MANAGEMENT STRUCTURES OF TIWI INDIGENOUS LANDOWNERS AND RESPONSES TO CHANGING RESOURCE VALUES

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Abstract

The Tiwi people of northern Australia have managed their land and natural resources continuously for 6000–8000 years. The elegance of traditional governance structures and decision making strategies discussed in this thesis illustrates how they did it; how reliable harvests were sustained, and how land and resources were maintained through generations. This study also includes more recent [from 1960] contrasts of post traditional land use highlighting impacts and responses of managers and landowners through their continuing transition from traditional to a market economy. Impacts and responses of this kind readily accord with a focus on social ecological systems and their management which frame the theoretical approach undertaken in this thesis. The reasons for this emerge from the prominence and persistence of Tiwi decision making techniques that influence land management actions and responses. Managers gathering information for their decisions rely upon embedded elements now vulnerable to changing meanings and beliefs. For example, traditional aspirations were attainable through knowledge and monitoring of landscape systems, and access sanctions that assured sustainable harvests. These elements are no longer available to post traditional decision makers. Landowner participation is no longer required to access or harvest resources; and the value of those resources, once a community consumption satisfaction, has been monetised. Achieving aspiration levels continues; the meanings have changed. Governance structures that once supported traditional processes with sanctions and verifications preserving their influence need also adapt to different meanings and beliefs. Impacts shaping social-ecological systems also shape the minds of those people managing them. None more so than monetised resources and rational economics. As task environments change they provide contrasts accentuating responsive Tiwi principles of adaptive management. Impacts can be identified through indicators revealed by these contrasts. Modifying the effects of impacts requires decisions for the use and management of developed land focus on the resilience of landscapes; be open to scientific collaboration to achieve it, and set within transparent and legitimate own governance structures. We provide a framework of indicators to reference Tiwi responses in these categories. Each category is touched by aspirations of land owners and managers asserting their own controls through Tiwi decision strategies. They are strategies that exploit the structure and attributes of the environment within which decision(s) are made. Aspirations change when a changed environment alters the categories of benefits sought from land resources. Decision strategies are then open to attributes of a new environment accommodating values of rational
Where aspirations once satisfied immediate resource needs they contained attributes capable of delivering long term sustainable resource management. Tiwi aspirations can no longer be relied upon to achieve those outcomes. By evaluating the relationship between changing land use and aspirations to benefit from that use, adaptive management systems can be observed evolving as aspirations change. Indicators are able to capture the changes occurring. They illuminate impacts occurring to Tiwi governance structures and to the principles that governance has relied on. Primarily, traditional governance established aspiration pathways and provided guidance for their attainment. Short cuts to attainment were strictly contained. This significant doctrine enshrining aspiration management techniques remain within traditional memory of the current generation. The capacity of adaptive governance to manage new aspirations by way of revised sanctions and achievement pathways suggests some prescriptions are possible for effective environmental management and conservation of Tiwi land in the longer term.
Declaration

This is to certify that:

i. The thesis comprises only my original work towards the masters except where indicated in the Preface.

ii. Due acknowledgement has been made in the text to all other material used.

iii. The thesis is less than 24,200 words in length, exclusive of tables, maps, bibliographies and appendices.

John.S.Hicks
30 November 2015.


**Preface**

The work presented herein was completed as a body of work for this thesis and is substantially my own work. Publications and contributions from others are detailed below:

**Chapter 2** was work in collaboration with others and published as:


Co-author authorisations have been executed by all co-authors accepting my own original contributions to the publication were not less than 66 per cent. A declaration by my supervisor confirms this detail and agreement to include this publication in this thesis.

**Chapter 3** was work in collaboration with others and published as:


Co-author authorisations have been executed by all co-authors accepting my own original contributions to the publication were not less than 80 per cent. A declaration by my supervisor confirms this detail and agreement to include this publication in this thesis.

**Third party editorial assistance** beyond my supervisors has been provided within the Faculty of Science by Stuart Jones who particularly assisted in formatting and with the flow of information contained herein. He also provided advice of sentence structure in Chapter 1 and Chapter 4.
Acknowledgements

Acknowledging the outstanding support and guidance received attempting and completing this Master’s thesis is to acknowledge those crucial influences in a lifetime that have made it possible. These have culminated, during the past six years, with my indebtedness to a remarkable educationalist and scientist – my principal supervisor, Professor Mark Burgman. His recognition that pathways to science can include students interested to find the meanings behind their experiences; his patience guiding my observations towards scientific methods and concern with explanatory active prose and structures to present them – all have been beyond any student entitlement. The weaknesses remaining are of my own making. The strengths contain my gratitude to Professor Burgman for his influence throughout this thesis and upon my own aspirations.

At the other end of the world I was fortunate to be influenced by another scientist of international standing – Professor Gerd Gigerenzer, Director of the Center for Adaptive Behaviour and Cognition at Berlin’s Max Planck Institute for Human Development. “You a lawyer.” he said. “Bet Law attracted you because you are no good at Maths!” My thanks to Professor Gigerenzer for his insightful encouragement and extraordinary inquisitiveness into the minds and rationality of us all: - including the mathematical nincompoops and risk illiterate whose difficulties absorb him and compel his leadership of other truly concerned scholars in our times.

I am grateful that the window on the world of economic analysis and probability was opened by my co-supervisor Professor Bill Malcolm. My thanks to him for patient explanations and his lectures on farm economics joining the science and maths with landscapes managed by the Nation’s more creative workers – our farmers.

And primarily among them the remarkable Tiwi people who extended their trust and friendship to me over many decades with the hope I would listen and learn. A privilege extended by great and secure leadership – there are too many among the Tiwi to thank by name, and offensive to do so. That I have been among them and marvelled at the skill and wisdom of landscape managers without equal in centuries past, is the gift of a working life beyond measure. I am thankful that Tiwi people live in our world; - for the dignity of their survival, and for their determination to secure their own Tiwi future upon their own land.
I thank also McKell medallist, scientist and Tiwi Land Council Environment Manager Kate Hadden who has commented on this thesis. My admiration for her work and management of the trickery of some environmental and ideological organisations and supportive media opposed to landowner development on aboriginal land is, to my knowledge, admiration and gratitude shared by Tiwi owners and managers through recent generations.

Stuart Jones of The University of Melbourne has also assisted my presentation of this thesis. I am grateful for his ideas and advice of sentence structure and layout to better represent my research observations and the presented sequence of them.

And finally my thanks for the experience, intellect, advice and love of the special person in my life - Carla Hicks. Her own PhD scholarship revoked following her public protests against an authoritarian regime in East Germany – she has experienced over 30 years how the purposeful erosion of traditions cower a people and shrink the courage of their society. Her support and apprehension for Tiwi leadership and for the strengths of their traditional governance, weakened by many Government policy settings of today, is shared by us both.
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Chapter 1

Managing Sustainable Landscapes - People, Principles and Indicators

Introduction
This Chapter begins with an overview of the thesis, how it is organised and an explanation of terms used. Connections are identified between land and the people who manage and sustain it, and of the benefits they seek. Literature relevant to this study provides reference to theories, principles and discussions of human, economic and governance elements that influence use and management of land. These elements contain characteristics that can be used as indicators of the influences involved. The chapter concludes with reference to elements in clusters of indicators particular to the environment that apply to land use and management by the Tiwi people.

The Tiwi people inhabit 760,000 ha, primarily on 2 large islands—Bathurst and Melville Islands, 80 kms off the northern coast of Australia’s Northern Territory. They also own and have access to 5 relatively large and a number of smaller islands covering 40,000 ha [total management area 800,000 ha]. Rising sea levels separated these islands [highest elevation 200 m] from mainland Australia between 8000 and 6000 years ago (Peterson and Taylor 1998).

Tiwi were isolated until interaction with Indonesian, Dutch, British, and possibly Portuguese sailors in the seventeenth century. The Tiwi population size was estimated to be around 1500 in 1910 (Peterson and Taylor 1998) and 2000 during the past 100 years (Clancy 2009). Tiwi consumed fish, birds, macropods, reptiles, wild honey, and yams and other vegetables (Hart 1930). The Tiwi thus were self-sustaining for at least 6000 years (Bowdler 1995; Sim and Wallis 2008). Observations by early explorers (Swaardecroon et al. 1705; King 1818) confirm that these resources were readily available to the Tiwi. More detailed studies by social scientists living among the people and able to converse in Tiwi have provided insights into governance and management techniques (Hart 1930; Pilling 1978; Venbrux 1995).
Overview
People throughout the world sustain their lives from the landscapes they occupy. Most commonly they aspire to management systems that attempt to ensure their use of the land can continue indefinitely. Complex interactions exist between the processes that satisfy people and the processes that sustain the land they use (Holling 2001). Observations contained in this thesis illustrate how Tiwi people manage their land sustainable, and draws lessons for natural resource management in other cultures and ecological settings.

Chapter 1 presents an introduction and background to the relevant literature. Chapter 2 (Hicks et al. 2012) is a qualitative study of traditional land management and decision making which illustrates Tiwi strategies for meeting human aspirations while managing uncertainty. By contrast, Chapter 3 (Hicks, Samsa and Malcolm 2015) analyses post-traditional land use data, drawing inferences based on economic models. The results include measurements and analysis of costs, sales and yields from plantation forestry. In Chapter 4, contrasts between traditional and post-traditional land use and management are discussed. This includes exploration of the reciprocal interaction between the changing satisfactions of people and their impacts on land. The important connections are classified using a framework of indicators.

Organisation, scope and limitations
The organisation of this thesis follows the requirements of Melbourne University Research Students Hub – Masters by Research Policy Guidelines 2014. The research has produced two published co-authored papers as acknowledged in the accompanying Preface and Declarations. The thesis and publications draws on four elements:

1. Observing and interacting over 47 continuing years among intemerate traditional and transitioning societies of land owners in Papua New Guinea and Australia; more particularly, the past 29 years working with landowners of the Tiwi Islands.
2. Working directions from landowners and managers, and reviews described in detailed records of meetings and consultations contained in 35 volumes held by the Australian National Archives, Canberra, together with analysis and responses indexed and filed in over 1000 categories contained within the Record Management System of the Tiwi Land Council, Darwin.

1 “Post-traditional” is defined as that period commencing with legal recognition of Tiwi ownership of land in 1978. “Current” is that most recent ten-year period of the post-traditional era: 2005 to 2015.
3. Consultations and preparations of reports, inquiries, business planning, strategic and financial modelling required for structuring of ten trustee corporations establishing the Tiwi private economy, held in the offices of these corporations with copies filed among records of the Tiwi Land Council. Records also extend to consultations and planning with Tiwi education, training, health and social organisations influenced by the new economy and held by Tiwi Health Board, Tiwi Islands Training and Employment Board, Tiwi College, Tiwi Sports and Social Clubs, Tiwi Art Centres, Northern Territory Departments of Health, Education and Local Government, Menzies School of Health Research, CSIRO and Federal Government Departments and Authorities, with copies included in the Record Management System of the Tiwi Land Council, Darwin.

4. Published literature and theories of scientists and academics researching spheres of interest related to the topic of this study.

A limitation of this thesis is that it is necessarily descriptive in nature. It does not include rigorous testing of hypotheses, nor can the variables be manipulated, for many practical and ethical reasons. Observations nonetheless are capable of providing valuable insight for accepted theories, and provide opportunities to test some predictions.

Terms
This thesis uses a number of terms that should be defined at the outset to distinguish their usage here from their common language interpretations. Aspirations commonly means hopes or desires. This research applies the term to decision-making mechanisms – including heuristics\(^2\) and strategies such as satisficing – used to attain hopes or desires. Sustainable management is applied initially in Chapter 2 within a closed traditional economy where benefit is the community perception of sustainable use of resources. In Chapter 3, benefit attaches to current aspirations leaving open the sustainability of achieving them. Discussion in Chapter 4 includes landowner approaches to these questions.

The terms landscape and landscape system(s) are used in two contexts. First, in reference to that area local land-owners and managers exert their jurisdiction. Second, in recognition that their knowledge and advice is the primary tool managing those estates. The term social-ecological systems, or SES, also used, refers to the dynamics and interactions of ecological and social science that include the influence

\(^2\) “Heuristics” are rules of thumb used to reduce the search time and extent of information required to arrive at satisfactory decisions. (See Chapter 2 – Theory of bounded rationality.)
of landscape managers (Berkes and Folke 1998; Reed, Dougill and Baker 2008; Sayer et al 2013).

*Land use indicators* include the measureable yields of renewable resources qualitatively described within traditional settings in Chapter 2, and more quantitatively assessed through post-traditional land use described in Chapter 3. Beyond yields are the human, economic and governance elements lurking behind land use indicator measurements, which are discussed below. These elements inform indicator clusters of motivations, benefit and sustainability, and suggest an indicator framework for landscape system sustainability detailed in Chapter 4. The term *Tiwi Landowners* is a compilation of names, recorded annually in a register maintained by the Tiwi Land Council, as being those qualified by tradition to be so recorded.

