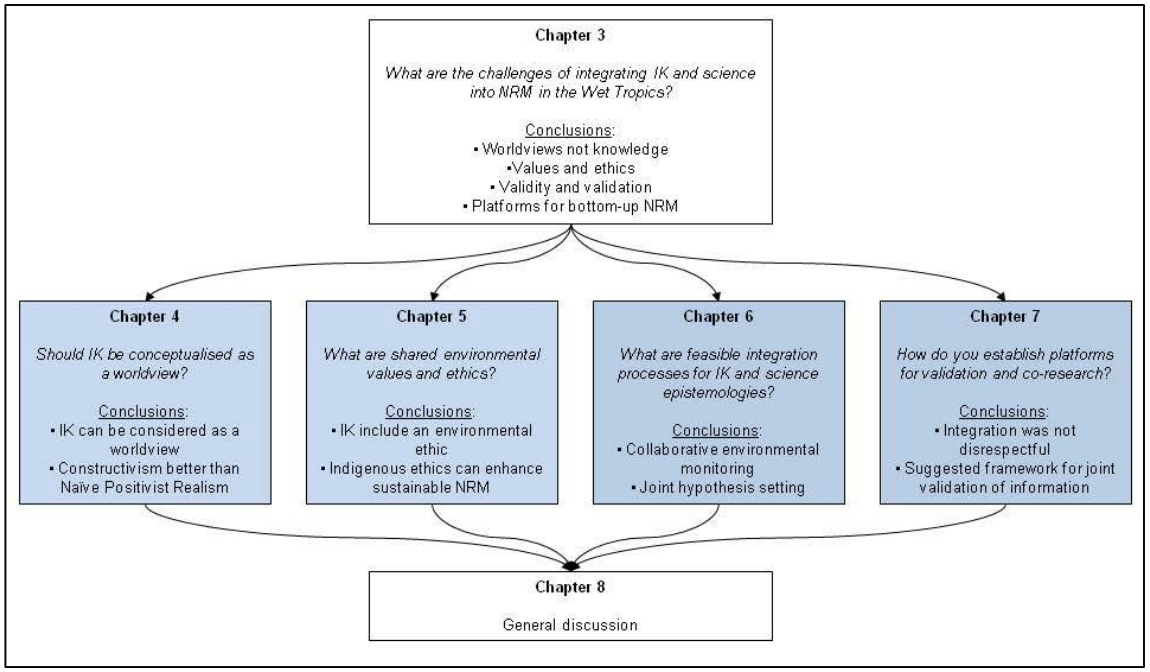
It could be argued that my conclusions are based on biased results because the indigenous knowledge holders initiated the validation process, and therefore were less likely to feel marginalised than in a situation where the initial challenge was made by scientists. This is possible and more empirical evidence and testing of my framework in different contexts is required, particularly where the initiative is taken by parties other than the knowledge holders. To minimise the chance of adverse outcomes I would recommend instead that collaborative validation should only proceed after sufficient trust has been generated through a co-management process, and validation begins after multilateral consensus has been reached.

The integration of IK and SK requires a change of social values if NRM is to accommodate indigenous perspectives and worldviews, and the development of community-based decision making for more effective NRM and resilient social-ecological systems (Casimirri, 2003). In Australia, the "healthy disturbance" necessary for generating diversity of thought and outlook, and hence resilience of social-ecological systems, is also relevant to NRM. In this context IK should be promoted in NRM to challenge the conventional wisdom of SK-based management, and introduce a more holistic paradigm wherein humankind is part of the natural world rather than superior to it (Royal, 2005). The integration of indigenous ecological knowledge and western scientific knowledge is particularly relevant at the local scale, where rapid detection and response to environmental change is required to promote resilience of social-ecological systems. The collaborative validation framework I conceptualised in this chapter represents a tool for environmental agencies to implement such change.

7.4 Chapter summary

In this chapter I have discussed why collaborative validation of information coming from a different knowledge system can support mutual understanding of different stances held by NRM stakeholders, with particular emphasis on indigenous and scientific perspectives. I have also outlined that, when under indigenous control, even the scientific validation of information coming from indigenous worldviews can be useful and respectful, and as a pragmatic way to draw attention and resources to the indigenous agenda.

In the following chapter, my final discussion, I draw together the main results of this thesis and conclude with some recommendations for NRM and future research.



Chapter 8: General discussion

The value of indigenous knowledge (IK) as a source of natural resource management practices is widely acknowledged. There is much evidence of the effectiveness of IK in monitoring complex ecological processes (Chalmers & Fabricius, 2007), in adding knowledge to scientific understanding (Johannes *et al.*, 2000; Moller *et al.,* 2004), and in providing adaptive approaches to the management of complex social-ecological systems (Mazzocchi, 2006). In synthesis, IK can enrich our current approach to NRM, mostly based on domination of ecosystems, a perspective that has often caused the loss of resilience of social-ecological systems (Berkes *et al.*, 2000). Furthermore, IK can support environmental based livelihoods, which represent a potential source of income for indigenous communities, as observed in Australia (Altman, 2004).

The Australian government supports a policy of integration of indigenous and non-indigenous values and knowledge in NRM. Many strategic documents promote this integration, for example *Australia's Biodiversity Conservation Strategy 2010-2030* and the *National Water Initiative*. It is at the local level, however, that environmental managers need to engage with indigenous people and other stakeholders in order to implement integration policies in NRM plans. Central governments, however, do not provide local natural resource managers with a clear path for the integration of indigenous and scientific knowledge in NRM (McDonald *et al.*, 2003). In particular, the lack of clarity of what IK is, if we should integrate knowledge or worldviews, and the perception that IK needs validation against science before inputting in NRM may have limited the potential contributions that indigenous people can make to NRM in Australia. This thesis sought to improve our understanding of how IK is perceived in relation to science in the Wet Tropics, and to identify avenues for their integration.

8.1 Summary of research findings

This thesis tackled the general research question, "How can western science and indigenous knowledge best work together to achieve community adaptation and transformation to sustainability?" I provided justification the question and its relevance to the Wet Tropics in Chapter 1 and in the introductory sections of the data chapters (3-7).

The Wet Tropics is characterised by a high politicisation of indigenous affairs, and by limited literature on the interaction between science and IK in informing NRM. This, coupled with the exploratory inductive nature of my case study and the need to serve the research priorities of the participant community, lead to my framing the research within the grounded theory approaches and, in less measure, with the action research approach. These two philosophies of research have strongly impacted the emergence of my findings, as well as the community involvement.

Following, I summarise the findings of my thesis and further discuss some key themes.

Objective 1

My first objective was to understand how IK and science are perceived in the Wet Tropics, and what hinders or supports their integration, by (a) exploring perceptions of IK and science and their integration held by natural resource management experts from the Wet Tropics (Chapter 3), and (b) tackling some aspects of the problem of integration from a theoretical stand point (Chapter 4). This initial exploration also rooted my thesis in the specific reality of my case study.

I found that, (1) conceptualising integration in terms of "knowledge" and "knowledge systems" was limiting, and suggested approaching integration from the worldview perspective, (2) knowledge validity and validation needed to be addressed to promote acceptance of diversity, (3) platforms for collaboration need to be specifically developed to bring strategic stakeholders together for bottom-up NRM, and (4) values and ethics play a great role in determining stakeholder collaboration in NRM. Chapter 3 adds to the literature on knowledge integration in Australia and provided a timely study on factors that may hinder or support the use of IK in the area.

I used the findings from Chapter 3 to frame the analyses presented in the following data chapters (3-7). In particular, in Chapter 4 I addressed the need to reframe the debate surrounding integration of IK and science in NRM in more holistic terms. Since Chapter 3 suggested looking at IK as a worldview, in Chapter 4 I analysed data from my case study and the literature to produce a model of IK as an eight-dimension worldview. I argued that integration of worldviews should be pursued by attempting to integrate all eight dimensions. While the relationship between concepts of knowledge and worldview has been explored in the literature on cross-cultural NRM, mine is the first study to affirm that indigenous knowledge *is* a worldview, and to relate issues of IK integration to the literature on worldview integration for sustainability. There is a theoretical nature to this chapter, which advocates to look at IK as a worldview, and to therefore reformulate its relationship with science for NRM.

Objective 2

My second objective was to identify avenues to further the integration of IK in the Wet Tropics NRM. Here, I used the results from Chapter 3 to guide my research, hence I focused on:

- Understanding indigenous environmental values and ethics in the area to identify reasons and ways for including them in the local NRM (Chapter 5).
- Exploring the need to better understand indigenous epistemologies as pre-requisite to support their validity and promote their acceptance and also to identify avenues for collaboration with science (Chapter 6);
- Developing platforms for collaboration which specifically bring strategic stakeholders together for bottom-up NRM (Chapter 7);

To address this second objective, I worked in collaboration with a community of traditional owners of the Wet Tropics who were interested in taking part in the project. Their input has entered the process mediated by my own understanding, since my research was conducted from a non-indigenous perspective. To avoid my own bias influencing the project, I regularly presented project results to community members and sought their endorsement before presenting results in official fora.

In Chapter 5 I discussed the importance of developing shared environmental values and ethics for NRM. In Chapter 5 I argue that the values and ethics we as society choose to

serve should be those which ensure sustainability of our social ecological systems. On this ground, I advocate a validation of the environmental values and ethics that guide current NRM in Australia to discard the non-sustainable ones.

In Chapter 6 I discussed some epistemological processes as they are implemented by the participant community's members. The literature on contemporary indigenous epistemologies is very limited, however understanding indigenous epistemologies and how they can be integrated with science is crucial for, (1) increasing confidence in the validity of IK, and (2) ensuring indigenous ways find representation in scientific based NRM. My work shed light on current indigenous epistemologies existing in the Wet Tropics. In Chapter 6 I propose collaborative environmental monitoring and joint hypothesis setting and testing as avenues for integration of the indigenous and scientific epistemologies. My approach of developing a criteria and indicator framework for water quality monitoring in the Wet Tropics is novel, since so far there have been limited attempts to include traditional indicators in water quality monitoring in Australia and in the Wet Tropics.

In Chapter 7 I designed a platform to support knowledge sharing and validation for NRM. My study is the first to bring to light and discuss in positive term the process of "validation". As discussed in Chapter 3, validation of IK in scientific terms is often expected before IK is applied in Wet Tropics NRM. An honest discussion around this theme was missing in the literature, perhaps due to the risk of such argument being politicised. As I argue in Chapter 7, validation is, however, a natural process of the human mind in seeking to understand; hence, it should not be demonised. In fact, collaborative and respectful validation has great potential for supporting mutual understanding and exchange around the natural world, and as such it should be supported. Ultimately, a sustainability validation of entire values sets and worldviews could be undertaken so that more sustainable values, ethics and worldviews are promoted (dan Egmond & de Vries, 2011).