**Management – land and people**

This section introduces the impact of human rationality upon landscape management and the influence of aspirations on processes and outcomes of that management. Tiwi traditional and post-traditional land management models illustrate significant changes occurring that are driven by changed land use and altered aspirations seeking to benefit from available resources.

**Management principles, influences and adaptations**

This study refers to the literature of *social-ecological systems* management (e.g., Berkes and Folke 1998), which contains principles of adaptation for sustainability. The discussion below identifies practices and processes of traditional Tiwi land management that accord with a number of these principles. These traditional practices and processes have been supplemented and sometimes displaced by more recent (post-traditional) processes. This has revealed the adoption of new beliefs in economically rational decision making. Chapter 4 presents a framework of classifications for values sought through Tiwi aspirations³. The classification tables describe the outcomes of traditional and current aspirations for each value. The differences between current and traditional outcomes reveal the impacts that have occurred. Indicators are described within each of the categories. These indicators measure the outcomes, which are a guide to actions necessary for resilient and sustainable land management. As such, the indicators provide a focus for future data collection.

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³ “Aspirations” are intrinsic values, which can be difficult to measure. (See Chapter 1 – Economic elements.)
There are three important reasons for using these measurements. First, landscape systems are governed by people. The governance structures they develop influence landscapes and the dynamics of ecological systems operating within their estates (Ostrom 1990). An appraisal of governance pressures, responses and legitimacy aids comprehension of the influences. Modern standards of effective governance require an openness to scientific collaboration (Folke et al. 2005), and outcomes that assure the resilience of systems being managed (Garmestani and Benson 2013). Second, Tiwi owners and managers have used and managed land sustainably for millennia, and created governance structures to do it. Transforming these structures exposes some of the risks involved. It is important to describe the extent of risks and uncover their impact on sustainability and resilience.

Finally, it is important to understand the significance of money in an economy that traditionally managed resources sustainably without it. Money causes changes to traditional values, processes and practices, aligning them more closely with rational choice economics4. In order to measure impacts, it is necessary to: value intrinsic and instrumental assets, calculate trade-offs, and weigh the anticipated benefits against the total costs and use of resources (Folke et al. 2005).

**Connecting management of land with the minds of managers**

During my 29 years working in the Tiwi Islands, I have observed changes in the land use and task environments5 of Tiwi people. These prolonged insights give me an understanding of the beliefs and meanings that Tiwi land managers attach to their decisions. People’s beliefs are substantiated by the meanings they attach to their beliefs. It is the meanings that provide reasons for beliefs; they are the design structure of rationality – *its architecture* (Campbell 2001). Tiwi rationality is structured by the meanings and beliefs of the Tiwi people, and is consistent with the concept of *ecological rationality* (Gigerenzer et al. 1999). Tiwi rationality contains strategies able to accommodate changing task environments. These strategies exploit the structure and attributes of the social and ecological contexts in which decisions are made. Furthermore, these strategies are open and adaptable to change (Hicks et al. 2012). This is consistent with *adaptive thinking* (Gigerenzer 2000), which advocates the exploitation of change.

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4 A theory, developed by D. Bernoulli 1738, assuming rational actors will continually make decisions to maximise (optimise) their wealth. See Kahneman 2003 for discussion and argument.
5 “Task environments” are the contextual environment (with a structure and attributes) within which decision strategies operate and decisions are made. (See Chapter 2 – Theory of bounded rationality.)
Impacts that shape social-ecological systems (Reed et al. 2010; Fagerholm et al. 2012) also shape the minds of the people managing them (Gigerenzer and Brighton 2009), altering their pathways\textsuperscript{6} to, and practices of, sustainable land management. Such changing of practices, described as adaptive management responses (Plummer, Armitage and de Loe 2013; Reed, Dougill and Baker 2008), relies upon each manager's ideas of sustainable land management. Therefore, with changing task environments, consideration of only physical and ecological changes is insufficient; an account of ecologically rational responses is needed (Anderies, Janssen and Ostrom 2004).

**Aboriginal land use – influences and aspirations**

Influences on aboriginal land use in Australia are scrutinised in numerous studies\textsuperscript{7}. Themes that emerge from this research include: community governance and ownership rights (Rowley 1978; Altman 2001), biodiversity degradation and threatened species (Woinarski and Ash 2002; Bowman 2002), consideration of influences on landowners and resource planning by the state (Barlow and Tietze 2001), landowner-centred governance for successful park management (Langton, Palmer and Rhea 2014), and harvesting practices and motivations (Jackson et al. 2011).

Aboriginal aspirations are commonly recognized in development policies and programs for aboriginal constituents. Often, they are aspirations about cultural attachment, political development and geographic remoteness (Dockery and Milsom 2007: 45-47). While recognised, aboriginal aspirations are less commonly defined and rarely acknowledged as subject to change.

The purpose of this research is to indicate how current land use practices are changing aspirations among Tiwi landowners of northern Australia. Traditionally, the process of gathering information for sustainable land use decisions concluded when a particular aspiration level was reached by the decision makers (Hicks et al. 2012). Different aspirations are now inspired by transitions to a market economy. The significance of these changes is manifest in management responses to these transitions.

\textsuperscript{6} “Pathways” are the direction of an action towards achieving an outcome or specified result.

\textsuperscript{7} Scopus Aboriginal land Australia database records 702 outputs from 1974 to 2015 with a peak of 51 studies in 2013 and averaging over 40 a year since 2004. Accessed 6 November 2015.
**Tiwi traditional land use and management**

Descriptions and locations of Tiwi people and land are provided in the following chapters. Chapter 2 describes the traditional sustainable management system, which relied upon harvesting resources for immediate needs. Management fluency relied upon flows of information between the managers monitoring, and the community harvesting, the resources. Risk was managed exercising constraints of access to resources. Sanctions were applied by authoritative managers whose prestige was validated by satisfactory harvests and maintained through their continuing performance. Millennia of development and operation of this management system demonstrated its sustainability. It is figuratively represented below in Figure 1.

![Figure 1 – Tiwi traditional land use and management system](image)

**Tiwi post-traditional land use and management**

Membership of an affluent Australian society has reduced Tiwi dependence on their own resources and also eroded traditional elements of social cohesion (Tipungwuti, Kerinaiuua, and Wonaearmirri 2000). Chapter 3 describes plantation forestry and changing land use, and provides quantitative data for decisions by land managers. Elements of the traditional land use and management system [Figure 1] have changed. The community no longer depends on traditional resource harvesting, which is now a recreational option. Because community benefits that are derived from resources no longer require participation in harvesting, traditional sanctions that limited access to harvesting are no longer effective as a tool for assuring resource sustainability. The post-traditional system of managing built environments is represented in Figure 2.
Tiwi land managers have adopted a 10 percent limit on new land developments in regard for landscape resilience, resource conservation and sustainability. The boundaries of the traditional estate are 800,000 ha\(^8\). Hence, the managers determined in 2001 that 80,000 ha of land would be made available for development (Hadden 2004). These decisions have been reiterated through the decade with managers recently requesting scientific research to substantiate their decisions (Illortaminni, Tungatulum and Hadden 2015).

**Elements of sustainable land management**

The significant elements: human faculties, economic values and the capacity of governance, are confirmed in the literature as those that most effect sustainable land management. The influence and consequences of these elements are discussed and referenced in this section.

**Human elements**

Research evaluations of human capabilities and intentions are emphasised in influential adaptive management studies (Holling 1978; Walker et al 2006; Berkes and Folke 2002; Gregory and Keeney 1994). A number of studies encourage further research into the processes that inform these intentions because of their influence

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\(^8\) See Chapter 2, page 25 for description.
on adaptability to manage the resilience of social-ecological systems (Walker et al. 2004). Disturbance of these systems is dominated by human actions. If disturbed, then at some earlier time they were undisturbed – they were resilient. Restoring resilience requires adaptations to manage a disturbed social-ecological system (Berkes, Colding and Folke 2003). Recommended further research includes the development of principles derived from scientific propositions of management and use of resources (Walker et al 2006), and to understand processes involved in the development of intentions and aspirations for sustainable landscapes (Cumming et al. 2013). Scholars generally accept that intentions are those aspirations that are established by the values [or trade-offs], endorsed by stakeholders (Selten 1999). Therefore, a question of interest for this thesis is: how are these values created and adopted?

While research provides knowledge of value creation, that knowledge is required to inform others. Policy makers also need to comprehend the values held by resource managers in order to obtain planning support for their policy objectives (Gregory and Keeney 1994). The values of people who manage, conserve and exploit natural resources vary both within and between groups (Reed 2008).

Stakeholder values that inform environmental monitoring and management choices on one estate may not be shared by those managing another (Lyons et al. 2008). Consultative methods are commonly used to discover these values, with methods tailored for the particular participants involved. Structured Decision Making is one method providing localised plans able to evaluate alternatives from value-based foundations (Gregory et al. 2012). This method uses tools from decision science to expose value based choices. Participants are required to defend their decisions and trade-offs through an inclusive process treating problems as decision centred opportunities rather than mere research possibilities. Inclusive collaboration and consultation of this kind is expensive and... “There is no doubt that successful structured decision making process involves good chemistry among participants” (Gregory et al. 2012; 264).

There is some evidence that establishing good chemistry among participants through fair and deliberative collaboration does improve the effective quality of decisions (Parkins and Mitchell 2005). Endurance of effectiveness is not disclosed, although questions qualifying effectiveness include, the weight to be attached to contributions from each of the participants? (Reed 2008) and who calculates that weighting? Processes of deliberative democracy (Rodela 2012) attempt to provide an answer by
ascribing weight and identifying a consensus among participants for various contributory values. These studies invite further questions: - can a gathering of all stakeholder participants’ work out objectively how to do it? Perhaps all stakeholders magnify the problem of weighting value contributions rather than solving it? There are grounds to believe they could have this effect. Policy is shaped and influenced by environmental and ideological organisations able to mobilise their responses and contributions (Hendricks 2006). An example provided (Fischer 2006) records how pedagogically oriented interventions shaped regional resource management policy in India.

Tools exist in English and American legal systems containing well-established rules of evidence weighting the impact of affidavits and cross-examination on a tested scale of verification (Best 1849). Weighting and testing contributions through an analytical framework able to verify motivations, relationships, meanings and assumptions is recommended for all environment, resource managers and stakeholder participants (Dryzek 1997).

Discussion of culture in the literature invariably refers to indigenous peoples and their lands (Gould et al. 2014). Complexities arise assigning cultural values across varied social, economic and political systems maintained by societies occupying these lands. Definitions and classifications requiring measurement of cultural values compound the difficulties (Satterfield et al. 2013). This thesis observes additional limitations of finite cultural memories effecting management structures. We conclude, in Chapter 4, that loss of cultural memory is exacerbated by changing land use and purposes for that use. Attempts to surmount these limitations include use of consultative questionnaires. One aims to elicit manager’s nonmaterial values through design of interview formats separating the value and benefits of land practices – hunting and gathering – from ecosystem contributions (Gould et al. 2014). Another attempt is through use of influence diagrams (Gregory et al. 2012). These compile qualitative data from the variables and link them to the relationships involved. This process is claimed particularly helpful for decision makers exposed to uncertainty (Beaudrie et al. 2015).

**Economic elements**

All measurements require a value to measure. Allocation of economic values to ecosystems, natural resources and to management services are necessary for their measurement (Freeman, Herriges and Kling 2014). Whether ecological economists concerned with the sustainability of systems, or environmental economists assessing
impacts upon sustainable development, both require an explicable valuation of all contributions, costs and benefits flowing through their analysis.

Valuation approaches vary and expose tensions between utilitarian and moral standards, as well as pricing in the market place (Carreño, Frank and Viglizzo 2011). Many natural resource managers quantify the utility of their decisions and select options with the greatest expected value (Costello and Polasky 2008), while others adopt preference-based value appraisal of contributions to social well-being (Freeman, Herriges and Kling 2014).

Extrinsic or instrumental values are measured by the means they provide to acquire something else - also of measurably value (Holsinger 2013). More complexity is involved calculating intrinsic values. One approach is through controlled surveys and responses of preferences and trade-offs agreed to by participants; although surveys of this kind are exposed to potential bias and the validity of data collected. Inexplicably anomalies arise. For example, respondents consistently setting higher prices on amenities invited to give up than they are willing to pay to obtain them (Mitchell and Carson 2013: 34-35). Such responses conflict with valuation principles and accepted economic rationality. They are inconsistent with traditional economic theory and tend to emerge where there are no markets for the decisions of rational optimisers (Mitchell and Carson 2013). Reasons for many irregularities are explained in findings from Public Choice traditions studying behaviours of self-interest that reject the interests of others (Ostrom 1997).

The influence of aspirations in sustainable land use require a measure of their intrinsic value to assess that influence. These are values “beyond instrumental value” (Vucetich, Bruskotter and Nelson 2015: 322.) that accept a value for being a value within the context of observable measureable other values. It is a value of good in itself (Holsinger 2013). One example of intrinsic values included in support of objective analysis can be found in government and corporate financial forecasting containing values of statistical human life (Davidson 2013). In this example, application of an intrinsic value supports other measureable values.

Intrinsic values exist. Measuring them is a difficulty (Chisholm 2005). What could be measured is the gap they leave when excluded. An undertaking of this study accepts aspirations as intrinsic values that can change; and are measurable by the impacts and influences caused by these changes – see Chapter 4. This approach resembles “precautionary principles” (Vucetich, Bruskotter and Nelson 2015:323) used in
environmental science to accommodate uncertain values and assignments. These principles evaluate the harm caused by failing to recognise impacts caused by excluding them. For example, precautionary principles that calculate the extent of buffer zones around vulnerable impact sites to contain infestations and impacts - what would have happened without the buffer zone? Similarly precautionary principles can evaluate intrinsic values by calculating the harm caused by failing to account for their contribution to value (Vucetich, Bruskotter and Nelson 2015).

Sustainable benefit from land remains a Tiwi aspiration [Chapter 2 and 3]. However, sustainable land use is compromised when the benefit extracted no longer relies upon aspirations that are satisfied by sustaining continual harvests. The nexus between aspirations and resource benefit, once secured by sustainably managing the land, is fractured. The breach can become one of potential harm, more likely to widen by failing to account for the gap.

Performance evaluations and economic assessments of environmental sustainability have also been adopted as accounting frameworks by some governments and corporations. Titled Triple Bottom Line performance measures for sustainability, they fail to include valuation guidelines beyond professional financial standards (Elkington 1994). In the absence of guidelines, valuation assessments are left up to the corporation itself to determine as their needs and location require. More recently Triple Bottom Line accounting includes a measuring index where categories of social, environmental and economic line items can be referenced for standardised reporting across corporations (Slaper and Hall 2011).

Economic theory explains processes and outcomes that would occur if decision makers acted rationally in managing their production systems and estates to maximise profit (Souty et al. 2012). Economic rationality includes optimizing strategies and fundamentals that drive markets, prices and consumer behaviours. Interaction of these fundamentals with the environment provide the framework for ecological and environmental economics (Callan and Thomas 2007). It is found that where frameworks include economic theory, planning and predictions are enhanced. For example, conclusions from data measuring trends in land values, incomes and agricultural investments in China improve planning processes and provide more accurate predictions than is possible without the use of such data (Li, Wu and Deng 2013). Inseparable interactions are also found between land use, sustainable development and rational economics when applied in studies of forest clearing and conservation in Indonesia (Wheeler et al. 2011).
Applications of economic theory are necessary to calculate and disclose environmental risks, and to analyse options and trade-offs. Generally, evaluating risk requires measures of costs and/or benefits to assure that costs do not exceed the anticipated benefits, and that good bets are made about using least resources to secure the benefits (Callan and Thomas 2007).

**Governance elements**

Rules and structures ratified by organisations sustainably managing their landscapes describe and endorse the subscribed values of these organisations. Managing values as *standards of behaviour* (Schotter 1980) or as *sets of rules* (Ostrom 1986) outlines approaches of self-governing institutions in the literature. Eight principles of sustainable *good governance* are endorsed by academics (Cumming et al. 2013; Wall 2014; Plummer, Armitage and de Loe 2013; Garamestani and Benson 2013; Zurba et al. 2012; Walker et al. 2006; Koontz et al. 2015; Teck et al. 2014; Sabetti and Aligica 2014; among others). These operate within distinct boundaries; have rules allocating resource access that is monitored and can be modified; are able to impose sanctions against rule violators, and operate simple and speedy conflict resolution forums, with recognised institutional authority not menaced by external authorities (Ostrom 1990). The eighth principle reiterates *polycentric* governance advantages for *common pooled resources* within larger systems (Ostrom 1999a). See Chapter 2 and indicator framework Table 11 at Chapter 4.

Institutions developing these principles internally are found more likely to entrench their significance (Ostrom 1990) than those organisations adopting principles that have been imposed (Burgman and Fox 2003). Successful governance adaptations for resilience of landscapes emerge from internally developed principles (Ostrom 1999). Adaptations are less likely to occur when management goals are imposed from without: – the so called *top down approach* (Cumming et al. 2013).

The adaptive capacity to manage resilience and change in social and ecological systems provides a measure of governance effectiveness (Koontz et al. 2015). Resilient and sustainable landscapes are those able to respond to demands upon ecosystems. This requires flexible governance open to learning how to do it (Cumming et al. 2013). The capacity of organisations to adapt to change are characterised by their legitimacy, transparency, empowerment, diversity of participants, and their recognition of social-ecological dynamics (Plummer, Armitage and de Loe 2013). Organizational ability to work out their own problems across a range of services and required products has been defined by the term *Polycentricism*
– inherent in self-governance and distinct from centralised legislative authority. Polycentric organisations are better equipped to manage change and desirable outcomes (Garmestani and Benson 2013; Ostrom 1999; Ostrom 1999a). People and organisations successfully govern social-ecological systems with actions that encourage resilience. A measure of effective governance adaptability is the capacity to manage resilience (Walker et al. 2006), where the resilience of a system is a calculation of the shocks it can absorb without becoming something else (Holling 1973).

**Indicators**

The following section discusses the development and use of indicators to identify and measure influences upon land that have repercussions for sustainable use and management of land. We observe indicators designed for specific landscapes measuring motivations, benefits and sustainability in local settings. This discussion is extended to the organisational use of indicator frameworks informed by clusters of indicators. These provide techniques in examining traditional Tiwi management structures at the conclusion of this Chapter.

**Land use indicators**

A United Nations definition provides “An indicator can be defined as a measure based on verifiable data that conveys information about more than itself.” (Hernández-Morcillo, Plieninger and Bieling 2013: 436). Dependable indicators rely upon the method adopted by the information gatherer and interpretation of the data gathered (Mayer 2008). Reliance upon indicators for landscape management, and the mandatory momentum of decision making processes of this kind, are widespread.

International standards require indicators capable of measuring impacts for sustainable land use. Environmental Performance Evaluation ISO 14031 includes the environmental objectives of land managers. Compliance is required of developers and corporations managing land. Melville Island forests are audited against Environmental Management Systems ISO 14001 and the attendant discretionary Environmental Management and Audit Scheme. Legislative requirements in Australia mandate the compliance of land managers with the Environment Protection and Biodiversity Conservation Act 1999.

Decisions, charters, conventions and protocols of the United Nations accelerate the use and measurement by indicators worldwide (Biodiversity Indicators Partnership 2011). These percolate to specific landscape interests as the United Nations
Convention to Combat Desertification (Ferrara et al. 2012). Regional governments have expanded the use of indicators in exploring their own interests. The European Union and Member States have adopted guidelines to establish standards of Global Sustainable Land Use (Fritsche, Eppler and Iriarte 2015). Some are influenced by non-government organisations similar to World Wildlife Fund and Conservation International (Walker et al. 2004).

Indicators have limitations as beacons navigating towards sustainable land management. Failure to identify the causes reflected in measurements capture an affect rather than the effect that indicators may claim. Causation is fundamental to a dictionary definition of effect (Collins 1986) and is a requirement for indicators claiming to measure effects upon land. They invariably involve human actions and responses, often difficult and expensive to evaluate (Ferrara et al. 2012).

**Indicators of motivation and benefit**

Indicators measuring motivations behind land use and benefits require studies of specific land forms including discovery of owner/manager ambitions. Indicators need expose and link behaviours with impacts interacting between conservation and development. Accurate indicators are claimed by incorporating the knowledge and advice of local land users and managers with ecological methods (Reed, Dougill and Baker 2008). Landscape approaches is a term applied to these combined investigative techniques where ecosystem studies alone are incomplete (Sayer et al. 2013).

Reliance upon indicators throughout Europe has led to adopted principles that guide their use. German Authorities, particularly, rely on ten principles [informed by other organisations and governments] to anchor indicator clusters for general applications. These rank the priorities of land users primarily seeking an equitable distribution of benefits and incentives (Korn, Bocmühl and Schliep 2011). These principles recognize different values of land and various needs and aspirations of users and managers. Implementation of principle centred processes rely heavily upon the quality and capacity of stakeholder governance. Indicators measuring compliance with principles are designed to enhance respect and consideration of land user decision making within deliberations of resource agencies (Sayer et al. 2013).

Indicators of landscape services have been used to capture environmental benefits for subsistence farmers that enhance community well-being in Africa. Findings confirm that farmers value those material assets that they rely upon; whereas more
non-material goods and services – social interaction, ceremony and cultural respects - are more highly valued by communities living in adjacent urban landscapes. (Fagerholm et al. 2012).

Indicators have also been used to evaluate New South Wales farmer motivations, behaviours, values and beliefs. Studies suggest pro-environment practices are influenced by motivations and perceptions of farmer own control over outcomes stimulated by these motivations. Pro-environment values are found to increase the likelihood of behaviours consistent with those values (Price and Leviston 2014). Purchasers of farm land for lifestyle purposes in the United States nevertheless record conservation and environment values but lack skills or knowledge to translate these to management actions (Sorice et al. 2014). Studies generally confirm that the level of resource dependency by land owners is a more predictive indicator of sustainable land management behaviours (Sorice et al. 2014).

One study reviewing the use of indicators confirms that those measuring benefit are applied most often to gathering information about the inspirational properties of landscapes and the educational and recreational opportunities these landscapes provide. This study further suggests a more pragmatic reason for the frequent use of indicators to measure benefits; – that economic evaluations are easier to assess (Hernández- Morcillo, Plieninger and Bieling 2013).

**Indicators of sustainability**

Sustainability is frequently defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (National Research Council of the United States 1999: 23) [endorsed extract from Brundtland Commission 1987]. Broad concepts generate meaning when reduced for applications in local settings. Enquiry and application of definitive measurements and analysis related to particular operating systems is required. Evaluating the sustainability of landscape systems examines their resilience to disturbances – how far can the system adjust before becoming another system (Holling 1973); the aspirations of land using stakeholders, and the boundaries and time constraints that contain these influences (Mayer 2008). Accumulated indicator data is not free from bias; - a bias that can be modified when transparently set within frameworks presented in qualitative aggregation formats (Mayer 2008).

Local indicators reflecting local conditions are essential among the world-wide variety of social, economic, cultural and environmental situations. Competent methodologies
position indicators in local settings to measure changes over time; the goals (aspirations) sought, and performance reflected (Weiland et al. 2011). Indicators are derived from applicable scientific concepts validated by involved owners, users and managers of land including governance administrators (Kopfmüller et al. 2001). Studies demonstrate that local knowledge involving natural and social sciences do enhance indicator robustness, notwithstanding challenges of inter-communication between groups, agreement of their common interests, and available and committed funding to undertake and continue these processes (Weiland et al. 2011). Processes measuring landscape costs are one thing; costs to land managers is another. Land user stakeholders may organise their own rules and processes when anticipated benefits from resource management exceed prevailing management and planning costs. These are not easy to measure (Ostrom 2009).

**Frameworks for indicators**

Setting indicators within frameworks are found to better accumulate transparent measures of social, economic and political influences (Mayer 2008). Among framework focused organisations the European Environment Agency has developed the DPSIR Driver-Pressure-State-Impact-Response framework where causes are identified as drivers to better inform the indicators (Nkonya et al. 2010). To standardise environmental reporting others focus on key performance indicators, some capturing the economic rationale and benefits of corporations (Hřebiček et al. 2011).

International standards require standardization of data base structures to validate data across various collection points. These reveal basic characteristics of what is being measured (Klug and Kmoch 2014). Critically, general frameworks and national monitoring programs depend on statistical consistency across social and cultural dimensions that are also blended with physical qualities of the landscape. Standardizing data collection improves navigation of social and geographic intersections and avoids differential comparisons providing easier interpretations by decision makers (Kienast et al. 2014).

Principles identifying organizational variables and social, economic and political linkages fit well within frameworks for resource governance (Ostrom 2009). Prior studies suggest, however, that principles adopted as rules for sustainable social-ecological systems found initially successful become inadequate over longer terms (Berkes and Folke 1998). Frameworks encapsulating principles with adopted rules are also found to decline in effectiveness within systems governed by traditional
societies. Reasons suggested are the extensive diversity of their own rules and the management costs they weigh against benefits perceived (Ostrom 2009).

Knowledge centred frameworks of sustainable land management include social and economic measures developed by the World Overview of Conservation Approaches and Technologies (WOCAT) (Schwilch et al. 2011). These initiatives, extended by the DESIRE project (a hybrid of DPSIR) of the European Union, expand WOCAT techniques. They address questions of sustainable land management through landowner workshops and questionnaires conducted by study teams. The aim is to improve understanding and adoption of sustainable land management practices.

Framework projects have been developed to encourage land management best practice. Reports of their difficulties and limitations include: communication with, and the participation of, landowner groups, especially those not members of an affiliated organisation; the training and skills of the study teams involved; the extensive detail of questionnaires, and the high costs involved that are resisted by funding bodies (Schwilch et al. 2012). Solutions are to embed these methods in government and organizational processes equipped with long term (inter-generational) budget commitments (Schwilch et al. 2012).