8.2 Integrating indigenous knowledge and science: opportunity, limit and equity of the process

This thesis is based on the assumption that promoting dialogue and/or integration between different stakeholders who hold different types of "knowledges" and worldviews for NRM could promote the indigenous perspective and ultimately result in greater participation of Australian traditional Owners in the management of their traditional estates. This assumption is substantiated by an ever increasing body of evidence to support the stance that collaborative research and NRM empower communities and that there is the need to increase the role of IK in NRM and its dialogue with science. This approach has its limitations, however, and there is need to clarify if this is an equitable process for all parties involved. In the following sections I draw some conclusions based on the case study I conducted, and outline some recommendations for future research on Indigenous knowledge in Australia and in the Wet Tropics.

The opportunity: indigenising NRM?

The worldview held by Indigenous Australians, at the time of contact with the colonists, was different from the colonial one. From the NRM point of view, belief in an interconnectedness with all sentient and non-sentient beings, of belonging to Country, and of a spiritual and material mutual nurturing relationship between people and their land, collided with the colonists' view of the natural world as having been created to the disposal of human beings, who are therefore allowed to "manage" them as "natural resources" and to exploit them. The indigenous worldview was an idealistic worldview; the western colonial, often referred to as the western scientific, worldview was more a materialistic one (Figure 4.1). Associated with these worldviews were eco-centric and anthropocentric or egoistic values and ethics respectively (Van Opstal & Hugé, 2013; Chapter 5).

As I discussed in Chapter 4 and 5, despite cultural erosion due to globalisation, some indigenous communities worldwide still hold idealistic worldviews and eco-centric values and beliefs, as do the Malanbarra and Dulabed Yidinji with whom I collaborated during my PhD. To survive in the post-colonial era, however, many Indigenous Australians are forced to "modernise" and find ways of conciliating their worldview

grounded in an almost religious veneration of Country with the need to exploit its natural resources to extract goods and services in a capitalistic context. To achieve this, many indigenous communities are embracing what they see as the next best option, "sustainable development".

The sustainability discourse offers opportunities for Indigenous Australians' "*Caring for Country*" philosophy implemented and their worldview perpetrated, however a focus on "indigenous knowledge", a term that does not convey many dimensions of what IK is. As it emerged in this thesis, the focus should be on identifying what the indigenous worldview can contribute to the worldview "sustainable development", which has been discussed as the integral worldview we should pursue (Van Opstal & Hugé, 2013).

The worldview that currently dominates globally is deemed unsustainable, embracing science as the only authoritative knowledge system, and unbalanced towards subjective and materialistic individualism, and this is at the root of ecological, financial-economic and social crises, which are causing wars, mass migration and starvation, and climate change related natural disasters (van Egmond and de Vries, 2011). Returning to venerate mother Earth, and implementing an ethic of interconnectedness, where human beings are part of a web of life together with other living and non-living parts of the ecosystems, is a way forward to achieve a more sustainable worldiview (Royal, 2012; Allendorf, 1997). My work with the Malanbarra and Dulabed Yidinji support the claim that indigenous societies can be reservoirs of worldviews that if restored could improve sustainability. Nevertheless, some pre-requisites are needed for integration to happen.

Firstly, worldviews need to become explicit and then consciously compared and improved to produce an integral worldview, since worldviews are usually implicit (Cobern, 1989; Olsen *et al.,* 1992; van Egmond & de Vries, 2011; Vidal, 2008, 2012). Criteria for worldview comparison to inform NRM have not been formulated, but I contend that such criteria should include, (1) the presence, in the worldview, of eco-centric environmental values and ethics; and (2) the presence of peer review processes that ensure epistemology validity that are cross-cultural and inclusive.

Secondly, both dominant and minority societies need to value the distinct perspectives available, and be willing to mutually accommodate their differences to achieve a greater common good: an integrated sustainable society (Berry, 1997). A shift in the way

traditional owners are regarded and an increased understanding of the contribution they can make to NRM is already happening in the Wet Tropics, and consensus has been building for their role in collaborative management of the area (WTMA, 2012). Indeed, in Australia more generally, the indigenous philosophy of "*Looking after Country*" is influencing a revision of the stand-point from which the western scientific tradition has contributed to the commodification of nature (Weir, 2012). Further knowledge on local indigenous worldviews and their content will support this process. My thesis contributed to such process and identified avenues to promote it.

The limits: does integration imply loss of cultural diversity?

The argument could be raised that promoting integration could imply accepting to lose cultural diversity. In Chapters 3 and 4 I outlined that I understand "integration" to be a "process in which the originality and core identity of each individual knowledge system remains valuable in itself and it is not diluted through its combination with other types of knowledge" (Bohensky & Maru, 2011), hence integration is not a process of cultural assimilation. Indeed, integration maintains – rather than erodes – cultural diversity: Berry (1997) explains how a pre-requisite for integration is the value assigned to the different cultural perspectives – in this thesis the worldviews – to be integrated. I claim that interest in integrating IK in NRM would promote the value of the indigenous worldview for NRM, both within traditional communities and outside them, and ultimately incentivize indigenous Australians to value and maintain their cultural distinctiveness, rather than contribute to their assimilation.

How to "integrate" when local governance systems are so different

As discussed in Chapter 3, I could not look extensively at how the governance of the Wet Tropics supports or hinders worldview integrations in NRM due to project time and budget limitations. Governance is, however, a crucial variable in determining the success of IK integration in NRM. Governance is the set of processes, relationships, institutions and structures that a group of people implements to collectively organise themselves to achieve their goals, and it is strictly determined by the decision making power the group is entitled to (Hunt & Smith, 2006). In the Wet Tropics, traditional owners remain disempowered and their governance needs to be strengthened (Hill *et al.*, 2011; Chapter 3). Collaborative research (Cullen-Unsworth *et al*., 2010), indigenous

driven research (Hill *et al*., 2011b), the use of boundary objects to improve the inclusiveness of NRM planning (Robinson), investigations on what represents good internal governance (Maclean *et al*., 2013), the Wet tropics heritage listing for its cultural values (Hill *et al*., 2011a) and the promotion of the biocultural conservation values for the area (Pert *et al.,* 2015) are processes currently being successfully employed to enhance indigenous governance in the area. Indigenous and non-indigenous governance systems in the area remain different, but increasingly new institutions, processes and relationships are built that are collaborative in nature and are proving effective in returning a sense of ownership and NRM tangible benefits to the local traditional owners (Pert *et al*., 2015). There is no easy fix to the problem of indigenous disempowerment across Australia, but collaborative research in the area is proving powerful in helping construing the relationships, processes and institutions empowerment can be built upon.

My thesis did not focus on governance; however some of my findings could contribute to improving Wet Tropics indigenous governance. In particular, indigenous worldview-informed environmental monitoring plans for the area (Chapter 6) and platforms for stakeholders' engagement around IK issues (Chapter 7) are processes I identified that can empower communities in negotiating a better involvement in the local NRM, hence overall improving their governance.

The equity: which knowledge paradigm better supports the validity of different epistemologies?

If mutual and collaborative validation of information, values and worldviews is useful, how can we ensure it stays equitable? In Chapters 3 and 5 I discussed how the epistemological validity of IK should be discussed when exploring opportunities for its use in NRM. Nevertheless, as I argued in Chapter 5, some philosophical perspectives on knowledge creation are more effective than others in building acceptance of different epistemological stances, in supporting the validity of different worldviews and, as a result, in promoting cross-cultural NRM. Constructivism, for example, works better than logic-positivism, which in fact has been discussed as limiting freedom in adaptation and, as a consequence, threatening societies' resilience and sustainability (Jiggins & Roling, 1997; Allison & Hobbs, 2006). Currently, however, environmental management in Australia remains based on a logic-positivist perspective (Weir, 2012),

while the indigenous epistemology is marginalised (Nursey-Bray, 2009).

For indigenous worldviews to be more represented in NRM, science has to change, and become more integrative, interdisciplinary and respectful of indigenous epistemologies (Muller, 2012). Insofar, the whole concept of sustainable development has been framed within a normal positivistic paradigm (Van Opstal and Hugé, 2013), which hinders the contribution indigenous worldviews can make to sustainability (Muller, 2012). For science to become integrative of other disciplines' paradigms, as well as other worldviews, science needs to change the way it is produced, and so the way research is done and "knowledge" is transmitted through education (Klay *et al.,* in press).

As for research, collaborative action research underpinned by a constructivist paradigm has been identified as the type of research needed to achieve sustainability science, also called post-normal science (Jiggins & Roling, 1997; Van Opstal and Hugé, 2013; Klay *et al.,* in press). Action research is research conducted with a positive social change agenda, and so it is research that acknowledge the values it serves (McNiff & Whitehead, 2009). By recognising and embracing such values, science will overcome the split between facts and values that has been identified as the main epistemological barrier on its route to becoming sustainability science (Klay *et al.,* in press).

As for education, to build understanding between indigenous and non-indigenous future natural resources managers, a higher representation of indigenous perspectives in education should be ensured, especially in tertiary education, where it is lacking. One way to achieve so is to host elders and/or indigenous leaders as guest lecturers in science based programs (Kimmerer, 2002). When this has been implemented it has awakened students' interests in cross-cultural NRM (Steve Sutton, pers. comm.). Aboriginal leaders treasure the opportunity to build understanding of their perspectives in tomorrow's environmental managers and researchers: as one of the Aboriginal leaders of the Wet Tropics once told me when discussing teaching the indigenous ways to non-Aboriginal students:

> *"We have a saying that when I die I will lend my spear down and my son will pick it up and carry it. However it could be one of those guys, one of these non-indigenous students that will pick it up, and not my own son. Once we were fighting with spears and shields, now we are fighting with*

brain and education. We have to build the critical mass for our minority to become a majority."

Mainstreaming indigenous worldviews in education would offer a strong path to the survivorship of Indigenous Australian culture.

8.3 Concluding remarks and recommendations for future research

Australian traditional owners generally wish to see more of their knowledge, values and worldview recognised and used in NRM. In my thesis I have explored some theoretical and practical aspects of the problem of integrating IK in NRM, and I have outlined some issues that arise when IK interacts with science, which is perceived as the currently preferred knowledge system to inform NRM.

Throughout my PhD I have been supported by the Malanbarra and Dulabed Yidinji people, who have shared their values and understanding of Country, something for which I am deeply grateful. Through this project I attempted to serve their desire to not just be *consulted about* Country.

I also served the needs of my "own people" to re-learn our connection to the mother Earth. Learning more about the ways of Indigenous Australians' has emerged as an effective strategy to do so.

Based on what I have learned through my collaboration with the Malanbarra and Dulabed Yidinji people I propose the following recommendations for NRM and for future NRM research:

1. Openly adopt an action research approach grounded in a constructivist paradigm.

2. Promote indigenous worldviews holistically and resist emphasising data and information that are part of them.

3. Relate research on indigenous values and ethics to the existing international literature on the psychological determinants of NRM decision making to strengthen the connection between the potential contribution that restoring an indigenous

environmental ethic – where this is eco-centric and sustainable – can make to sustainability.