**Examining an influential indicator framework – DPSIR**

*DRIVING* forces result in environmental *PRESSURES* affecting the *STATE* of the environment with *IMPACTS* manifesting quality changes of the environment, that in turn elicit organizational and individual *RESPONSES*. Established as the DPSIR framework by the European Environment Agency in 1998 (Smeets and Weterings 1999) to analyse environment problems for quinquennial state of environment reporting, the framework evolved from earlier north American and UN agency formats. It has been widely adopted (Gari, Newton and Icely 2015).

Attributes of DPSIR are in defining relationships of cause and effect with links between the elements involved (Smeets and Weterings 1999). For example, economic linkages between *drivers* and *pressures* expose efficiencies of technology utilised in ecological systems. This is reflected by levels of production and consumption. *State* of the environment exhibit *impacts* on humans and ecosystems through yields and system thresholds generating a *response* to these evaluations. *Responses* are claimed capable of modifying the *drivers* alleged to be causing the *impacts* (Kristensen 2004).
Cautions do apply to DPSIR frameworks when used beyond their intended purpose. Respect accorded DPSIR [also used by the United Nations Environment Program] increase risks of perpetuating their limitations when applied without regard for their weaknesses (Carr et al. 2007). Dynamics in the linkages and relationships of cause and effect are not adequately caught in DPSIR frameworks (Rekolainen, Kamari and Hiltunen 2003). A summary of DPSIR limitations includes: the linear chain direction of information gathering; weak consultative pathways between clients and gatherers of information; imprecise formats used; the cloistered library effect of published reports, and definitional discrepancies across the framework (Gari, Newton and Icely 2015). The DPSIR typology is also inclined to embed the impotence of local knowledge and responses. Neither does it capture the influences of these responses in aggregation of them. Requirements for statistical consistency across the framework can produce unrecognizable data in local contexts where the interaction of nature-society relationships and local management occur (Carr et al. 2007).

Limitations have encouraged DPSIR modifications, amending monitoring and evaluating frameworks, and their methodologies. For example the restructuring of reporting formats through four phases of planning, communication, action and review of formal and informal communications (Ramos et al. 2013). The skills and emphasis of data collectors, however, remain prone to bias and validity beyond their sources and applications at local levels (Carr et al. 2007).

**Tiwi indicators**

Observations of changed task environments for Tiwi land managers, observed in Chapter 3, reveal strategies adopted exploiting these changes. Embedded within these strategies lie, not only the variables and relationships being exploited, but the beliefs and meanings motivating these transformations. Indicators are a technique exposing the composition of employed strategies. Their application attempt to reduce a measurement of clustered land management practices, features and processes to a single property capable of reflecting the attributes of the cluster. Tiwi clusters have coalesced around shifts from traditional sustainable land management. For example: when the community abandon reliance upon harvesting the resources; when relationships rewarding status for resource access change as direct harvest is abandoned; when resource benefits threaten the status of land managers; and when benefit sufficiency and sustainability calculations are adjusted. Chapter 2 describes the important influence of aspirations to manage traditional land in sustaining continued benefit from its use. Post-traditional land managers in Chapter 3 no longer assign such an integrated management role for aspirations beyond the benefits of
land use itself. Indictors set within governance and value frameworks at Chapter 4 disclose the critical contribution of aspiration management to landscape sustainability, among the other attributes and risks to be managed.

The indicator framework defined in this thesis for traditional Tiwi resource management contains three clusters. First, measures that reflect community satisfactions\(^9\) and interactions. Second, indicators informing resource capacity and availability. Third, management skills and performance measures. The framework confirms the predictability of resource-dependent landowners adopting sustainable land management practices (Sorice, Kreuter, Wilcox and Fox 2014).

Community indicators require measurements of two inputs – access to the resource and harvesting of the resource; and one output – approvals bestowed as status on land managers for performance. Access is a fundamental permission principle of Tiwi governance. Access indicators operate as stop/go constraints informed by seasonality for resource abundance; resource conditions at the time; conflict of other harvest expeditions planned; relationships and existing obligations of intending harvesters; group harvest techniques known to be used; purposes for this harvest at this time, and the availability of any alternatives.

Harvest indicators are subjectively assessed by satisfactions rated against abundance; ease of harvest; difficulties of resource locations, and accuracy of the managers’ advice. The output indicator is a measure of management performance validated by harvest results that acknowledge the skills and competence of the land managers.

Resource indicators require information of location, quantity and the annual cycles that enhance quality of all resources. Cultural analysis of *force majeure* and the success of recent harvests also inform these indicators.

Monitoring of management skills and performance combine indicators that measure and assess the acquisition and application of skills through a lifetime. Skills are proven prior to adulthood. Persons exhibiting these skills are elevated to positions of authority within a governance structure designed for the purposes of sustaining

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\(^9\) “Satisfactions” are those of consumers referred to in the literature as comprising three basic components: a response pertaining to a particular focus determined at a particular time. (Giese and Cote 2000). Consumers can be satisfied with one aspect and dissatisfied with another. Community satisfactions referred to above are focused on the advice provided by land managers reflected in the quality, ease and abundance of their actual harvests at a particular time.
resources. Governance effectively demands constant and unceasing sustainable land management.

The next chapter describes development and application of Tiwi decision strategies and the significance of aspirations in gathering information for decisions. The chapter includes geographic and resource detail of the Tiwi Islands in addition to the relationships and demographic features of the Tiwi people.
Chapter 2
Decision Making in a Human Population Living Sustainable

Abstract
The Tiwi people of northern Australia have managed natural resources continuously for 6000-8000 years. Tiwi management objectives and outcomes may reflect how they gather information about the environment. We qualitatively analysed Tiwi documents and management techniques to examine the relation between the social and physical environment of decision makers and their decision-making strategies. We hypothesized that principles of bounded rationality, namely, the use of efficient rules to navigate complex decision problems, explain how Tiwi managers use simple decision strategies [i.e., heuristics] to make robust decisions. Tiwi natural resource managers reduced complexity in decision making through a process that gathers incomplete and uncertain information to quickly guide decisions toward effective outcomes. They used management feedback to validate decisions through an information loop that resulted in long-term sustainability of environmental use. We examined the Tiwi decision-making processes relative to management of barramundi \textit{lates calcarifer} fisheries and contrasted their management with the state government’s management of barramundi. Decisions that enhanced the status of individual people and their attainment of aspiration levels resulted in reliable resource availability for Tiwi consumers. Different decision processes adopted by the state for management of barramundi may not secure similarly sustainable outcomes.

Introduction
Most management and environmental decisions are based on fragmented, anecdotal, and incomplete information. The principles of adaptive management suggest that managers should keep their decision options open, gather data to discriminate among competing explanations of biological processes, and test whether alternative management strategies achieve objectives (Linkov et al. 2006; Lyons et al. 2008). However, there are few examples of the successful application of these principles (Walters and Holling 1990; Keith et al. 2011). In practice, managers often establish operational processes that are difficult to change before the adaptive-management cycle can be iterated.

Information-gathering processes and the aspirations of those making decisions influence decision making. Many natural-resource managers define the utility of a
decision in terms of yield, revenue, or some other quantitative ecological measure, and then select the option with the greatest expected value (e.g., Costello and Polasky 2008).

Until recently, this maximization approach dominated the management of fisheries worldwide (see Punt and Hilborn 1997). The idea is that people decide on a management action [e.g., which fish to catch] by assessing the expected value of the various options available to them. For example, barramundi [Lates calcarifer] are an important cultural and food resource for many people in northern Australia. A person may assess fishing barramundi versus other species by weighting the utilities of these options [e.g., the net revenue from fishing barramundi versus the revenue from fishing other species] on the basis of their probability of occurrence [e.g., the probability of gaining the revenues associated with barramundi versus other fishes]. A rational decision maker would try to maximize benefits by choosing the option with the greatest expected value.

Some alternative strategies for managing natural resources do not rely on maximization approaches (Punt and Hilborn 1997), for example, adaptive management and ecosystem management (Holling 1978; Smith et al. 2007). These approaches have been applied in many contexts, including in the management of harvested populations (Nichols et al. 2007).

The Theory of Bounded Rationality

When people make decisions, they are limited by available information, the cognitive limitations of their minds, and the limited time they have to make a decision. The theory of bounded rationality recognizes these limitations and suggests that people often make decisions to satisfy basic aspirations rather than to optimize the expected value of the outcomes (Simon et al. 1958; Simon 1978), especially when there is great uncertainty in observations and causal relations. For instance, Simon (1958, 1978) proposed that people follow a simple “satisficing strategy,” one that is sufficient to achieve a goal, rather than one that is optimal (Simon 1991; Gigerenzer and Selten 2001).

According to Simon and other proponents of bounded-rationality theory, optimization is rarely possible in the real world. In most practical circumstances, humans do not have the knowledge and information-processing capacities that are typically needed to compute optimal solutions. In addition, optimal solutions are often fragile in the sense that if estimates of expected outcomes are slightly wrong, then benefits may
be much less than expected. A satisficing strategy requires ways of making decisions that aim to deliver specified minimum satisfactory goals, thereby minimizing the effects of uncertainty on outcomes. For example, when assessing whether a particular fish species may be harvested, the decision maker assesses whether there are sufficient fish to satisfy the immediate needs of the individuals making the request [their aspirations]. If there is an appreciable chance that satisfactory goals will not be met, the decision maker may deny access to this species and suggest an alternate resource.

To find such approximate and satisfactory solutions, people use a class of simple rules and strategies, termed heuristics [or rules of thumb]. Heuristics are “any principle or device that contributes to the reduction in the average search to solution” (Simon et al. 1958:22).

Ideas of satisficing and decision heuristics provide a foundation not only for the notion of bounded rationality as Simon developed it, but also for a host of successful applications and theoretical extensions. One of these extensions, the “fast-and-frugal heuristics” framework (Gigerenzer et al. 1999), could be used to explain how and when human reliance on simple decision strategies [i.e., fast-and-frugal heuristics] can result in behaviour that reflects adaptive-management principles. This framework assumes not only that rationality is bounded, but also that people’s decision strategies are ecologically rational. Being ecologically rational means that a strategy exploits the structure and attributes of the context in which a decision is made; that is, decision strategies account for the so-called task environment (Gigerenzer et al. 1999), including the aspirations of stakeholders, the extent and reliability of information, predictable environmental patterns, and the availability of alternatives.

For example, there is evidence that people exploit the task environment to make judgements about future events or unknown quantities by relying on patterns such as the frequency with which they have encountered information about a particular topic before. For instance, the frequency with which one hears the name of an object [e.g., the frequency of hearing the name of a clan member] might serve as a cue to make inferences about the associated object [e.g., how powerful that clan member is]. In doing so, people can make relatively accurate estimates and fast decisions (Marewski et al. 2010; Gigerenzer et al. 2011). By exploiting the task environment, these simple decision strategies can render decision making faster and more accurate than more complex techniques that require more information, such as
machine learning, artificial intelligence, and optimization approaches (see Gigerenzer and Brighton 2009 for an overview).

Despite these developments, the field of resource management is, arguably, still dominated by maximization approaches. The natural resource management strategies of the Tiwi people of northern Australia illustrate an alternative, successful, approach to conservation.

The Tiwi

The Tiwi people inhabit 760,000 ha, primarily on 2 large islands—Bathurst and Melville Islands, off the northern coast of Australia’s Northern Territory. They also own and have access to 5 relatively large and a number of smaller islands covering 40,000 ha [total management area 800,000 ha]. Rising sea levels separated these islands [highest elevation 200 m] from mainland Australia between 8000 and 6000 years ago (Peterson and Taylor 1998).

Tiwi were isolated until interaction with Indonesian, Dutch, British, and possibly Portuguese sailors in the seventeenth century. The Tiwi population size was estimated to be around 1500 in 1910 (Peterson and Taylor 1998) and 2000 during the past 100 years (Clancy 2009). Tiwi consumed fish, birds, macropods, reptiles, wild honey, and yams and other vegetables (Hart 1930). The Tiwi thus were self-sustaining for at least 6000 years (Bowdler 1995; Sim and Wallis 2008). Observations by early explorers (Swaardecroon et al. 1705; King 1818) confirm that these resources were readily available to the Tiwi. More detailed studies by social scientists living among the people and able to converse in Tiwi have provided insights into governance and management techniques (Hart 1930; Pilling 1978; Venbrux 1995).

Tiwi culture lends itself to a study of sustainable resource management for at least two reasons. First, the Tiwi have not constructed a language of numbers and have no language for probabilities—concepts that are fundamental to maximization approaches that assume decision makers weight the utilities of the various options available to them [e.g., revenues of fishing different species] on the basis of the utilities’ probabilities of occurrence (e.g., Linkov et al. 2006). The Tiwi process of gathering and representing information for decisions instead relies on simply communicating whether resources are satisfactory for immediate needs—a strategy that is consistent with the aspiration levels sought through the satisficing heuristic.
Second, decision-making processes of the Tiwi differ from those of Australia’s Northern Territory government. Government uses more conventional maximization approaches that rely implicitly on estimates of the size and productivity of harvested populations. We sought to describe Tiwi decision processes and relate them to the theory of bounded rationality. We contrasted Tiwi sustainable resource management with more conventional resource management prescriptions. Lastly, we considered why the Tiwi management strategies deliver long-term sustainable resource management.

**Methods**

We used 4 primary sources of evidence to explore the Tiwi decision-making strategies. The first source was the large number of scientific and other relevant literature [published between 1705 and the present, many of which appear in the citation list below]. We focused on the evidence-based conclusions of scientists whose field work on the Tiwi exceeded 2 successive years (Davis 1983; Venbrux 1995; Wightman 2001) or, in 3 instances, was over 30 successive years (Hart 1926-1960, Pilling 1928-1978, and Goodale 1966-1998).

Second, we used decisions over 35 years (1977-2012) documented in Tiwi Land Council [TLC] proceedings collected by the Australian National Archives, Canberra, and compiled into 29 annual volumes. We supplemented TLC proceedings with 32 Tiwi Land Council Annual Reports 1978-2011 held by the Parliamentary Library of the Parliament of Australia, Canberra.

The third source was 26 years of personal, direct, continuous, daily interactions and observations by one of us [J.H.] with 3 generations of the 40 Tiwi Big Men who represented all Tiwi landowning groups and their families (1986-2012). Tiwi Big Men have particular knowledge of resources, are deferred to in decision making, and govern access to and use of natural resources allocated among 100 or so families occupying 8 geographic regions across the islands. Deference to this authority is enforced by strict behavioural rules and penalties. We also refer to these individuals as the Tiwi natural resource managers. Their status and skills are personal assets that cannot be inherited or bequeathed. Each generation finds, tests, and validates their Big Men through youth training [over 8-12 years] and tests their abilities within families prior to participation at communal forums. The Tiwi community accords these individuals elevated social status. The prestigious status of resource managers is reinforced by the availability and maintenance of resources under their stewardship.
Fourth, we used records of discussions and resource management decisions collected in poems, songs [many contained in over 300 booklets published by the Nguiu Literature Centre, Bathurst Island], and notes of boards, committees, and forums owned by the Tiwi Health Board, Tiwi Education Board, Tiwi Training and Employment Board, Tiwi Land and Marine Rangers, Tiwi College, and the 24 private corporations that have been developed and sustained by the Tiwi people.

On the basis of a qualitative assessment of the data, we constructed a model of Tiwi decision making [Figure 3]. Our model reflects some recent developments in decision theory. Specifically, we documented current Tiwi resource management procedures [Table 1] and explored their relation with bounded rationality and information-collection processes.

To illustrate the model, we considered management of barramundi, a major food source. Management of this resource is an increasing source of conflict between different interest groups in the Tiwi Islands (Northern Territory Fisheries Status Reports 2010). We contrasted information gathering and decision-making procedures of Tiwi decision makers and other fisheries managers.

There is no guarantee in qualitative analyses that biases in the examination of materials do not exist. Thus, our objective was not to present a fully developed and validated theory of Tiwi sustainable resource management. Rather, our results represent an effort to create hypotheses that may be tested subsequently. Thus, although there is no direct tie to structured data, our qualitative assessment of the sources outlined above has generated a testable, relevant, and valid model (Huberman and Miles 2002).

**Results**

Results of detailed anthropological and ethnographic studies over the past 100 years (Hart 1930; Goodale 1971; Venbrux 1995) show in general that the Tiwi aspire to prestige and influence. For example, Hart and Pilling (1960) note prestige and influence dominate Tiwi political processes. Goodale (1971) suggest that all Tiwi strive for personal achievement. Venbrux's (1995:25) observations confirm these earlier conclusions.

Our direct observations and documentary analyses indicate that among the Tiwi, accruing surplus food enhances prestige. Quantitative analysis of adjacent mainland aboriginal households at Fitzroy, Daly River, and Pine Creek indicate that over two-
thirds of commonly harvested species, including barramundi, are not consumed exclusively by the households that harvest those species (Jackson et al. 2011). Wightman (2001) describes how cooking and distributing food are organized by Tiwi. The hunter is obliged to cook while the prestigious landowner supervises cooking and is offered the best cut. Surplus barramundi harvests accrue prestige to a Tiwi as a provider beyond the person’s immediate family. Surplus is possible only if the land manager [the responsible Big Man] has been able to manage harvest activities to sustainable levels; and he can only do this by gathering information on the current status of the fish population and by applying cultural compliance measures that restrict access and use.

Permission and access rights are exercised within complex Tiwi governance and risk-management structures. Environmental management decisions must respect relationship bonds. For example, the most skilled fishing partners may not be granted permission to fish if they do not satisfy complex relationship priorities. Surplus harvests reinforce relationship bonds. For instance, sharing a fish catch with culturally distant friends, without first providing for more immediate family, can invite trouble for those caught doing it (Puruntatameri, M. 1995). The model we propose to represent the simple, efficient, and sustainable system of resource management used by Tiwi managers creates a feedback loop in which the status of managers encourages them to make decisions to ensure the ongoing availability of critical resources that satisfy vital needs [Figure 3; Table 1].

Resources are subject to access that can be granted or denied. For example, a family used axes to cut trees [an action for which they had not sought permission from the responsible Big Man] instead of climbing trees for foods and fruit. This action required meetings of managers (Pilling 1958) and the presentation of arguments. The community reached a consensus on legal sanctions that resulted in the family’s prestige being diminished. Penalties included having their authority over harvest rights for other resources being allocated to another family group (Kalippa et al. 2008). The ideal strategy for any Tiwi manager [Big Man] is to accumulate ongoing prestige and influence by ensuring the availability of the resources under his control.
Managers monitor the status of resource stocks, advise the community, and grant access. Harvest information validates the manager's knowledge. The role of manager is prestigious and reliable managers are afforded elevated status. Arrows reflect the flow of information between the system elements.

In the Tiwi management system, experienced decision makers “... re-assess the situation every time new and relevant information comes to them. This leads to a consensual redefinition of what is going on” (Venbrux 1995:178). Big Men deal with new information and uncertainty by frequently revising and amending the details of assessments. Thirty-five years of Land Council minutes show continual revisiting and recrafting of numerous decisions. Permission to fish in Tiwi creeks and estuaries, for example, was discussed at over 600 meetings. Seeking and gaining permission remains the consistent principle. For example, meetings of the Land Council through October 2011 considered permission to access areas of Bathurst and Melville Islands. The meetings considered a range of new applications from township residents, visitors, contractors, and invitees seeking access for fishing. These deliberations required daily renegotiation of broader social relationships, economic and personal influence, and any number of family and individual advantages.

In all these negotiations, Tiwi managers dealt with pervasive environmental uncertainty by using past experience to guide decisions aimed at attaining satisfactory outcomes. Managers did not attempt explicitly to predict the future, but prediction was implicit in their ongoing responsibility to know where and when critical resources may be accessed.

There were no examples in the materials we examined of decision makers attempting to estimate population sizes or maximize expected value. The Tiwi have no language for numbers and no way of computing probabilistic forecasts. Instead, managers are rewarded when they satisfy family and community demands for reliable access to...
sufficient resources. Big Men may have many wives only if they can provide surplus (Cook 1994), itself an outcome of reliable judgments (Tipungwuti, R et al 2008). Venbrux (1995:28) notes how influential Tiwi men sometimes obtain an exceptionally large number of wives. Earlier Pilling (1958:244) stated, “T. was an important Tiwi ‘big man. ‘Like C., with 25 wives, he was a man of importance and prestige.”

In the wider Northern Territory community, commercial and recreational fishing is attractive to many people. Recreational fishing is unlicensed, and there are few restrictions on access to waterways and fisheries. Recently, Tiwi decision makers have been under government pressure to abandon their traditional permission principle in favour of government management principles. This suggestion threatens pathways to prestige. In response, landowners have affirmed their interests to protect the traditional principle. Tiwi meetings through 2011 assert that the principle is non-negotiable but allow exploration of complementary pathways to prestige and influence consistent with permissions and consents. For example, government funding of infrastructure projects may elevate the prestige of land managers in remote areas and relax access rules (Tipungwuti, R. Tiwi Land Council Minutes 1978-2014).

Managers monitor the condition of natural resources. Evidence they use includes resource conditions relative to those expected for the season, success of recent harvests, and the presence of habitat or breeding conditions for harvested species such as barramundi. When community members are granted access and harvest the resource, they report the abundance of the resource to the community, thereby validating the manager’s decision. Access may be denied on a number of grounds including the time of year; condition of the resource; purpose of expeditions and planned harvest techniques; relationships of people involved, including their indebtedness to particular land owners; and the availability of alternatives. For example, when authority was sought for access to barramundi populations that managers considered at risk of depletion, they invoked river closures as a mark of respect for a deceased relative (Wonaeamirri. Goose Creek Closure, 2010 TLC minutes).

To summarize, Tiwi language defines a prestigious land manager, *aluwura murrakupuni*, as one whose prestige flows from his ability to maintain the resources of land and on whom people can rely for their well-being (Lee and M. Puruntatameri, 2010 TLC records). A manager’s status is reinforced and authority over access is reflected in the punitive actions taken toward people who breach protocols [Figure 3]. The feedback loop encourages managers to make decisions that lead to reliably
available resources. They are encouraged by the feedback mechanism to monitor and satisfy community demand, thereby increasing the chances that critical resources will be available in the future. The concept of well-being is “crucial to the integrity of (Tiwi) relations with their estates” (Jackson 2004:220) and with each other. Stock depletion of a prized species diminishes the manager’s well-being and status by limiting surplus sharing (Davis 1983; Jackson et al. 2011).

The Barramundi fishery

There is evidence that harvesting practices over the last 50 years [by non-Tiwi consumers] have depleted barramundi stocks. For example, in 1972 a survey of Melville Island found abundant fish in the river system (Messel et al. 1980: 21–22). Five years later (1977), there were few fish in the same system; researchers speculated the decrease in abundance was the result of illegal poaching and the continuous presence of professional fishers (Messel et al. 1980).

The actions of poachers in the system and the imposition of commercial harvest outside the control of traditional decision makers affect Tiwi management of these systems (Northern Territory Government Fisheries Status Reports 2010). Resources are taken independent of the feedback loop [Figure 3] that links satisficing performance to the individual prestige of the Tiwi decision maker.

Under government management of the barramundi fishery, regulations are triggered by 20 percent increases or decreases over 2 years measured in terms of monetary value, catch, or effort and client satisfaction statements (Northern Territory Fisheries Status Reports 2010). This approach differs from Tiwi decision strategies because it omits personal responsibility and requires quantification of abundance of fish. Currently, professional fisheries in the Northern Territory of Australia harvest about 416,000 saleable [or plate-sized, usually 330-800 gm] barramundi [and a total of about 625 tonne] annually. Recreational anglers harvest another 100,000, whereas indigenous estuary owners across the same territorial waters may gather up to 44,000 barramundi annually (Northern Territory Government Fisheries Status Reports 2010). In 2009 the Northern Territory government issued 20 professional licenses to harvest barramundi in Northern Territory waters. In response to declining stocks, the government decreased the number of licenses in 2010 by 4. Future area closures to commercial barramundi fishing are being considered (Northern Territory Government Fisheries Status Reports 2010).
Licenses contribute to effective management; however, noncompliance is a serious problem. There are few incentives to comply with license conditions, apart from the punitive actions government may take if offences are detected. Compliance infractions in the commercial sector include the use of gill nets, fishing in closed waters, exceeding catch limits, retaining undersized barramundi, and fishing in seasonally closed areas (Northern Territory Government Fisheries Status Reports 2010).

Potential for conflict between aboriginal landowners in coastal zones and state government arose following a decision of the High Court of Australia (Northern Territory of Australia v Arnhem Land Aboriginal Land Trust 2008) that allowed continued management and regulation of coastal fishing by the Northern Territory government but granted Tiwi ownership over those resources in streams, creeks, and estuaries surrounding the islands they inhabit. The effect is that fishing is governed by a licensing and management regime that is guided by conventional government regulation. However, access is legally constrained by owners whose decisions aim to satisfy their own aspirations, rather than maximizing expected values or responding to quantitative management triggers.

Decision strategies under uncertainty depend in part on simplicity, itself an important feature of effective searches for satisfactory solutions (Todd and Gigerenzer 2007). For example, discussion of environmental management issues at a Tiwi Land Council meeting in 2010 recommended management to increase abundance of barramundi in the fishery. Traditional rules of access were reiterated and a restrictive access regime imposed for the restoration of and abundant supply of barramundi (Wonaeamirri. TLC minutes 2010).