4. Adopt collaborative validation and indigenous worldview-informed environmental monitoring systems in guiding local NRM.

5. Further investigate the utility of collaborative validation and indigenous worldview-informed environmental monitoring in strengthening indigenous governance in the area.

References

Ackoff, R.L. 1989. From data to wisdom. Presidential address to ISGSR, June 1988. *Journal of Applied Systems Analysis* 16: 3-9.

Adam, M.C. & D. Kneeshaw. 2008. Local level criteria and indicator frameworks: a tool used to assess aboriginal forest ecosystem values. *Forest Ecology and Management* 255(7): 2024-2037.

Aerts, D., L. Apostel, B. De Moor, S. Hellemans, E. Maex, H. Van Belle & J. Van der Veken. 1994. *World Views. From fragmentation to integration. Internet Edition 2007.* Originally published in 1994 by VUB Press, Brussels. Internet edition by Clément Vidal and Alexander RieglerVUB Press, Brussels.

Agrawal, A. 1995. Dismantling the divide between indigenous and scientific knowledge. *Development and Change* 26: 413-439.

Aikenhead, G. S. & M. Ogawa. 2007. Indigenous knowledge and science revisited. *Cultural Studies of Science Education* 2: 539-620.

Allendorf, F. W. 1997. The conservation biologist as Zen student. *Conservation Biology* 11(5): 1045-1046.

Allison, H. & R. Hobbs. 2006. *Science and policy in natural resource management. Understanding system complexity.* Cambridge University Press, Melbourne, Australia.

Altman, J. & K. Jordan. 2008. *Impact of Climate Change on Indigenous Australians: Submission to the Garnaut Climate Change Review.* Centre for Aboriginal Economic Policy Research, Australian National University, Canberra, Australia.

Altman, J. 2004. Indigenous interests and water property rights. *Dialogue* 23: 29-43.

Arendt, H. 1978. *The life of the mind.* Harcourt Brace Jovanovich, New York.

Axsen, J. & K. S. Kurani. 2013. Developing sustainability-oriented vlaues: insights

from households in a trail of plug-in hybrid electric vehicles. *Global Environmental Change* 23: 70-80.

AIATSIS. 2011. *Guidelines for ethical research in Australian Indigenous studies*. Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra, Australia.

Bagalwa, M. & K. Chifundera. 2007. Environmental impact evaluation of the stem bark extract of *Maesa lanceolata* used in Democratic Republic of Congo. *Journal of Ethnopharmacology* 114: 281-284.

Ballard, H. L., M. E. Fernandez-Gimenez & V. E. Sturtevant. 2008. Integration of local ecological knowledge and conventional science: a study of seven community-based forestry organizations in the USA. *Ecology and Society* 13(2):37.

Banerjee, S. B. 2002. Reinventing colonialism: biotechnology, intellectual property rights and the new economics of sustainable development. Paper presented at the *Ninth Biennial Conference of the International Association for the Study of Common Property,* Victoria Falls, Zimbabwe, 17-21 June 2002.

Barber, M. & S. Jackson. 2011. Aboriginal water values and resource development pressures in the Pilbara region of north-west Australia. *Australian Aboriginal Studies* (2): 32-49.

Bartlett, C. Y., K. Pakoa & C. Manua. 2009. Marine reserve phenomenon in the Pacific islands. *Marine Policy* 33(4): 673-678.

Bellinger, G., D. Castro & A. Mills. 2006. Data, Information, Knowledge, and Wisdom. *www. systems-thinking.org/dikw/dikw.htm*

Bentrupperbäumer, J.M., T. J. Day & J.P. Reser. 2006. Uses, meanings and understandings of values in the environmental and protected area arena: a consideration of "World Heritage" values. *Society & Natural Resources* 19(8): 723-741.

Berger, P. L. & T. Luckmann. 1966. *The social construction of reality: a treatise in the sociology of knowledge.* Penguin, Harmondsworth, United Kingdom.

Berkes, F. 2009. Indigenous ways of knowing and the study of environmental change. *Journal of the Royal Society of New Zealand* 39: 151-156.

Berkes, F. 2012. *Sacred ecology*. Third edition. Routledge, Taylor and Francis Group, New York and London.

Berkes, F., J. Colding & C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10: 1251-1262.

Berry, J. W. 1997. Immigration, acculturation, and adaptation. *Applied Psychology: An International Review* 46(1): 5-68.

Bernard, H. R. 2006. *Research methods in anthropology. Qualitative and quantitative approaches.* Altamira Press, Lanham, Maryland, United States.

Beumer, J. P. 1980. Hydrology and fish diversity of a North Queensland tropical stream. *Australian Journal of Ecology* 5: 159-186.

Bickmeyer, U., C. Drechsler, M. Köck & M. Assmann. 2004. Brominated pyrrole alkaloids from marine *Agelas* sponges reduce depolarization induced cellular calcium elevation. *Toxicon* 44: 45-51.

Birks, M. & J. Mills. 2011. *Grounded theory: a practical guide.* SAGE Publications. Thousand Oaks, California, United States.

Bishop, K. A., S. A. Allen, D. A. Pollard & M. G. Cook. 2001. *Ecological studies on the freshwater fishes of the Alligator Rivers Region, Northern Territory: autecology*. Supervising Scientist Report 145. Supervising Scientist, Department of the Environment, Darwin.

Bisong, F., & E. Andrew-Essien. 2010. Indigenous knowledge systems for promoting community conservation education in a Nigerian protected area. *International Journal of Biology* 2(2): 149-157.

Bohensky, E. L. & Y. Maru. 2011. Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on "integration"? *Ecology and Society* 16(4): 6.

Bohensky, E. L., J. R. A. Butler & J. Davies. 2013. Integrating indigenous ecological knowledge and science in natural resource management: perspectives from Australia. *Ecology and Society* 18(3): 20.

Bohnet, I. & C. Kinjun. 2009. Community uses and values of water informing water quality improvement planning: a study from the Great Barrier Reef region, Australia. *Marine and Freshwater Research* 60: 1176-1182.

Boudon, R. 2005. The social science and two types of relativism. *Journal of Classical Sociology* 5: 157-174.

Bowman, D. M. J. S. 1998. Tansley Review No. 101. The impact of Aboriginal landscape burning on the Australian biota. *New Phytologist* 140: 385-410.

Brennan, M. J., D. E. Roth, M. D. Feldman & A. R. Greene. 2003. Square pegs and round holes: application of the "best available scientific data available" standard in the Endangered Species Act. *Tullane Environmental Law Journal* 16: 386-444.

Brook, R. K. & S. M. McLachlan. 2005. On using expert-based science to "test" local ecological knowledge. *Ecology and Society* 10(2): r3.

Brown, V.A., A. J. Harris & J. Y. Russell (Eds.). 2010. *Tackling wicked problems. Through the transdisciplinarity imagination*. Earthscan Ltd., London, United Kingdom.

Burgess, C.P., H. L. Berry, W. Gunthorpe & R. S. Bailie. 2008. Development and preliminary validation of the 'Caring for Country' questionnaire: measurement of an Indigenous Australian health determinant. *International Journal for Equity in Health* 7: 26.

Burgess, C. P., F. H. Johnston, D. M. J. S. Bowman & P. J. Whitehead. 2005. Healthy country: healthy people? Exploring the health benefits of Indigenous natural resource management. *Australian and New Zealand Journal of Public Health* 29(2): 117-122.

Burrows, D. W. 2009. *Distribution of exotic freshwater fishes in the Wet Tropics Region, Northern Queensland, Australia.* Technical Report 09/19, Australian

Centre for Tropical Freshwater Research, James Cook University, Townsville.

Busilacchi, S., G. R. Russ, A. J. Williams, S. G. Sutton & G. A. Begg. 2013. The role of subsistence fishing in the hybrid economy of an indigenous community. *Marine Policy* 37: 183-191.

Butler, J. R. A., A. Tawake, T. Skewes, L. Tawake & V. McGrath. 2012. Integrating traditional ecological knowledge and fisheries management in the Torres Strait, Australia: the catalytic role of turtles and dugong as cultural keystone species. *Ecology and Society* 17(4): 34.

Cadet-James, Y. 2001. Thoughts about research from an indigenous perspective. *Aboriginal and Islander Health Worker Journal* 25: 17-18.

Cairns Regional Council. 2009. *Our water: too good to waste. Water Demand Management Strategy, 2009-2012*. Cairns Regional Council, Cairns, Australia.

Callanan, P.L. 2010. Intrinsic Value for the Environmental Pragmatist. *Res Cogitans* 1(1): 132-142 (Article 17).

Canonico, G. C., A. Arthington, J. K. McCrary & M. L. Thieme. 2005. The effects of introduced tilapias on native biodiversity. *Aquatic Conservation: Marine and Freshwater Ecosystems* 15: 463-483.

Carter, J. & G. J. E. Hill. 2007. Critiquing environmental management in indigenous Australia: two case studies. *Area* 39: 43-54.

Casimirri, G. 2003. Problems with integrating traditional ecological knowledge into contemporary resource management. Paper presented at the *XII World Forestry Congress*, Québec City, Canada.

Castillo, A. R. 2009. The Whizz of Electrons and the Wisdom of Elders: Linking Traditional Knowledge and Western Science. Guest article in: *Traditional Knowledge Bulletin.* United Nations University Institute for the Advanced Study of Sustainability (http://www.unutki.org/news.php?news_id=178&doc_id=39)

Chalmers, A. F. 1976. *What is this thing called science?* Hackett Publishing Company Inc. Cambridge, UK.

References

Chalmers, N., & C. Fabricius. 2007. Expert and generalist local knowledge about land-cover change on South Africa's Wild Coast: can local ecological knowledge add value to science? *Ecology and Society* 12(1): 10.

Charmaz, K. 2008 *Developing grounded theory: The second generation*. Left Coast Press Inc.

Chartres, C. & J. Williams. 2006. Can Australia overcome its water scarcity problems? *Journal of Development in Sustainable Agriculture* 1: 17-24.

Choo, J., E. L. Zent & B. B. Simpson. 2009. The Importance of Traditional Ecological Knowledge for Palmweevil Cultivation in the Venezuelan Amazon. *Journal of Ethnobiology* 29(1): 113-128.

Clark, C. F., M. J. Kotchenb & M. R. Moorea. 2003. Internal and external influences on pro-environmental behavior: Participation in a green electricity program. *Journal of Environmental Psychology* 23: 237-246.

Cobern, W. W. 1989. *Worldview Theory and Science Education Research: Fundamental Epistemological Structure as a Critical Factor in Science Learning and Attitude Development.* Scientific Literacy and Cultural Studies Project, Paper 5. National Association for Research in Science Teaching, San Francisco, United States.

Cobern, W. W. 1991. *World View Theory and Science Education Research.* Scientific Literacy and Cultural Studies Project, Paper 44. National Association for Research in Science Teaching, San Francisco, United States.

Cobern, W. W. 1993. *World view, metaphysics and epistemology*. Paper presented to the annual meeting of the National Association for Research in Science Teaching. Scientific Literacy and Cultural Studies Project, Working Paper No. 106. National Association for Research in Science Training, San Francisco, United States.

Cork, S. 2009. Resilience of ecosystems and social-ecological systems. In: S. Cork (Ed.). *Brighter prospects: enhancing the resilience of Australia: technical report.* Australia 21 Organising Group, Canberra, Australia.

Crawford, S. 2009. Matauranga Maori and Western science: the importance of hypotheses, predictions and protocols. *Journal of the Royal Society of New Zealand* 39:163-166.

Crawford, S., C. A. Wehkamp & N. Smith. 2010. *Translation of Indigenous/Western science perspectives on adaptive management for environmental assessments*. Report prepared for the Research and Development Monograph Series. Canadian Environmental Assessment Agency.

Cullen, L. C., J. R. A. Butler, R. Hill & C. R. Margules. 2008. Framework for the identification of linked cultural and biophysical indicators for the Wet Tropics World Heritage Area. *The International Journal of Environmental, Cultural, Economic and Social Sustainability* 4: 37-45.

Cullen-Unsworth, L. C., J. R. A. Butler, R. Hill & M. Wallace. 2010. Cooperative research: an example from the Wet Tropics of Queensland. *The International Journal of Interdisciplinary Social Sciences* 5: 139-154.

Darnault, C.J.G. 2008. Sustainable development and integrated management of water resources. In: C.J.G. Darnault (Ed.) *Overexploitation and contamination of shared Groundwater resources.* Spinger, New York, United States.

DASETT. 1986. Nomination of Wet Tropical Rainforests of North-East Australia by the Government of Australia for inclusion in the World Heritage List. Department of Arts, Sports, the Environment, Tourism and Territories, Australian Government.

Davidson-Hunt, I. J. & R. M. O'Flaherty. 2007. Researchers, indigenous peoples, and place-based learning communities. *Society & Natural Resources* 20: 291-305.

Davies, J. 2003. Contemporary geographies of indigenous rights and interests in rural Australia. *Australian Geographer* 34(1): 19-45.

Davies, J., R. Hill, F. J. Walsh, M. Sandford, D. Smyth & M. C. Holmes. 2013 Innovation in management plans for community conserved areas: experiences from Australian indigenous protected areas. *Ecology and Society* 18(2): 14.

Davis, J. E. 2008. Culture and relativism. *Society* 45: 270-276.

Delisle, A. 2008. *Understanding the links between wild resources and Aboriginal well-being in the Wet Tropics: results from a pilot study.* Thesis submitted in April 2008 in fulfilment of the degree of Master of Economics by Coursework, School of Business, James Cook University, Townsville.

Denzin, N. K., Y. S. Lincoln & L. T. Smith (Eds.) 2008. *Critical and indigenous methodologies.* SAGE, Thousand Oaks, California, United States.

Dickison, M. 2009. The asymmetry between science and traditional knowledge. *Journal of the Royal Society of New Zealand* 39: 171-172.

Diemers, D. 1999. On the social dimension of information quality and knowledge. In: Y. W. Lee & G. K. Tayi (Eds.) *Proceedings of the 1999 MIT Conference on Information Quality.* MIT Press, Cambridge, Massachusetts, United States.

Dietz, T., A. Fitzgerald & R. Shwom. 2005. Environmental values. *Annual Review of Environment and Resources* 30: 335-372.

Douterlungne, D., S. I. Levy-Tacher, D. J. Golicher & F. R. Danobeytia. 2010. Applying indigenous knowledge to the restoration of degraded tropical rainforest clearings dominated by braken fern. *Restoration Ecology* 18: 322-329.

DPC. 2009. *Reef Water Quality Protection Plan 2009. For the Great Barrier Reef World Heritage Area and adjacent catchments.* Report prepared for the Queensland Department of the Premier and Cabinet. Reef Water Quality Protection Secretariat, Brisbane, Australia.

Drahos, P. 2000. Indigenous knowledge, intellectual property and biopiracy: is a global biocollection society the answer. *European Intellectual Property Review* 22(6): 245-250.

Edwards, S. E. & M. Heinrich. 2006. Readressing cultural erosion and ecological decline in far North Queensland Aboriginal commmunityu (Australia): the Aurutjun ethnobioology database project. *Environment, Development and Sustainability* 8: 569-583.

Elkin, A. P. 1974. *The Australian Aborigines*. Angus and Robertson, Sydney, Australia.

Elkin, A. P. 1977. *Aboriginal men of high degree. Initiation and sorcery in the World's oldest tradition.* Inner Traditions, Rochester, Vermount.

Ens, E. J., P. Pert, P. A. Clarke, M. Budden, L. Clubb, B. Doran, C. Douras, J. Gaikwad, B. Gott, S. Leonard, J. Locke, J. Packer, G. Turpin & S. Wason. 2015. Indigenous biocultural knowelde in ecosystem science and management: review and insight from Australia. *Biological Conservation* 181: 133-149.

Ens, E. J., M. Finlayson, K. Preuss, S. Jackson & S. Holcombe. 2012a. Australian approaches for managing 'country' using indigenous and non-indigenous knoweldge. *Ecological Management and Restoration* 13(1): 100-107.

Ens, E. J., G. M. Towler, C. Daniels, the Yugul Mangi Rangers and the Manwurrk Rangers. 2012b. Looking back to move forward: collaborative ecological monitoring in remote Arnhem Land. *Ecological Management and Restoration* 13(1): 26-35.

Ewing, S. A., R. G. Grayson & R. M. Argent. 2000. Science, citizens, and catchments: decision support for catchment planning in Australia. *Society and Natural Resources* 13(5): 443-459.

Fereday, J. & E. Muir-Cochrane. 2006. Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods* 5(1): 79-92.

Foale, S. J. & M. A. Macintyre. 2005. Green Fantasies: Photographic representations of biodiversity and ecotourism in the Western Pacific. *Journal of Political Ecology* 13: 1-22.

Foale, S., F. Cohen, S. Januchowski-Hartley, A. Wenger & M. Macintyre. 2011. Tenures and taboos: origins and implication for fisheries in the Pacific region. *Fish and Fisheries* 12: 357-369.

Foley, G. & T. Anderson. 2006. Land rights and Aboriginal voices. *Australian Journal of Human Rights* 12(1): 83-108.

Folke, C., F. Berkes & J. Colding. 1998. Ecological practices and social mechanisms for

bulding resilience and sustainability. In: F. Berkes & C. Folke (Eds.). *Linking social and ecological systems: management practices and social mechanisms for building resilience.* Cambridge University Press, Cambridge, United Kingdom.

FNQ NRM Ltd. & Rainforest CRC. 2004. *Sustaining the Wet Tropics: A Regional Plan for Natural Resource Management 2004-2008.* FNQ NRM Ltd., Innisfail, Australia.

Garcia, C.A. & G. Lescuyer. 2008. Monitoring, indicators and community based forest management in the tropics: pretexts or red herrings? *Biodiversity and Conservation* 17(6): 1303-1317.

Garling, T., S. Fujiib, A. Garling & C. Jakobsson. 2003. Moderating effects of social value orientation on determinants of proenvironmental behavior intention. *Journal of Environmental Psychology* 23: 1-9.

German, L., J. J. Ramish & R. Verna (Eds.). 2010. *Beyond the biophysical. Knowledge, culture and powet in agriculture and natural resource management.* Springer, London, United Kingdom.

Gilchrist, G. & M. L. Mallory. 2007. Comparing expert-based science with local ecological knowledge: what are we afraid of? *Ecology and Society* 12(1): r1.

Gilchrist, G., M. Mallory & F. Merkel. 2005. Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. *Ecology and Society* 10(1): 20.

Glaser, B. G. & A. Strauss. 1967. *The discovery of grounded theory: strategies for qualitative research.* Aldine Publishing, Chicago, United States.

Goode, B., C. Irvine & G.Iguana (2003) *South West Yarragadee – Blackwood Groundwater Area. Aboriginal Cultural Values Survey.* A report prepared for the Department of Environmental Protection. Water & Rivers Commission.

Gough, I. 2004. Human well-being and social structures: relating the universal and the local. *Global Social Policy* 4(3): 289-311.

Grice, A.C., J. Cassady & D. M.Nicholas. 2012. Indigenous and non-Indigenous

knowledge and values combine to support management of Nywaigi lands in the Queensland coastal tropics. *Ecological Management and Restoration* 13(1): 93-97.

Johnson, T. H. 2007. Culture relativism: interpretations of a concept. *Anthropological Quartetly* 80(3): 791-802.

Halliday, I., J. Ley, A. Tobin, G. N. Garrett, N. Gribble & D. Mayer. 2001. *The effect of net fishing: addressing biodiversity and bycatch issues in Queensland inshore waters.* Queensland Department of Primary Industries, Southern Fisheries Centre, Deception Bay.

Hamlyn-Harris, R. & F. Smith. 1916. On fish poisoning and poisons employed among the Aborigines of Queensland. *Memoirs of the Queensland Museum* 5: 1-27.

Hawke, S.M. 2012. Water literacy: An other wise, active and cross-cultural approach to pedagogy, sustainability and human rights. *Continuum* 26(2): 235-247.

Heaslip, R. 2008. Monitoring salmon aquaculture waste: The contribution of First Nations' rights, knowledge, and practices in British Columbia, Canada. *Marine Policy* 32(6): 988-996.

Hikuroa, D., T. K. K. Morgan, D. Gravley & M. Henare. 2010. Integrating indigenous values in geothermal development. In: J. S. Te Rito & S. M. Healy (Eds.) Proceedings of the 4th International Traditional Knowledge Conference. *Kei muri i te awe kāpara, he tangata kē: Recognising, engaging, understanding difference.* 6-9 June 2010, Ngā Pae o te Māramatanga, New Zealand's Maori Centre of Research Excellence, Auckland, New Zealand.

Hill, R., A. Baird & D. Buchanan. 1999. Aborigines and fire in the Wet Tropics of Queensland, Australia: ecosystem management across cultures. *Society & Natural Resources* 12(3): 205-223.

Hill, R., C. Grant, M. George, C. Robinson, S. Jackson & N. Abel. 2012. A typology of indigenous engagement in Australian environmental management: implications for knowledge integration and social ecological system sustainability. *Ecology and Society* 17(1): 23.