Introduced tools [fish hooks, axes, and guns], all readily available to Tiwi and capable of increasing harvest efficiency, some for over 200 years, were rarely used. We speculate that none could increase harvest levels sufficiently to supersede the goal to satisfy essential demands and to enhance prestige and influence of the land manager.

**Discussion**

Tiwi management strategies address the present exclusively; the future is managed implicitly by the incentives for managers to provide reliable, ongoing access to critical resources. There is no analogy in Tiwi culture for foresight or scenario analyses. Both the Tiwi management practices outlined above and adaptive-management theory
(Linkov et al. 2006) acknowledge that decisions should not foreclose on future options. We speculate that Tiwi decision-making processes and decision strategies accord with the principles of bounded rationality.

We acknowledge that our current analyses are by no means complete. More rigorous, quantitative analyses are necessary to test our model and extend our analysis. For example, careful observational studies and statistical analyses may reveal a broader spectrum of decision-making strategies deployed by Tiwi decision makers, environments to which these strategies are adapted and situations in which these strategies lead to effective decisions.

There are 3 lessons to be learned from our assessment of Tiwi management systems that may assist in successful use of adaptive management. First, decisions on natural resource management may improve if they are personalized in the sense that they become the responsibility of an identifiable manager who monitors the natural system, is responsible, and is seen to be responsible for the outcomes of decisions. Second, decisions may improve if managers who make good decisions are rewarded in ways that encourage them to manage the system to improve its condition. And finally, decisions may improve if verified performance is related directly to prestige. Our evaluation of Tiwi systems suggests that these social prescriptions are at least as important as are the technical aspects if adaptive management systems are to be deployed effectively for environmental management and conservation in the long term.

Table 1 - Sample of evidence illustrating the decision-making system for sustainable management outlined in Figure 3

<table>
<thead>
<tr>
<th>Decision process</th>
<th>Quotations, statements, and observations*</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access and sanctions</td>
<td>Many knew where the large mud mussel grow.</td>
<td>Wightman 2001: 69</td>
</tr>
<tr>
<td></td>
<td>But J. said others cannot go without permission.</td>
<td>W. Kerinaiaua, 2010</td>
</tr>
<tr>
<td></td>
<td>We must protect your own land. It is risky for other people to go without permission.</td>
<td>TLC (Tiwi Land Council) records</td>
</tr>
<tr>
<td></td>
<td>C. and P. traveling together through X.’s land when P. decided to burn the grass. C. distanced himself from P. who was later punished for youthful disrespect.</td>
<td>Pilling 1958: case 59</td>
</tr>
<tr>
<td>Status and reward</td>
<td>Only clever Tiwi know all the plants and animals. They are Big Men. Women too.</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A dominant Big Man devoted his adult life to accumulating wives.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ceremonial foods, yams, and most meats and fish, together with legal sanctions relied upon men with recognized privilege.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power and prestige is gained by Tiwi Big Men by utilizing resources to manipulate kinship relationships.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prestige and influence accrues to those with best knowledge of growth, seasonal variations, and best harvest time.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male leaders [Big Men] can declare a new rule. T. gained general approval for a new rule and his right to punish breaches was not disputed.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Harvest (validation)</th>
<th>Up to 300 Tiwi attend ceremony. They come from other Tiwi regions.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>When you go to ceremony you can get ochre and see the country belonging to other people. No</td>
</tr>
</tbody>
</table>

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<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Pupungamirri, 1983 TLC records</td>
<td>Pilling 1958: 48</td>
</tr>
<tr>
<td>J.B. Pupungamirri, 2001 TLC records</td>
<td>Cook 1994: 16</td>
</tr>
<tr>
<td>Goodale 1971: 337</td>
<td>Pilling 1978:89</td>
</tr>
<tr>
<td>Davis 1983:12</td>
<td>M. Wonaeamirri, 2003 TLC records</td>
</tr>
</tbody>
</table>
problems. They all want Magpie Geese when they come here.

Activity within households may have occupied up to 40 weeks of the year leaving 12 or so weeks for collective activity and ritual outside the household.

We must get dugong, turtle, and fish. Buffalo too for people coming for ceremony. Big shame for us without the food for visitors.

On the bark are marks for sponges on the rocks, crocodiles, turtles, octopus, and crabs near the Imalu Creek. People know what’s there.

I put mussels in the basket and came back and told everybody. “Look what I brought from Wulinto. Plenty of Mussels.”

<table>
<thead>
<tr>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>The mimosa is flowering. Now the terns will arrive, and their eggs will be ready to harvest.</td>
</tr>
<tr>
<td>Now is not the time for turtle. The big moon brings crabs up on the high tide. We get crabs today.</td>
</tr>
<tr>
<td>The 3 main seasons each have recognizable variations, all with flowerings that signal, for example, when possums are fat because they feast on such flowers.</td>
</tr>
<tr>
<td>The Emerald Dove calls to signal it is time to harvest Muranga yams.</td>
</tr>
<tr>
<td>We need to restrict the tern eggs this season. Too many outsiders getting them. Not so many terns arrived this year.</td>
</tr>
<tr>
<td>C. was a real Big Man. I remember as a kid seeing him alone in a canoe or in the bush, sometimes fishing but mostly just checking up on things.</td>
</tr>
</tbody>
</table>

| Hart et al 1988 |
| J. Tipungwuti, 1995 TLC records |
| Davis 1983:105 |
| J. Puruntatameri, 1981 TLC records |
| C Kalippa, 2009 TLC records |
| W. Kerinaia, 2010 TLC records |
| Wightman 2001:144. |
| Wightman 2001:44. |
| 1998 TLC minutes |
| L. Tungatulum & R. Tipungwuti, 2011 TLC records |
| **Consequence of Poor Management decisions.** | Tipakalippa families use new introduced steel axes to wantonly cut trees instead of climbing them for fruits and small animals. Confronted by Warlapinni families who sought meetings to assert their better management practices. They successful and rights and prestige shifted to Warlapinni.  

“I stand at Fourcroy with half my face.” Cousins and relatives have left an area considered vulnerable to illegal access and not correctly managed.  

Amalgamation of land units from 13 in 1980 to 8 unchanged since 1995 are a landowner response to intrusion and impacts unable to be managed by scattered and smaller family groups.  

Large vessel enters Shark Bay 15 April 1982. Group land without permission or consent. Meetings discuss regular nature of these illegal landings. Wulirankuwila complain they cannot stop these landings. However meetings reduce the influence of Wulirankuwila people and the ascendancy of adjacent Yimpinari people. Wulirankuwila considered to have lost significant authority and were lesser people. | C. Kalippa, 2009 TLC records  

J. Puruntatameri, 1980 TLC records  

TLC minutes 1978-2011  

Davis 1983: 89 |

*Note:  
Examples selected as representative of frequent interactions and cultural norms among Tiwi*
Chapter 3

Plantation Forestry and Economic Development in the Tiwi Islands

Abstract
The maritime borders of Australia include over 8,000 islands. The second largest of these – Melville Island 5,786 km² together with the fourth largest – Bathurst Island 1,693 km² [and a number of tiny outlier islands] comprise the Tiwi Island group within the Northern Territory. Since 1960 seven investment groups have attempted to develop forestry plantations on Melville Island. The Tiwi landowners and the investors have sought sustainable outcomes from plantation forestry. Fifty years’ experience has provided a range of data and understanding that informs the Tiwi Plantations corporate model developed by landowners. Three substantial independent financial appraisals of the Tiwi islands forestry project have been undertaken by Poyry Forest Industry Pty Ltd in 2009, 2012 and 2014. All analyses were for a single rotation of A. mangium, and they provide useful guidance about the economic merit, from a private investment viewpoint, of establishing, growing and harvesting this species over a series of ten year cycles of forest plantation on Melville Island.

In this chapter, a social benefit cost framework is used to appraise the potential contribution to Tiwi Islanders of plantation forestry on Melville Island. Analysis of the priced benefits and costs of investment of a ten year cycle of A. mangium under most likely yields and prices indicates that the investment in Acacia plantation forestry has a 35 per cent probability of earning a 4 per cent p.a. or greater real return on capital. To double the odds to two chances in three of earning the annual required return of 4 per cent real return on capital, an additional $100m of unpriced benefits need to be generated over the forty years life of the plantation rotation. This would require unpriced annual benefits of $5.1m or $2550 per Tiwi Islander.

The Tiwi Islanders currently have 30,000 ha of mature Acacia to harvest. They have relatively small landowner debt to service, an established port and confirmed buyers. Re-investment of the cash returns from the current harvest into more plantation forestry to secure future community benefit is not a compelling attraction; re-investing these revenues to grow-out Acacia over further rotations is unlikely to benefit landowners as much as investing the proceeds in a sovereign wealth fund.
Introduction

Bathurst and Melville islands lie 80kms north of Darwin in Australia’s Northern Territory. These two large islands with eight smaller outlier islands comprise the Tiwi Island Group containing 800,000 ha of land secured under Statutory Aboriginal Freehold Title enacted in 1978 (Australian Government Gazette 1978). Two thousand Tiwi people are registered as owners (Clancy 2014). Following a series of corporate misadventures, the Tiwi Islanders have ended up being owners of the plantation forestry activity that exists on their land.

Plantation forestry was commenced on Melville Island in 1960 and has expanded to 30,000 hectares in 2015 representing 1.5 per cent of the total Australian plantation forestry estate and over 3 per cent of the hardwood species estate (Bureau of Rural Sciences 2014). In 2014-15 the Melville Island Plantations are ready for initial harvest. Since 2012 interested buyers of wood chip from the plantation have informed themselves of density values and other crop qualities. They have also explored infrastructure constraints and operational capacity leading up to harvest. On 10 February 2014 Mitsui completed a memorandum of understanding [MOU] with Tiwi landowners confirming contractual intentions for five year’s purchase and supply of Acacia chip valued by the parties in excess of $220m (Tiwi Plantations Corporation 2014). Sales income will retire all Tiwi plantation debt by 2018, excluding any additional decisions and costs of replanting (Tiwi Plantations Corporation 2014).

The purpose of this chapter is to investigate the medium to long term economic merit of Acacia plantation forestry\(^\text{10}\) as an economic activity on land owned by the Tiwi Islanders. This question is viewed from two perspectives. First the investment options from the perspective of private investment risk are assessed using private Benefit Cost Analysis methods. Second the Melville Island estate is viewed as an economic industrial asset, rather than a simple financial asset, using a Social Benefit Cost framework. The merit of re-investing the proceeds from the current plantation in a renewed cycle of Acacia is analysed, identifying the expected returns on such an investment and identifying the size of the unpriced social benefits that would be required to make the investment a sound use of the resources involved. This use of resources – renewed plantation forestry with associated social benefits - is then compared with the alternative of establishing a Sovereign Wealth Fund from harvest

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\(^\text{10}\) The Melville Island Plantation Estate comprises Acacia (A. mangium) and is evaluated in this chapter as the plantation of that species now ready for harvest. Tiwi Plantations Corporation has aged trials and blocks of a more promising species established since 2009. Performance of this species is encouraging.
proceeds of the current plantation, coupled with leasing the land to private investors and obtaining associated social benefits from this source.

**Background**

**Location**
The Tiwi Islands Forestry Project is located wholly on Melville Island. It is strategically close to Asian markets [Figure 4].

![Figure 4 - Location within the Region – Shipping days travel](image)

**Climate and Soils**
The Tiwi islands have a tropical monsoon climate with distinct wet summer and dry winter seasons. The islands receive over 2,000 mm towards the northern tip of Bathurst and Melville Island decreasing to 1,200 mm in the east of Melville Island. In excess of 95 per cent of rainfall is received between October and May [Figure 5]. On average during the dry season less than 30 mm is received per month. Mean maximum temperatures [30-34 degrees C.] remain relatively constant throughout the year, whilst mean minimum temperatures vary between the wet and dry seasons.
The soils on the Tiwi islands are predominantly derived from sandstones. Van Diemen Mesozoic (Australian Stratigraphic data base 2012) - very fine sandstone, is the main aquifer. It is recharged every year with the abundant wet season rainfall sustaining ample and reliable water throughout the Islands. The soils derived from these geological features are highly weathered and variable in depth. Soils derived from transported material are often deep: soils developed in situ are more variable. Texture ranges from sands to light clays, some with gravel. Nutrient status is variable but generally poor. Most soils are acid, high in aluminium and iron, and phosphorus fixation capacity often high. The soils are periodically saturated and root development is naturally limited by density [transported soils] or by rock in situ (Hadden 2004).

**Estate and Species**

Tiwi plantation forestry commenced in 1960 with 3.6ha of Cypress [*Callitris intratropica*] planted (Sprengel 1985). Caribbean Pine [*Pinus caribaea var. hondurensis*] was planted in 1973 when the initial Cypress trees did not grow well (Sprengel 1985). By 1978, when the Tiwi landowners secured title to their land, 1600ha of Cypress and 1210ha of Caribbean Pine plantation (Sprengel 1985) had been planted. In July 1986 the plantation managers and developers at the time [the Northern Territory Government] withdrew from Melville forestry (Northern Territory Government 1986). At this time the Melville Island plantation estate was 4,000 ha,
including 1,200 ha of research plantings, provenance and species trials and ineffective plantation defined as trees incapable of producing ten cubic metres of marketable product per year for a twenty five year rotation (Haines 1986). The initial business model was based on growing saw log timber. This model concluded that a plantation estate of 42,800ha would be required to establish a viable forestry plantation industry on Melville Island (Montefiore 1986).

The strategy has changed through the past twenty years, with economic models now favouring wood chip products. A significant majority of the plantation estate comprises *Acacia mangium* [Table 2]. *A. mangium* was first planted commercially on Melville Island in 1998 [small pilot plantings occurred in the 1980s and in 1997]. The *A. mangium* plantation estate continued to expand to 5,200 ha after the 2004 planting season. At this time [early 2005] Cyclone Ingrid passed over the island damaging most of the plantation estate over the age of eighteen months. The current *A. mangium* stands were planted between 2003 and 2008 – over 50 per cent of the entire estate in the two years’ post cyclone 2005-6. In light of the impacts of Cyclone Ingrid, a strategy of diversifying the plantation estate spatially across the landscape within and among age classes has been employed [Figure 6].

![Figure 6 - Plantation of scattered compartments – managing cyclone risks](image)
The older *C. intratropica* and *P. caribaea* plantation estates remained largely intact after Cyclone Ingrid although the less viable areas of these plantations have reduced in size as a result of harvesting and replanting to *A. mangium*.

<table>
<thead>
<tr>
<th>Table 2 - Species by planting year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Species</strong></td>
</tr>
<tr>
<td><em>Acacia crassicarpa</em></td>
</tr>
<tr>
<td><em>Acacia mangium</em></td>
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<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td><em>Callitris intratropica</em></td>
</tr>
<tr>
<td><em>Pinus caribaea</em></td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

*A. mangium* is a fast growing, nitrogen fixing hardwood which is native to coastal northern Queensland, Papua New Guinea and Indonesia. Where found naturally, *A. mangium* can be a large dominant tree over 30m tall with a straight bole extending well up into the crown, with diameters over 50cm. (CABI International 2003).

*A. mangium* has been widely planted in the tropics, particularly Indonesia, Malaysia, Vietnam and Laos for the production of wood fibre and for the manufacture of pulp and paper products. There are over two million hectares of *Acacia* grown in plantations in South-East Asian tropical regions (CSIRO 2011) with *A. mangium* most dominant. *A. mangium* is ideally suited for plantation pulpwood production in the tropics due to its fast growth [potential volume increments over 30 m$^3$ ha$^{-1}$ yr$^{-1}$]; tolerance for low nutrient and acid soils; relative resilience to weed competition [i.e., grasses and broadleaves]; relative pest and disease resilience; and wood properties making it suitable for a range of uses (Turnbull, Crompton and Pinyopusarerk 1998).

Pulp yields [Kraft sulphate analysis] range from 47-57 per cent with air dry density of 500 - 600 kg m$^{-3}$. *A. mangium* is classed as a light hardwood with low to moderate strength properties. The timber is known to have a close grain, is relatively stable during sawing and drying, and is well suited to cabinetry and joinery.

**Investment for Establishment**

Since 1960 expectations of seven investment developers and managers who have established the Melville Island plantations relied upon varying estimates of yield.
Table 2 shows the range of yield expectations on which these investors based their decisions. Tiwi land owners supported these investors (Tiwi Land Council 1978-2014) in actively attracting private investment of over $250m for plantation forestry (Sylvatech and Great Southern 1998-2009). The landowner's historical approach of relying upon investors, developers and managers changed on 30 September 2009 when the entire plantation estate of 30,000 ha reverted to the Tiwi landowners when the last investor entity, Great Southern Limited, collapsed into receivership.

Table 3 - Period of involvement and range of mean annual increment (M³ ha⁻¹ y⁻¹) expectations of the various forestry operators on Melville Island

|---------------------------|--------------------|---------------|--------------------------|----------------|-------------------|------------------------|-----------------------------|

Note: MAI – Mean Annual Increment

The analysis of the economics of sustainable Acacia plantation development discussed in the rest of this chapter draws on past information, and upon evidence accumulated by Tiwi ownership and operation of the plantations by the Tiwi Plantations Corporation [TPC] since 2009 [see Appendix A]. Tiwi Plantations Corporation is a wholly owned landowner beneficial trust¹¹ employing skilled forestry management.

Analysis

Investment for Acacia Plantation Forestry – economic activity and risk perspective

The analysis is based on a potential future in which 30,000 ha of land is planted to Acacia plantation forestry on Melville Island, in a series of repeated ten year rotations, with one fifth of the 30,000 ha of land [6,000 ha] planted in each of the first five years. The entire planning period is 40 years, in which each 6,000 ha block matures – [four times ten year rotations]. This analysis does not include rehabilitation of the land at

¹¹ Tiwi Plantations Corporation Trust, a charitable trust whose principal purpose is in respect to the 2000 landowners registered, and includes - the advancement of education; the relief of poverty, sickness, suffering, disease, distress, misfortune, disability and helplessness; the advancement of religion; and any other beneficial and charitable purpose.
the end of the production cycle, nor costs of controlling post-harvest *A. mangium* wildings.

Investment in *Acacia* plantation forestry was analysed using risk analysis in which the range of possible yields and exchange rates and the associated prices are incorporated in a 30 year investment budget run 10,000 times with yields and prices randomly chosen in each run of the model. The distributions of yields and prices used are shown in Table 4. Mean yields expected are 115 total recoverable volume – [TRV m$^3$/ha] with a triangular distribution demonstrating an expected possible variability of yield being plus or minus 33 per cent of the mean. This distribution was chosen on the basis of expert judgement combined with empirical evidence of yields achieved in plantation forestry on the Tiwi Islands in the past. The required rate of return on the capital invested is 4 per cent real return. The justification for this opportunity cost is that 4 per cent real return is a rate of return used by Australian State and Federal governments for the use of public funds, as well as being a reasonable approximation of public rates of time preference as indicated by the returns offered by the long term Commonwealth bond rate. If the resources involved in the potential investment in Tiwi plantation forestry had no other use, a case for zero discount rate could be made. However, in this case, the land does have alternative use in private hands, and the capital has an alternative use such as being placed in a sovereign wealth fund.

Prices received for timber produced by this project will be determined by international settings. The prices received for Tiwi Island timber is strongly affected by the $A exchange rate. Thus in this analysis the distribution of timber prices was based on the range of prices derived from the range of exchange rates that have occurred for the $A to the $US since 1970. The timber price on offer for Tiwi plantation timber in recent times has been $US144.50/t and $A155 per bone dry metric tonne [BDMT] when the $A/$US exchange rate was $0.93. The timber price on offer at this exchange rate reflects current demand and supply conditions. This price at this exchange rate was used to estimate a range of prices that could apply under the range of $A to $US that have applied over the past 40 years. This range is from $US 1.30 to $US 0.47. Implicit in using the resulting distribution of timber prices derived from the range of exchange rates is that the international conditions of supply and demand for the type of timber that would be produced from the potential investment is a sound guide to the conditions of timber supply and demand in 30 years’ time when the timber from this project would be harvested.
The results are shown in Figure 7 and Tables 5 and 6. In Figure 7 is the distribution of possible NPVs at 4 per cent discount rate from investing in the 30,000 hectares of Tiwi plantation forestry. In Table 5 is the cumulative distribution function [CDF] of NPVs from this investment. These results indicate that a renewed investment in *Acacia* plantation forestry would have a 35 per cent probability of earning 4 per cent or more return on capital required. That is, there is a roughly 67 per cent chance that the investment will *not* earn 4 per cent return required by landowners. Global assessments of forestry returns on capital in 2011-12 were 3.6 per cent (Price Waterhouse Cooper 2012). To improve the odds of earning the required 4 per cent return on capital from 33 per cent to 67 per cent, an additional $100m of unpriced benefits would be needed. This means additional unpriced benefits would be required to generate the required rate of return on capital. This would need to be an annuity of $5.1m or $2550 per Tiwi Islander, each year, for the 39 years of the plantation rotation.

**Figure 7** - Net Present Value comparisons with probability range
Unpriced social net benefit perspective

The investment analysis above invites the question - how attractive is *A.mangium* plantation forestry as an economic activity from the viewpoint of net social welfare? The social net benefits of investment of publicly-owned resources include all benefits and costs - including priced and unpriced, primary and secondary. The historical medium term government real bond rate, and the real opportunity cost of public capital, means 4 per cent real discount rate is a credible approximation of real social rates of time preference and opportunity costs.
A social benefit cost framework set out by Sinden and Thampapillai (1995) is used [Tables 7 and 8] to identify primary and secondary, and priced and unpriced benefits and costs of current plantation species forestry land use on Melville Island. A consolidation of available 2011 Tiwi census data was undertaken by the Tiwi Land Council (Atkin and Harari 2013). Demographics, education, employment and income detail provide the context for assessing benefits and contributions attributable to subsequent development impacts [see Appendix B].

The investment analysis raises the issue of unpriced benefits and costs. Elders and current landowners have consistently affirmed plantation forestry benefits (almost exclusively) as social benefits. This is the assessment undertaken by Tiwi landowners themselves. Their gut feeling about plantation forestry is recorded continuously from the 1960s (Tiwi Land Council 1978-2014). 'Forestry is to supply jobs for our kids upon our land,' and a 'Purpose for the kids at Tiwi College' (Kalippa 1978, 2014). Further, any major or sole industry in remote aboriginal Australia impacts extensively on general community well-being. Identifying the financial implications alone of investments of capital in projects in these regions also isolates the magnitude of the other outcomes necessary to assess such use of capital.

In managing the limitations of cost-benefit analysis a framework which uses a lexicon of primary [Table 7] and secondary benefits [Table 8] is adopted to illustrate the contributions an investment such as plantation forestry in-situ may make to the support of community sustainability.
Table 7 - Primary Benefits - Priced and Unpriced Benefits of a future investment in 10 year cycles of plantation forestry growing *A.mangium* from 2015 to 2055

<table>
<thead>
<tr>
<th>Able to be priced</th>
<th>Potential benefits unable to be priced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sale price of timber</td>
<td>Increasing skill sets – technical and managerial</td>
</tr>
<tr>
<td>timber chip price/demand range</td>
<td>Development of negotiating skills</td>
</tr>
<tr>
<td>$130-$200/T</td>
<td>Broadening work experience – stimulates conceptual tools</td>
</tr>
<tr>
<td></td>
<td>Budgeting and financial concepts and skill development</td>
</tr>
<tr>
<td></td>
<td>More and varied options – stronger personal resilience</td>
</tr>
<tr>
<td></td>
<td>Healthier lives</td>
</tr>
<tr>
<td>Child learns working ethics and routine structures from employed parents.</td>
<td>Participation with a language of numbers opens considerations of probability and capacity to plan a future.</td>
</tr>
<tr>
<td>Sophisticated plant and equipment → operator's status and pride → expansion of skills and status in industry impacts on parenting → increased enthusiasm for schooling</td>
<td>Identified work purposes → develops personal ambitions → goals and outcomes → self-harm declines.</td>
</tr>
</tbody>
</table>
Table 8 - Secondary Benefits - Priced and Unpriced Benefits of a future investment in 10 year cycles of plantation forestry growing *A. mangium* from 2015 to 2055

<table>
<thead>
<tr>
<th>Employment</th>
<th>Influence on regional economy</th>
<th>Extended use of port</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Able to be priced</strong></td>
<td><strong>Able to be priced</strong></td>
<td><strong>Able to be priced</strong></td>
</tr>
<tr>
<td>Jobs relieve Government’s burden (Federal and NT). Expenditure 2011/12 = $67,761 per head of NT indigenous peoples across 86 categories (Productivity Commission 2012). Individual assumes risk burdens → insurance, superannuation and other money management industries stimulated. Personal contributions to schooling, health and other needs. Fewer health issues → social costs change. Structured work → planning skills develop → lifestyle changes. Self-identity strengthened. Personal risks and goals identified through personal planning. Employed group influences behaviour → fewer drop outs; drug free safety through elite belonging. Self-worth outstrips money’s worth</td>
<td>Own asset identification stimulates savings → self-driven ambitions expand e.g. Do it yourself R &amp; M; enterprise; home ownership. Access to capital improves through elevated standards of ethics and governance required of workers. Plantation forestry unique among 57 investment interests over 35 years. Known foundations, depth of managerial excellence is normal.</td>
<td>Potential benefits unable to be priced</td>
</tr>
<tr>
<td>Potential benefits unable to be priced</td>
<td>Potential benefits unable to be priced</td>
<td>Potential benefits unable to be priced</td>
</tr>
</tbody>
</table>

The qualitative detail provided poses questions of economic and community sustainability for landowners. Are the unpriced primary and secondary benefits listed likely to amount to $100m over the next 30 years and thereby justify the investment?
That is, would the non-priced benefits amount to $5.1m per year, or $2550 for every Tiwi Islander?