Hill, R., L. C. Cullen-Unsworth, L. D.Talbot & S. McIntyre-Tamwoy. 2011a. Empowering indigenous peoples' biocultural diversity through World Heritage cultural landscapes: a case study from the Australian humid tropical forests. *International Journal of Heritage Studies* 17(6): 571-591.

Hill, R., G. Turpin, G., W. Canendo, P. Standley, D. Crayn, S. Warne, K. Keith, E. Addicott, & F. Zich. 2011b. Indigenous-driven tropical Ethnobotany. *Australasian Plant Conservation* 19: 7-8.

Horsfall, N. 1984. The Prehistoric occupation of Australian rainforests. In: Werren, G.L. & A.P. Kershaw (Eds.) Australian Rainforest Study. *Proceedings of a workshop on The Past, Present and Future of Australian Rainforests.* Griffith University, Brisbane, Australia.

Houde, N. 2007. The six faces of traditional ecological knowledge: challenges and opportunities for Canadian co-management arrangements. *Ecology and Society* 12(2): 34.

Hunt, J. & D. Smith. 2006. *Building Indigenous Community Governance in Australia. Preliminary research findings*. CAEPR Working Paper No. 31. The Australian National University, Canberra, Australia.

Huntington, H. P. 2000. Using traditional ecological knowledge in science: methods and applications. *Ecological Applications* 10: 1270-1274.

Ibrahim, B., B. M'batchi, H. Mounzeo, H. P. B. Bourobou & P. Posso. 2000. Effect of *Tephrosia vogelii* and *Justicia extensa* on *Tilapia nilotica* in vivo. *Journal of Ethnopharmacology* 69: 99-104.

Inglis, J. 1880. *Our Australian Cousins*. Macmillan and Co., London, United Kingdom.

Ingold, T. 1993. Globes and spheres: the topology of environmentalism. In: K. Milton (Ed.). *Environmentalism: the view from anthropology.* Routledge, London.

IUCN. 1988. *World Heritage Nomination – IUCN Summary: Wet Tropical Rainforests (North-East Australia)*. International Union Conservation Nature.

Irzik, G. & R. Nola. 2009. Worldviews and their relation to science. *Science and Education* 18(6-7): 129-745.

Jackson, S. 2005. Indigenous values and water resource management: a case study from the Northern Territory. *Australasian Journal of Environmental Management* 12: 136-146.

Jackson, S. 2006. Compartmentalising culture: the articulation and consideration of Indigenous values in water resource management. *Australian Geographer* 37(1): 19-31.

Jackson, S., M. Finn & P. Featherston. 2012. Aquatic resource use by Indigenous Australians in two tropics river catchments: the Fitzroy River and Daly River. *Human Ecology* 40(6): 893-908.

Jackson, S., M. Storrs & J. Morrison. 2005. Recognition of Aboriginal rights, interests and values in river research and management: Perspectives from northern Australia. *Ecological Management and Restoration* 6(2): 105-110.

Jackson, S., N. Stoeckl, A. Straton & O. Stanley. 2008. The changing value of Australian tropical rivers. *Geographical Research* 46(3): 275-290.

Jiggins, J., N. Roling, C. Albaladejo & F. Casabianca. 1997. Action research in natural resource management. Marginal in the first paradigm, core in the second. *Etudes et Recherchés sur les Systemes Agraires et le Developpement* 30: 151-167.

Johannes, R. E., M. M. R. Freeman & R. J. Hamilton. 2000. Ignore fishers' knowledge and miss the boat. *Fish and Fisheries* 1:257-271.

Johnston, F.H., S. P. Jacups, A. J. Vickery & D. Bowman. 2007. Ecohealth and Aboriginal testimony of the nexus between human health and place. *Ecohealth* 4(4): 489-499.

Kalita, B., A. Dutta & M. Choundhurt. 2007. Herbal fish toxicant used by fishers of Karbi-Anglong district, Assam. *Indian Journal of Traditional Knowledge* 6: 334-336.

Keane, M. 2008. Science education and worldview. *Cultural Studies of Science*

Education 3(3): 587-613.

Kearney, M. 1984. *World view*. Chandler & Sharp Publishers, Novato, CA, USA.

Kelbessa, W. 2005. The rehabilitation of indigenous environmental ethics in Africa. *Diogenes* 52(3): 17-34.

Kendall, C.N. & S. Meddin. 2004. Accessoring aboriginality: heritage piracy and the failure of intellectual property regimes to safeguard indigenous culture. *Bond Law Review* 16(1): 166-185.

Kemmis, S. & R. McTaggart. 2000. Participatory action reseasch. In: Denzin, N. & Y. Lincoln (Eds.). *Handbook of qualitative reseach*. SAGE publications, London, United Kingdom.

Kimmerer, R. W. 2002. Weaving Traditional Ecological Knowledge into biological education: a call to action. *Bioscience* 52(5): 432-438.

Klay, A., A. B. Zimmermann & F. Schneider. In press. Rethinking science for sustrainable development: reflecive interaction for a paradigm transformation. *Futures.*

Kopnina, H. 2012. Re-examining culture/conservation conflict: the view of anthropology of conservation through the lens of environmental ethics. *Journal of Integrative Environmental Sciences* 9(1): 9-25.

Kuhn, T. S. 1970. *The structure of scientific revolutions*. The University of Chicago Press, Chicago, USA.

Kumar, S. & Kumar, S. (2002). *Methods for community participation: a complete guide for practitioners.* ITDG Publishing, London, UK.

Lane-West, B. 1991. *Vision Malanbarra*. Report prepared for the Malanbarra Tribal Aboriginal Corporation, Cairns, Australia.

Langton, M. 1994. Aboriginal art and film: The politics of representation. *Race and Class* 35: 98-104.

Langton, M. 2011. Anthropology, politics and the changing world of aboriginal

Australians. *Anthropological Forum* 21(1): 1-22.

Lans, C., K. Georges & G. Brown. 2007. Non experimental validation of ethno veterinary plants and indigenous knowledge used for backyard pigs and chickens in Trinidad and Tobago. *Tropical Animal Health Production* 39: 375-385.

Larrakia, H. C. 2008. *Larrakia Values of Darwin Harbour.* A report on the cultural values and Larrakia perspective of the waters of Darwin Harbour and its Catchment. Larrakia Harbour Committee. Department of Natural Resources, Environment and the Arts, Northern Territory Government.

Lee Long, D. 1992. *An assessment of the research needs and important areas of rainforest Aboriginal groups and organisation*. Report prepared for the Wet Tropics Management Authority (WTMA) and the Aboriginal and Torres Strait Islander Commission (ATSIC).

Leonard, S., M. Parsons, K. Olawsky & F. Kofod. 2013. The role of culture and traditional knowledge in climate change adaptation: insights from East Kimberley, Australia. *Global Environmental Change* 23: 623-632.

Leopold, A. 1966. *Sand Country Almanac: With Essays on Conservation from Round River*. Ballantine Books, New York.

Lewis, S. E. & J. E. Brodie. 2011. *A water quality issues analysis for the Johnstone River basin.* Report No. 11/05 for Terrain NRM. Australian Centre for Tropical Freshwater Research, James Cook University, Townsville.

Lewis, A. E., M. O. Hamiviill, M. Power, D. W. Doidge & V. Lesage. 2009. Movement and Aggregation of Eastern Hudson Bay Beluga Whales (*Delphinapterus leucas*): A Comparison of Patterns Found through Satellite Telemetry and Nunavik Traditional Ecological Knowledge. *Arctic* 62(1): 13-24.

Ling, N. 2002. *Rotenone: a review of its toxicity and use for fisheries management.* Science for Conservation 211. Department of Conservation, Wellington, New Zealand.

Lintermans, M. 2004. Human-assisted dispersal of alien freshwater fish in Australia.

New Zealand Journal of Marine and Freshwater Research 38: 481-501.

Luitgards-Moura, J. F., E. G. C. Bermudez, A. F. Rocha, P. Tsouris & M. G. Rosa-Freitas. 2002. Preliminary assays indicate that *Antonia ovate* (Loganiaceae) and *Derris amazonica* (Papilionaceae), ichthyotoxic plants used for fishing in Roraima, Brazil, have an insecticide effect on *Lutzomyia longipalpis* (Diptera : Psychodidae : Phlebotominae). *Memórias do Instituto Oswaldo Cruz* 97: 737-742.

Lyver P. O'B, C. Jones & H. Moller. 2009. Looking past the wallpaper: considerate evaluation of traditional environmental knowledge by science. *Journal of the Royal Society of New Zealand* 39: 219-223.

Maclean, K. & Bana Yaralji Bubu Inc. 2011a. *Water dreaming: Kuku Nyungkal people, water and country in the Wet Tropics.* CSIRO Ecosystem Sciences, Queensland.

Maclean, K. & C. Robinson. 2011b. *Aboriginal knowledge partnership for water planning and assessment in the Wet Tropics region*. CSIRO Ecosystem Sciences, Queensland.

Maclean, K., H. Ross, M. Cuthill & P. Rist, P. 2013. Healthy country, healthy people: an Australian Aboriginal organisation's adaptive governance to enhance its social-ecological system. *Geoforum* 45: 94-105.

Maffi, L. & E. Woodley. 2010. *Biocultural diversity conservation: a global sourcebook*. Earthscan, London, United Kingdom.

Marika R., Y. Yunupingu, R. Marika-Mununggiritj & S. Muller. 2009. Leaching the poison – the importance of process and partnership in working with Yolngu. *Journal of Rural Studies* 25(4): 404-413.

Mazzocchi, F. 2006. Western science and traditional knowledge. Despite their variations, different forms of knowledge can learn from each other. *EMBO reports* 7(5): 463-466.

Mazzocchi, F. 2008. Analysing knowledge as a part of a cultural framework: the case of traditional ecological knowledge. *Environments* 36: 39-57.

Mcalpine, C. A., S. Heyenga, B. Taylor, A. Peterson & G. McDonald. 2007. Regional

planning in Queensland's rangelands: challenges and prospects for biodiversity conservation. *Geographical Research* 45(1): 27-42.

McDonald, G., N. Weston & B. Dorrington. 2003. The potential contribution of the Queensland Wet Tropics Region Natural Resource Plan to river improvement and water quality. *Water Science & Technology* 48(7): 25-34.

McDonald, G., B. Taylor & C. Robinson (Eds.) 2005. *Findings from a review of regional NRM plans.* Healthy Savanna Planning Systems, Project 3.3.5, Tropical Savannas Cooperative Research Centre, Australia.

McKillop, C. 2011. Interview with Andrew McLean: Rural News and Information for North and Far North Queensland, Wednesday, November 16, 2011, Cairns. Retrieved from ABC Website on 18 January 2012.

McNiff, J. & J. Whitehead. 2009. *Doing and writing action research.* SAGE publications, London, United Kingdom.

McRae, H., G. Nettheim & L. Beacroft. 1997. *Indigenous Legal Issues: Commentary and Materials* (2nd Ed.). Sydney: LBC Information Services.

Mercer, D., L. Christesen & M. Buxton. 2005. Squandering the future-climate change, policy failure and the water crisis in Australia. *Futures* 39(2-3): 272-287.

Mercer, J., I. Kelman, L. Taranis & S. Suchet-Pearson. 2010. Framework for integrating indigenous and scientific knowledge for disaster risk reduction. *Disasters* 34: 214-239.

Merchant, C. 1992. *Radical ecology. The search for a livable world. Revolutionary thought, radical movements.* Routledge, New York, London.

Michell, H. 2005. Nehithewak of Reindeer Lake, Canada: worldview, epistemology and relationships with the natural world. *Australian Journal of Indigenous Education* 34: 33-43.

MLCG. 2010. Mulgrave Landcare & Catchment Group Inc. submission to Commonwealth Department of the Environment, Water, Heritage and the Arts concerning Assessment of Mulgrave Aquifer Feasibility Study.

Moller, H., F. Berkes, P. O. B. Lyver, & M. Kislalioglu. 2004. Combining science and traditional ecological knowledge: monitoring populations for co-management. *Ecology and Society* 9(3): 2.

Moller, H., K. Charleton, B. Knight & P. Lyver. 2009a. Traditional Ecological Knowledge and scientific inference of prey availability: Harvests of sooty shearwater (*Puffinus griseus*) chicks by Rakiura Maori. *New Zealand Journal of Zoology* 36: 259-274.

Moller, H., J. C. Kitson & T. M. Downs. 2009b. Knowing by doing: learning for sustainable muttonbird harvesting. *New Zealand Journal of Zoology* 36: 243-258.

Moller, H., P. O'Blyver, C. Bragg, J. Newman, R. Clucas, D. Fletcher, J. Kitson, S. McKechnie, D. Scott & Rakiura Titi Islands Administering Body. 2009c. Guidelines for cross-cultural participatory action research partnerships: a case study of a customary seabird harvest in New Zealand. *New Zealand Journal of Zoology* 36: 211-241.

Morgan, M., L. Strelein & J. Weir. 2004. Indigenous water rights within the Murray Darling Basin. *Indigenous Law Bullettin* 5(26): 17-20.

Muller, L. 2014. *A theory for indigenous Australian health and human service work: connecting indigenous knowledge and practice.* Allen & Unwin, Sydney, Australia.

Muller, S. 2008. Indigenous payment for environmental service (PES) opportunities in the Northern Territory: negotiating with customs. *Australian Geographer* 39(2): 149-170.

Muller, S. 2012. "Two-ways": bringing indigenous and non-indigenous knowledges together. In: Weir J. K. (Ed.) *Country, Native Title and Ecology.* Australian National University E Press, Canberra, Australia.

Nadasdy, P. 1999. The politics of TEK: power and the "integration" of knowledge. *Arctic Anthropology* 36: 1-18.

Nakashima, D. & M. Roué. 2002. Indigenous knowledge, peoples and sustainable

practice. In: T. Munn (Ed.). *Encyclopedia of global environmental change.* John Wiley & Sons, Chichester, United Kingdom.

Nelson, M. 2005. Paradigm shifts in Aboriginal cultures? Understanding TEK in historical and cultural context. *Canadian Journal of Native Studies* 25: 289-310.

Neuwinger, H. D. 2004. Plants used for poison fishing in tropical Africa. *Toxicon* 44: 417-430.

Newman, J. & H. Moller. 2005. Use of Matauranga (Maori Traditional Knowledge) and science to guide seabird harvest: getting the best of both worlds? In: Kishigami, N. & J. M. Savelle (Eds.) *Indigenous use and management of marine resources.* Senri Ethnological Studies 67, National Museum of Ethnology, Osaka, Japan.

NHMRC. 2003. *Values and Ethics: guidelines for ethical conduct in Aboriginal and Torres Strait Islander health research.* National Health and Medical Research Council, Australian Government.

Nordas, R. & N. P. Gleditsch. 2007. Climate change and conflict. *Political Geography* 26(6): 627-638.

Nungabana, G. D. 1996. *The Mullunburra, people of the Mulgrave River.* Cassowary Publications, Queensland, Australia.

Nursey-Bray, M. 2009. A Guugu Yimmithir bam wii: ngawiya and girrbithi: hunting, planning and management along the Great Barrier Reef, Australia. *Geoforum* 40: 442-453.

O'Dea, K., 1991. Traditional diet and food preferences of Australian Aboriginal hunter-gatherers. *Philosophical Transactions of the Royal Society of London* 334: 233-241.

Olsen, M. E., D. Lodwick & R. E. Dunlap. 1992. Theoretical Framework. In: M. E. Olsen, D. G. Lodwick and R. E. Dunlap (Eds.). *Viewing the World Ecologically.* Westview Press, Boulder, Colorado, United States.

Orr, D. W. & S. Hill. 1978. Leviathan, the open society and the crisis of ecology. *The Western Political Quarterly* 31(4): 457-469.

Ostrom, E. 1999. Coping with the tragedies of the commons. *Annual Review of Political Science* 2: 493-535.

Ovenden, J. (Ed.). 1998. *Tilapia. Options for biological control.* Conference and Workshop Series QC98004 Fisheries. Department of Primary Industries, Queensland, Australia.

Paton, S., A. Curtis, G. McDonald & M. Woods. 2004. Regional natural resource management: is it sustainable. *Australasian Journal of Environmental Management* 11: 259-267.

Pearson, N. 1998. Co-existence, negotiation and certainty: our common future. Paper presented to *Talking Common Ground Conference – Rural Landholders for Co-existence.* 1-2 August 1998, Charters Towers, Australia.

Peterson, A., C. A. McAlpine, D. Ward & S. Rayner. 2007. New regionalism and nature conservation: lessons from South East Queensland, Australia. *Landscape and Urban Planning* 82: 132-144.

Pierotti, R. & D. Wildcat. 2000. Traditional ecological knowledge: the third alternative (commentary). *Ecological Applications* 10(5): 1333-1340.

Popper, K. R. 1959. *The logic of scientific discovery.* Hutchinson, London, UK.

Pottier, J. 2003. Negotiating local knowledge: an introduction. In: Pottier, J., A. Bicker & P. Sillitoe (Eds.) *Negotiating local knowledge: power and identity in development.* Pluto Press, London.

Prasad, A. 2007. Cultural relativism in human rights discourse. *Peace Review: A Journal of Social Justice* 19(4): 589-596.

Pretty, J., B. Adams, F. Berkes, S. Ferreira de Athayde, N. Dudley, E. Hunn, L. Maffi, K. Milton, D. Rapport, P. Robbins, E. Sterling, S. Stolton, A. Tsing, E. Vintinner & S. Pilgrim. 2009. The intersection of biological and cultural diversity: towards integration. *Conservation and Society* 7(2): 100-112.

Prober, S. M., M. H. O'Connor & F. J. Walsh. 2011. Australian Aboriginal peoples' seasonal knowledge: a potential basis for shared understanding in environmental

management. *Ecology and Society* 16(2): 12.

Proctor, J. D. 1998. The social construction of nature: relativist accusation, pragmatist and critical realist responses. *Annals of the Association of American Geographers* 88(3): 352-376.

Purcell, T. & E.A. Onjoro. 2002. Indigenous knowledge, power and parity. In: P. Sillitoe, A. Bicker & J. Pottier (Eds.) *Participating in development: approaches to indigenous knowledge.* Routledge, New York.

Pusey, B. J., A. H. Arthington & M. G. Read. 1995a. Species richness and spatial variation in fish assemblage structure in two rivers of the Wet Tropics of northern Queensland, Australia. *Environmental Biology of Fishes* 42(2): 181-199.

Pusey, B. J., A. H. Arthington & M. G. Read. 1995b. The feeding ecology of freshwater fishes in two rivers of the Australian wet tropics. *Environmental Biology of Fishes* 43: 85-103.

Pusey, B. J. & M. J. Kennard. 1996. Species richness and geographical variation in assemblage structure of the freshwater fish fauna of the Wet Tropics region of northern Queensland. *Marine and Freshwater Research* 47(3): 563-573.

QFS. 2001. *Control of exotic pest fishes. An operational strategy for Queensland freshwaters 2000-2005.* QI01005. Queensland Fisheries Services, Department of Primary Industries, Brisbane, Australia.

Ramanujam, S. N. & B. K. Ratha. 1980. Studies on piscicidal plants of North-Eastern India: hope for an indigenous plant poison for fish nursery management. *Current Science* 49: 251-252.

RAPA. 2011. *A Discussion Paper from the Rainforest Aboriginal Peoples' Alliance (RAPA) regarding Indigenous Input into the Wet Tropics' Water Resource Planning Process.* Unpublished material. Rainforest Aboriginal People Alliance, Queensland, Australia.

Razak, V.M. 2003. Can indigenous cultures survive the future? *Futures* 35: 907-915.

Reeves, J. 2013. On the relationship between science and the scientific worldview. *The*

Heythrop Journal LIV: 554-562.

Reser, J., P. & J. M. Bentrupperbäumer. 2005. What and where are environmental values? Assessing the impacts of current diversity of use of 'environmental' and 'World Heritage' values. *Journal of Environmental Psychology* 25: 125-146.

Rigney, L.I. 2001. A first perspective of Indigenous Australian participation in science: framing Indigenous research towards Indigenous Australian intellectual sovereignty. *Kaurna Higher Education Journal* 7: 1-13.

Robinson, C.J. & T. J. Wallington. 2012. Boundary work: engaging knowledge systems in co-management of feral animals on indigenous lands. *Ecology and Society* 17(2): 16.

Robson, J. P., A. M. Miller, C. J. Idrobo, C. Burlando, N. Deutsch, J.-E. Kocho-Schellenberg, R. D. Pengelly & K. L. Turner. 2009. Building communities of learning: indigenous ways of knowing in contemporary natural resources and environmental management. *Journal of the Royal Society of New Zealand* 39: 173-177.

Rose, D. 1996. *Nourishing Terrains: Australian Aboriginal Views of Landscape and Wilderness*. Australian Heritage Commission, Commonwealth of Australia, Canberra, Australia.

Ross, A. 1996. More than archaeology: new directions in cultural heritage management. *Queensland Archaeological Research* 10: 17-24.

Ross, A. & K. Pickering. 2002. The politics of reintegrating Australian Aboriginal and American Indian indigenous knowledge into resource management: the dynamics of resource appropriation and cultural revival. *Human Ecology* 30: 187-214.

Roy, P. K. & J. D. Munshi. 1989. Effect of saponin extracts on oxygen uptake and haematology of an air-breathing climbing perch, *Anabas testudineus* (Bloch). *Journal of Freshwater Biology* 1: 167-172.

Royal, C. 2005. Exploring indigenous knowledge. In: J. Kidman, J. Te Rito & W. Penetito (Eds.) *Proceedings of the Indigenous Knowledges Conference:*

Reconciling Academic Priorities with Indigenous Realities. 22-25 June 2005, Wellington, New Zealand.

Royal, C. 2009. *Te Kaimānga: Towards a New Vision for Mātauranga Māori*. Lecture 1 of the Macmillan Brown Lecture Series, 16 September 2009. Macmillan Brown Centre for Pacific Studies, University of Canterbury, New Zealand.

Royal, C. 2012. *Towards a Manifesto for Indigenous Development*. Fifth Biennial International Indigenous Development Research Conference, 27-30 June 2012. Ngā Pae o te Māramatanga, New Zealand's Māori Centre of Research Excellence, University of Auckland, New Zealand.

Russell, J. Y. 2010. A philosophical framework for an open and critical transdisciplinary inquiry. In: Brown, V.A., A. J. Harris & J. Y. Russell (Eds.). *Tackling wicked problems. Through the transdisciplinarity imagination*. Earthscan Ltd., London, United Kingdom.

Russell-Smith, J., B. P. Murphy, C. M. Meyer, G. D. Cook, S. Maier, A. C. Edwards & P. Brocklehurst. 2009. Improving estimates of savanna burning emissions for greenhouse accounting in northern Australia: limitations, challenges, applications. *International Journal of Wildland Fire* 18(1): 1-18.

Ryder, D. S., M. Tomlinson, B. Gawne & G.E. Likens. 2010. Defining and using 'best available science': a policy conundrum for the management of aquatic ecosystems. *Marine and Freshwater Research* 61: 821-828.

Sangha, K. K., J. R. A. Butler, A. Delisle & O. Stanley. 2011. Identifying links between ecosystem services and human well-being for Aboriginal people in north Australia: applying the Millennium Ecosystem Assessment framework. *Journal of Environmental Science and Engineering* 5: 381-387.

Schultz, P.W. & L. C. Zelezny. 1998. Values and proenvironmental behavior : a five-country survey. *Journal of Cross-Cultural Psychology* 29: 540-558.

Schwartz, S.H. 1994. Are there universal aspects in the structure and contents of human values? *Journal of Social Issues* 50(4): 19-45.

Schwartz, S. H. & W. Bilsky. 1987. Toward a universal psychological structure of human values. *Journal of Personality and Social Psychology* 53: 550-562.

Schwartz, S.H., J. Cieciuch, M. Vecchione, E. Davidov, R. Fischer, C. Beierlein, A. Ramos, M. Verkasalo, J. E. Lonnwvist, K. Demirutku, O. D. Gumus & M. Konty. 2012. Refining the Theory of Basic Individual Values. *Journal of Personality and Social Psychology* 103(4): 663-688.

Shiva, V. 2000. Foreword: cultural diversity and the politics of knowledge. In: G. J. Sefa Dei, B. L. Hall & D. G. Rosemberg (Eds.). *Indigenous knowledge in global contexts: multiple readings of our world.* University of Toronto Press, Toronto, Canada.

Shizha, E. 2006. Legitimizing indigenous knowledge in Zimbabwe: a theoretical analysis of postcolonial school knowledge and its colonial legacy. *Journal of Contemporary Issues in Education* 1(1): 20-35.

Sillitoe, P. 1998. The development of Indigenous Knowledge: a new applied anthropology. *Current Anthropolgy* 39(2): 223-252.

Sillitoe, P. 2007. Local science vs. Global science: an overview. In: Sillitoe, P. (Ed.) *Local science vs global science: approaches to indigenous knowledge in international development*. Berghan Books, Oxford.

Sillitoe, P. & A. Bicker. 2004. Introduction: hunting for theory, gathering ideology. In: Bicker, A., P. Sillitoe, J. Pottier (Eds.) *Development and local knowledge.* Routeledge, New York.

Sinclair, J. R., L. Tuke & M. Opiang. 2010. What the locals know: comparing traditional and scientific knowledge of Megapodes in Melanesia. In: Gosler, A. & S. C. Tidemann (Eds.) *Ethno-Ornithology: birds, indigenous peoples, culture and society*. Earthscan Ltd., Oxford, United Kingdom.

Singh, A. & S. K. Singh. 2005. Molluscicidal evaluation of three common plants from India. *Fitoterapia* 76: 747-751.

Smith, L., A. Morgan & A. van der Meer. 2003. Community driven research in cultural

heritage management: the Waanyi Women's history project. *International Journal of Heritage Studies* 9(1): 65-80.

Snodgrass, J.G., S. K. Sharma, Y. S. Jhala, M. G. Lacy, M. Advani, N. K. Bhargava & C. Upadhyay. 2007. Beyond self-interest and altruism: Herbalist and leopard brothers in an Indian wildlife sanctuary. *Human Dimensions of Wildlife* 12(5): 375-387.

Spender, J. 2009. Comments included in his awarding of the Combined Dulabed and Malanbarra Yidinji Native Title Claim, 'Combined Dulabed Malanbarra Yidinji People vs. State of Queensland', Tribunal File No. QCD2009/005, National Native Title Tribunal (*http://www.nntt.gov.au/SearchRegApps/NativeTitleClaims/*)

Standely, P. & R. Hill (Eds). 2011. *Exploring the potential for indigenous driven tropical ethnobotany.* Report of the Tropical Indigenous Ethnobotany Centre Workshop on the cutlural use of plants. 19 November 2010, CSIRO, Cairns, Australia.

Standley, P. M., N. J. Bidwell, T. George, V. Steffensen & J. Gothe. 2009. Connecting communities and the environment through media: doing, saying and seeing along Traditional Knowledge Revival Pathways. *Journal of Community, Citizen's and Third Sector Media and Communication* 5: 8-27.

Stephenson, J. & H. Moller. 2009. Cross-cultural environmental research and management: challenges and progress. *Journal of the Royal Society of New Zealand* 39: 139-149.

Stern, P. C. 2000. Toward a coherent theory of environmental significant behavior. *Journal of Social Issues* 56: 407-424.

Stern, P.C. & T. Dietz. 1994. The Value Basis of Environmental Concern. *Journal of Social Issues* 50(3): 65-84.

Strauss, A. & J. Corbin. 1998. *Basics of qualitative research techniques and procedures for developing grounded theory.* SAGE, London, United Kingdom.

Struch, N. & S. H. Schwartz. 2002. Meanings of basic values for women and me: a

cross-cultural analysis. *Personality and Social Psychology Bulletin* 28: 16-28.

Suchet, S. 2002. 'Totally Wild'? Colonising discourses, indigenous knowledges and managing wildlife. *Australian Geographer* 33(2): 141-157.

Sutton, S. G. & R. C. Tobin. 2011. Constraints on community engagement with Great Barrier Reef climate change reduction and mitigation. *Global Environmental Change* 21: 894-905.

Tabara, J. D. & I. Chabay. 2013. Coupling human information andknowledge systems with social-ecological systems change reframing research, education and policy for sustainability. *Environmental Science and Policy* 28: 71-81.

Teel, T.L., M. J. Manfredo and H. M. Stinchfield. 2007. The need and theoretical basis for exploring wildlife value orientations cross-culturally, *Human Dimensions of Wildlife: An International Journal* 12(5): 297-305.

Tindale, N. B. 1974. *Aboriginal tribes of Australa: their terrain, environmental controls, distribution limits and proper names.* Australian National University Press, Canberra, Australia.

Toussaint S., P. Sullivan, Yu, S. & M. Mularty Jnr. 2001. *Fitzroy Valley Indigenous Cultural Values Study (a preliminary assessment).* Report for the Waters & Rivers Commission. Centre for Anthropological Research, The University of Western Australia, Perth, WA.

Toussaint, S., P. Sullivan & S. Yu. 2005. Water ways in Aboriginal Australia: an interconnected analysis. *Anthropological Forum* 15(1): 61-74.

Trigger, D. & J. Mulcock. 2005. Forests as spiritually significant places: nature, culture and 'belonging' in Australia. *The Australian Journal of Anthropology* 16(3): 306-320.

Tsatsaros, J. H., J. E. Brodie, I. C. Bohnet & P. Valentine. 2013. Water quality degradation of coastal waterways in the Wet Tropics, Australia. *Water Air Soil Pollution* 224: 1-22.

Tuhiwai Smith, L. 1999. *Decolonizing methodologies: research and indigenous*

peoples. University of Otago Press, Dunedin, New Zealand.

Turnbull, D. 2009. Futures for indigenous knowledges. *Futures* 41: 1-5.

Tuner, N. J. & F. Berkes. 2006. Coming to Understanding: Developing Conservation through Incremental Learning in the Pacific Northwest. *Human Ecology* 34: 495-513.

UN-WCED. 1987. Our Common Future, United Nations General Assembly Resolution 42/187. World Commission on Environment and Development (Brundtland Commission).

Usher, P. J. 2000. Traditional ecological knowledge in environmental assessment and management. *Arctic* 53(2): 183-193.

van Egmond, N.D. & H. J. M. de Vries. 2011. Sustainability: The search for the integral worldview. *Futures* 43:853-867.

Van Opstal, M. & J. Hugé. 2013. Knowledge for sustainable development: a worldviews perspective. *Environment, Development and Sustainability* 15: 687-709.

Venn, T.J. & J. Quiggin. 2006. Accommodating indigenous cultural heritage values in resource assessment: Cape York Peninsula and the Murray–Darling Basin, Australia. *Ecological Economics* 61(2-3): 334-344.

Vidal, C. 2008. Wat is een wereldbeeld? (What is a worldview?) In: H. Van Belle & J. Van der Veken (Eds.). *Nieuwheid denken. De wetenschappen en het creatieve aspect van de werkelijkheid.* Acco, Leuven, Belgium.

Vidal, C. 2012. Methaphilosophical criteria for worldview comparison. *Metaphilosophy* 43: 306-347.

Voeller, E. 2011. Renewing a Naxi environmental ethic in Lijiang, China: An approach for water management. *Lakes and Reservoirs: Research and Management* 16(3): 223-229.

Wallington, T., K. Maclean, T. Darbas & C. Robinson. 2010. *Knowledge-Action*

Systems for Integrated Water Management: National and International Experiences, and Implications for South East Queensland. Technical Report No. 29. Urban Water Security Research Alliance (*www.urbanwateralliance.org.au/index.html*)

Walsh, F. J., P. V. Dobson & J. C. Douglas. 2013. *Anpernirrentye*: a framework for enhanced application of indigenous ecological knowledge in natural resource management. *Ecology and Society* 18(3): 18.

Webb, A. C. 2003. *The ecology of freshwater invasions of non-indigenous freshwater fishes in North Queensland.* Dissertation. James Cook University, Townsville, Australia.

Webb, A. C. 2007. Status of non-native freshwater fishes in tropical North Queensland, including establishment success, rate of spread, range and introduction pathways. *Journal and Proceedings of the Royal Society of New South Wales* 140: 63-78.

Wei, F. H., X.-J. Xu, J.-B. Liu, Y.-H. Dai, G. Dussart & J. Trigwell. 2002. Toxicology of a potential molluscicide derived from the plant *Solanum xanthocarpum*: a preliminary study. *Annals of Tropical Medicine and Parasitology* 96: 325-331.

Weir, J. K. 2008. Local Science vs. Global Science: Approaches to Indigenous Knowledge in International Development (Environmental Anthropology and Ethnobiology). *Australian Aboriginal Studies* 2: 122-124.

Weir, J. K. 2012. Country, Native Title and Ecology. In: Weir J. K. (Ed) *Country, Native Title and Ecology.* Australian National University E Press, Canberra, Australia.

Weiss, K., M. Hamman & H. Marsh. 2012. Bridging knowledges: understanding and applying Indigenous and Western Scientific Knowledge for marine wildlife management. *Society & Natural Resources: An International Journal* 26(3): 285-302.

Wet Tropics Aboriginal Plan Project Team. 2005. *Caring for Country and Culture – The Wet Tropics Aboriginal Cultural and Natural Resource Management Plan*. Rainforest CRC and FNQ NRM Ltd., Cairns.

WIPO. 2001. *Intellectual property needs and expectations of traditional knowledge holders.* WIPO report on fact finding missions on intellectual property and traditional knowledge (1998-1999). WIPO, Geneva, Switzerland.

WTMA. 1998. *Wet Tropics Management Plan, 1998*. Wet Tropics Management Authority, Cairns, Australia.

WTMA. 2002. *Report on the State of Conservation of the Wet Tropics of Queensland.* Wet Tropics Management Authority, Cairns, Australia.

WTMA. 2004. *Wet Tropics conservation strategy, 2004: The conservation, rehabilitation and transmission to future generations of the Wet Tropics World Heritage Area*. Wet Tropics Management Authority, Cairns, Australia.

WTMA. 2007. *State of the Wet Tropics Report 2006-2007.* Wet Tropics Management Authority, Cairns, Australia.

WTMA. 2011. *Annual report and state of the Wet Tropics report 2010-2011*. Wet Tropics Management Authority, Cairns, Australia.

WTMA. 2012. *Annual Report and State of the Wet Tropics Report 2011-2012*. Wet Tropics Management Authority, Cairns, Australia.

White, N. 2010. Indigenous Australian women's leadership: Stayin' strong against the post-colonial tide. *International Journal of Leadership in Education* 13(1): 7-25.

Wickens, G. E. (Ed.). 2001. *Economic botany: principles and practices.* Kluwer Academic, Dordrecht, Netherlands.

Williams, J. (Ngai Tahu). 2009. "O ye of little faith": traditional knowledge and Western science. *Journal of the Royal Society of New Zealand* 39: 167-169.

Wiseman, N. D. & D. K. Bardsley. 2013. Climate change and indigenous natural resource management: a review of socio-ecological interactions in the Alinytjara Wilurara NRM region. *Local Environment: International Journal of Justice and Sustainability* 18(9): 1024-1045.

Wohling, M. 2009. The problem of scale in indigenous knowledge: a perspective from

northern Australia. *Ecology and Society* 14(1): 1.

Wroe, S., J. Field, R. Fullagar & L. S. Jermin. 2004. Megafaunal extinction in the late Quaternary and the global overkill hypothesis. *Alcheringa: An Australasian Journal of Palaeontology* 28(1): 291-331.

Wynberg, R. & J. van Niekerk. 2014. Global ambitions and local realities: achieving equity and sustainability in two high-value natural product trade chains. *Forests, Trees and Livelihoods* 23(1-2): 19-35.

Yunupingu, D. & S. Muller. 2009. Cross-cultural challenges for Indigenous sea country management in Australia. *Australasian Journal of Environmental Management* 16(3): 158-167.

Ziembicki, M. R., J. C. Z. Woinarski & B. Mackey. 2013. Evaluating the status of species using Indigenous knowledge: novel evidence for major native mammal declines in northern Australia. *Biological Conservation* 157: 78-92.

Appendix

List of references used in the systematic literature review

Bethel, M. B., L. F., Brien, E. J. Danielson, S. B. Laska, J. P. Troutman, W. M. Boshart, M. J. Giardino & M. A. Phillips. 2011. Blending Geospatial Technology and Traditional Ecological Knowledge to Enhance Restoration Decision-Support Processes in Coastal Louisiana. *Journal of Coastal Research* 27(3): 555-571.

Choo, J., E. L. Zent & B. B. Simpson. 2009. The Importance of Traditional Ecological Knowledge for Palmweevil Cultivation in the Venezuelan Amazon. *Journal of Ethnobiology* 29(1): 113-128.

Couly, C. & S. Plinio. 2013. Use and knowledge of forest plants among the Ribeirinhos, a traditional Amazonian population. *Agroforest Systems* 87: 543-554.

Darimont C. T., P. C. Paquet, T. E. Reimchen & V. Crichton. 2005. Range expansion by moose into coastal temperate rainforests of British Columbia, Canada. *Diversity and Distributions* 11: 235-239.

Diemont, S. A. W. & J. F. Martin. 2009. Lacandon Maya Ecosystem Management: Sustainable Design for Subsistence and Environmental Restoration. *Ecological Applications* 19(1): 254-266.

Dinero, S. C. 2013. Indigenous perspectives of climate change and its effects upon subsistence activities in the Arctic: the case of the Nets'aii Gwich'in. *GeoJournal* 78: 117-137.

Douterlungne, D., S. I. Levy-Tacher, D. J. Golicher & F. R. Danobeytia. 2010. Applying indigenous knowledge to the restoration of degraded tropical rainforest clearings dominated by bracken fern. *Restoration Ecology* 18: 322-329.

Feinstein, B. C. 2004. Learning and Transformation in the Context of Hawaiian Traditional Ecological Knowledge. *Adult Education Quarterly* 54(2): 105-120.

Ferguson, S. H., M. C. S. Kingsley & J. W. Higdon. 2012. Killer whale (*Orcinus orca*) predation in a multi-prey system. *Population Ecology* 54: 31-41.

Ferguson, S. H., J. W. Higdon & K. H Westdal. 2012. Prey items and predation behaviour of killer whales (*Orcinus orca*) in Nunavut, Canada based on Inuit hunter interviews. *Aquatic Biosystems* 8(3): 1-16.

Fraser, D. J., A. M. Calvert, L. Bernatchez & A. Coon. 2013. Multidisciplinary population monitoring when demographic data are sparse: a case study of remote trout populations. *Ecology and Evolution* 3(15): 4954-4969.

Ignatowski J. A. & J. Rosales. 2013. Identifying the exposure of two subsistence villages in Alaska to climate change using traditional ecological knowledge. *Climatic Change* 121: 285-299.

Kasper, K. 2012. Seeds for the Future: The Materialities of Traditional Ecological Knowledge. *Journal of the World Archaeological Congress* 8(3): 269-292.

Kapa, M. 2010. Ethnobotany of Kuta (*Eleocharis sphacelata*) in Bay of Plenty and Northland, New Zealand. *The Journal of the Polynesian Society* 119(2): 131-148.

Kellogg, J., J., Wang, C., Flint, D., Ribnicky, P., Kuhn, E., Gonzalez De Mejia, I. Raskin & M. A. Lila. 2009. Alaskan wild berry resources and human health under the cloud of climate change. *Journal of Agriculture and Food Chemistry* 58: 3884-3900.

Khan, S. M., Page, S., Ahmad, H. & D. Harper. 2014. Ethno-ecological importance of plant biodiversity in mountain ecosystems with special emphasis on indicator species of a Himalayan Valley in the northern Pakistan. *Ecological Indicators* 37: 175-185.

Lefale, P. F. 2010. Ua ‘afa le Aso Stormy weather today: traditional ecological knowledge of weather and climate. The Samoa experience. *Climatic Change* 100: 317-335

Lewis, A. E., M. O. Hamiviill, M. Power, D. W. Doidge & V. Lesage. 2009. Movement and Aggregation of Eastern Hudson Bay Beluga Whales (*Delphinapterus leucas*):

A Comparison of Patterns Found through Satellite Telemetry and Nunavik Traditional Ecological Knowledge. *Arctic* 62(1): 13-24.

Mulyoutami, E., R. Rismawan & L. Joshi. 2009. Local knowledge and management of simpukng (forest gardens) among the Dayak people in East Kalimantan, Indonesia. *Forest Ecology and Management* 257: 2054-2061.

Peloquin, C. & F. Berkes. 2009. Local knowledge, subsistence harvests, and social–ecological complexity in James Bay, *Human Ecology* 37: 533-545.

Phuthego, T. C. & R. Chanda. 2004. Traditional ecological knowledge and community-based natural resource management: lessons from a Botswana wildlife management area. *Applied Geography* 24: 57-76.

Polfus, J. L., K. Heinemeyer, M. H. White and Taku River Tlingit First Nation. 2013. Comparing traditional ecological knowledge and Western science Woodland Caribou habitat models. *The Journal of Wildlife Management* 78(1): 112-121.

Rai, P. K. & H. Lalramnghinglova. 2011. Threatened and less known ethnomedicinal plants of an Indo-Burma hotspot region: conservation implications. *Environmental Monitoring and Assessment* 178: 53-62.

Reo, N. J. & K. P. Whyte. 2012. Hunting and Morality as Elements of Traditional Ecological Knowledge. *Human Ecology* 40: 15-27.

Ruiz-Mallén, I., C. Morsello, V. Reyes-García & R. Barros Marcondes De Faria. 2013. Children's use of time and traditional ecological learning. A case study in two Amazonian indigenous societies. *Learning and Individual Differences* 27: 213-222.

Shen, X., S. Li, N. Chen, S. Li, W. J. McShea & Z. Lu. 2012. Does science replace traditions? Correlates between traditional Tibetan culture and local bird diversity in Southwest China. *Biological Conservation* 145: 160-170.

Turner, N. J. & F. Berkes. 2006. Coming to Understanding: Developing Conservation through Incremental Learning in the Pacific Northwest. *Human Ecology* 34: 495-513.

Velásquez-Milla, D., A. Casas, J. Torres-Guevara & A. Cruz-Soriano. 2011. Ecological and socio-cultural factors influencing in situ conservation of crop diversity by traditional Andean households in Peru. *Journal of Ethnobiology and Ethnomedicine* 7: 40.

Wekesa, C., P. M. Makenzi, B. N. Chikamai, A. M. Luvanda & M. O. Muga. 2010. Traditional Ecological Knowledge Associated with *Acacia senegal* (Gum Arabic Tree) Management and Gum Arabic Production in Northern Kenya. *International Forestry Review* 12(3): 240-246.