**Another Option – A Sovereign Wealth Fund (SWF)**

The potential investment analysis above assumes re-investment of the proceeds of harvesting the current plantation in a further cycle of the same plantation investment, and considers both pecuniary and social benefits and costs. What if another option existed? What if the proceeds of harvesting the current plantation could be invested in a sovereign wealth fund [SWF], and the land currently under plantation forest leased to another investor?

Meetings and consultations with landowners from 2010 confirm their rights and expectations that plantation harvest net benefits will provide [among other interests] education, infrastructure, cultural and recreation support for the entire Tiwi community (Tiwi Land Council records 1978-2014). The definition provided below\(^ {12}\) (Clark, Dixon and Monk 2013) satisfies Tiwi landowner expectations and rights as owners and beneficiaries of the plantation estate. Most SWF are linked to resource-related non-renewable revenues (Australian Treasury 2012). In this case the source of the fund is harvesting the plantation forest that prior investors were unable to sustain or bring to harvest. Continuing rotations, calculating the costs of replanting, together with management and cropping risks, determine it is very unlikely that revenues to be received from harvest of the current plantations be a worthwhile application for this purpose.

Total plantation tonnage of 3.45m tonnes is anticipated, requiring harvest rates of 492,857 tonnes a year to achieve a seven year take-off. The anticipation of Tiwi Plantations Corporation is a six week requirement to stack 30,000 tonnes at the Port utilizing one harvesting unit comprising a skidder, feller-buncher and chipper plus associated chip trucks. Other limitations on harvest rates are a 35 week weather-related working year, and shipping availability. To achieve total harvest within seven years, additional harvesting units would be required. Table 9 shows the harvest units required to take-off the crop over seven years and the anticipated revenue to provide for the establishment of a SWF generating the required annual revenues.

\(^{12}\) “Sovereign Wealth Funds are government-owned and controlled (directly or indirectly) investment funds that have no outside beneficiaries or liabilities (beyond the government or citizenry in abstract) and invest their assets, either in the short or long term, according to the interests and objectives of the sovereign sponsor.”
Table 9 - A Sovereign Wealth Fund 2015-2021 scenario established by focused harvesting

<table>
<thead>
<tr>
<th>YEAR</th>
<th>HARVEST UNITS</th>
<th>TONNAGE HARVESTED</th>
<th>TONNAGE REMAINING TO HARVEST</th>
<th>INCOME RECEIVED AUDS</th>
<th>CONTRIBUTION TO SWF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>One</td>
<td>150,000</td>
<td>3.3m</td>
<td>$15.768m</td>
<td>$4m</td>
</tr>
<tr>
<td>2016</td>
<td>Two</td>
<td>300,000</td>
<td>3.0m</td>
<td>$31.536m</td>
<td>$10m</td>
</tr>
<tr>
<td>2017</td>
<td>Three</td>
<td>450,000</td>
<td>2.55m</td>
<td>$47.304m</td>
<td>$25m</td>
</tr>
<tr>
<td>2018</td>
<td>Four</td>
<td>600,000</td>
<td>1.95m</td>
<td>$63.072m</td>
<td>$31m</td>
</tr>
<tr>
<td>2019</td>
<td>Five</td>
<td>750,000</td>
<td>1.2m</td>
<td>$78.840m</td>
<td>$38m</td>
</tr>
<tr>
<td>2020</td>
<td>Four</td>
<td>600,000</td>
<td>0.6m</td>
<td>$63.072m</td>
<td>$33m</td>
</tr>
<tr>
<td>2021</td>
<td>Four</td>
<td>600,000</td>
<td>-</td>
<td>$63.072m</td>
<td>$30m</td>
</tr>
</tbody>
</table>

The range and distribution of prices and yields at Table 4 are reinforced by other opinions and authority. At February 2015 the exchange rate was 0.77c when the Reserve Bank observed that, 'Most estimates suggest the Australian dollar remains above its fundamental value' (Reserve Bank of Australia 2015). A study by the Western Australian Government records that linear averages of the exchange rate over the long run are the most reliable predication [accurate in 55 of 86 years] (Department of Treasury and Finance 2009). The Australian dollar has averaged 0.77c from 1993 to 2015. It was 0.77c in February 2015 (Trading Economics 2015). An exchange rate of 0.75c has been used in Table 9. Price studies for hardwood chip record price increase of 9.9 per cent in twelve months to April 2014 to $173.53 FOB per BDMT (ForestConnect 2014). A forecast of annual prices for hardwood chip for 2015-18 suggests an average high of $US 190 and a low range of $US 162.50 (Macquarie Forestry Services 2013). A conversion factor of 54 per cent from green to bone dry, has been used. With sample tested harvest volumes of 115 tonne per ha we predict a harvest volume of 1,863,000 BDMT off 30,000ha. Applying an exchange rate of 0.75c to an average $US 146 BDMT sale price suggests a total income of $A 363m over the entire plantation harvest.

Significant costs applied include total harvest and handling at $48.51 per GMT totalling $167m over the entire harvest. Total administration and management costs of $4.7m a year reducing after three years to average $2.7m per annum in years four to seven suggest, if the SWF option was acceptable, a total of $25m over the harvest years. Other associated costs of rehabilitation would be assisted by successful forestry and/or agri-business investor lessees converting harvested blocks.

Analysis of expected net revenues from harvesting the current crop suggests that a range of $150-$200m could be available from harvesting the current crop of timber for a Sovereign Wealth Fund. This sum is derived from total income of $363m, less costs of $192m, providing a corpus of $171m. Given the uncertainties, the potential
is for a SWF of the order of $150m-$200m accumulating by 2022. At 4 per cent real return, this would earn $6m-$8m per year in current dollars.

A mid-range $171m invested by a transparent and ethically managed SWF at 4 per cent real return would provide low risk annual net revenues of $6.84m, exceeding both the expectations of owners and the most optimistic modelling of continuing plantation harvests.

Further, re-investment in plantation timber on the land on which the current plantation stands could be an option for new investors, or the growing of different crops.

**Concluding Discussion**

The option of re-investment in plantation forestry, even allowing for both financial and social benefits looks a poor bet against the SWF coupled with the possibility of leasing the land to other forest or agri-business investors, with this option providing some of the benefits such as employment that the current stand of forest provides to the community. Most of the extra unpriced net benefit required to make re-investment by Tiwi Islanders in another cycle of *Acacia* plantation forestry a sound investment from a social net benefit perspective depends on the value placed on skills and cultural changes that may manifest as a result of forestry activity. Given this, the comparison of the options available to landowners has to include consideration of how the proceeds from a SWF, and possible leasing of the forest plantation land might also provide social benefits that would otherwise be supplied by the re-investment option.

For re-investment in forestry plantations to be attractive, it requires $5m per year in unpriced extra benefits for the investment to have a 67 per cent probability of earning the required rate of return. The SWF has a high probability of earning annual monetary net benefits $6m-8m per year for use by Tiwi Islanders. Deposit of harvest revenues into a SWF secures what continuing with plantation forestry cannot – a reliable, low risk annual net income stream that would be considerably superior to the much more uncertain and notably lower monetary net benefits attainable from a 30,000 ha plantation. Additionally with a SWF there remains the possibility of leasing the current plantation land to other users for other uses, with the potential of generating some of the unpriced benefits currently attributed to plantation forestry. Tiwi plantation workers and supervisors have developed skills and interests readily transferable to other land use projects. A number have already transferred to maritime, township farms, vegetable cropping, and other maintenance and heavy equipment operations. Training and satisfactions acquired through forestry have
been a continuing labour source for public and private Tiwi industry established in the past five decades.

Superior SWF returns should not compromise the primary and secondary unpriced benefits from plantations that can also be obtained from external forestry or agribusiness lease-hold investment. Recent initiatives have already attracted interest from a variety of investors for these investment purposes. The secured buyers of first rotation chip have also stated an investment interest in continuing plantation forestry on Melville Island (Takahashi 2014). Options of crops on the land are beginning to attract investment interest with detailed land use capability studies completed over the past twelve months by the Northern Territory Government. These have informed a (Tiwi Islands Investment Prospectus 2014) and attracted some international agribusiness interest from a number of Asian and South-East Asian investors. Landowners and Tiwi Plantations Corporation have also successfully grown and trialled an alternate species, a eucalypt, over the past decade which appears to provide superior yields and buyer attractions. Whether this species of forest could overcome the shortfall of return on capital of the dimensions that we have outlined from growing Acacia is not known.

Return on capital has not motivated Tiwi landowners in the past (Hicks et al. 2012). Plantation forestry benefits have been sought as a source of other benefits [Tables 7 and 8] and secured through lease of land rather than their own direct management and use. Attracting lease-hold investment at investor’s risk has been a strategy employed by landowners since the 1980s (Tiwi Land Council records 1978-2014), that has had some success. Ten private Tiwi trust corporations have been established (Tiwi Business Guide 2011) and resourced by lease agreements and revenues over 30 years. These have contributed in excess of $5m to establish and operate the Tiwi College; $4m for clinics and medical services; $4-5m for construction of community stores and other community facilities; $2-3m for sporting activity and Tiwi Bombers football; $3-4m for roads, airstrips and infrastructure; $80,000 annually for cultural, funeral and ceremony; $70,000 annually for books, newsletters, CD’s and information pamphlets, in addition to subsidizing group projects, schooling and scholarships (Tiwi Corporate records 1986-2014).

Existing plantations were developed during more traditional times and the option of creating a SWF may be attractive in respect to those traditional developments and the general Tiwi expectations that they inspired. Land development projects, once unanimously initiated by all Tiwi elders of all land groups as a whole, and are now
fracturing to assert single group interests. These single group attractions will increase with cleared and more fertile land becoming available post-harvest for individual group decisions and for their own group investor relationships in future.

Establishing a SWF prevents alternative uses of these funds. Standards of governance, transparency and ethical management are genuine risks of SWFs and need to be managed with rigour. Rather than a risk that invites discussion in mature economies, a SWF is suggested as a potential means of transition from a traditional Tiwi economy. The SWF approach contains the elements of sustainability inherent in those traditions. It derives from a past land use that, while including external investment benefits, has been fundamental to the evolution of a unique Tiwi culture. Further, a SWF provides the promise of annual reliable income, without those post-traditional land use cropping risks that landowners have no developed capacity to manage within the foreseeable future. Their adopted strategy of lease-hold investment at investor’s risk substantiates Tiwi recognition of these limitations and keeps open the possibility of supplying valuable social benefits.

This analysis clarifies that current harvest revenues from the Acacia plantation have a low probability of being repeatable and earning a competitive return to landowners from the same activity. Landholders will have to evaluate for themselves the full costs and benefits of the security of returns from an established SWF and associated land leasing to other users for other uses with associated social benefits. The analysis completed and evidence summarized here serve to inform these considerations.
Chapter 4

Tiwi Indicator Frameworks - Discussion and Final Comments

Introduction
In Chapter 2 we ascertained that, traditionally, laws and sanctions sustained Tiwi social-ecological systems through human actions and reciprocal influences upon the environment. The aspirations of people to attain status and prestige were only achievable through demonstration of knowledge and managerial excellence, verified by outcomes in sustaining resources. This process of elevating the status of skilled land managers could be relied upon to sustainably manage the landscape. Sanctions ensured no short cuts, such that aspirations effectively led to the sustainable management of the land.

Chapter 3 demonstrated that changing land use and monetisation of resources have created new aspirations which are divorced from the skills and prestige that traditionally assured sustainability. Short cuts to fulfilment have appeared due to the lack of the internally developed sanctions that traditionally adjudicated the nexus between acquired skills, performance and aspirations.

This chapter presents three indicator frameworks each containing clusters of values searched for by: aspirations; by standards for good governance; and by adaptive demands to manage sustainable landscapes. Finally, this chapter includes some discussion and concluding remarks.

Indicator frameworks
Advocacy of indicator design for specific landscapes and for those managing them has been noted in Chapter 1. Here we provide three Tiwi frameworks. They capture the three elements of sustainable land management: human, economic and governance [Chapter 1], and contrast an appraisal of their values across traditional and current situations. Clusters contained within these frameworks are useful in exposing the contrasts and revealing the challenges confronting Tiwi governance and landowners. Contrasting values also promote remedial options derived from the detail gathered by indicators within the frameworks.
Aspiration value framework

Table 10 describes impacts and outcomes from aspirations as the desired values change. The impacts of change can be observed in the differences between the traditional and current responses to altered aspiration values. Tensions are exposed between aspirations that traditionally sustained land through reliance upon resources from it, and new aspirations which generally lead people to seek to maximise monetary values from resources.

The outcomes described in this framework show that while traditional governance structures supported aspirations for sustainable land management, those structures are now threatened by new aspirations. These new aspirations are causing fractured decision making.

The current outcomes also indicate impacts of changing aspirations beyond land management. Aspiring to membership of an entitled class diminishes direct identity with the land and weakens participatory obligations of land ownership and the perpetuation of cultural protocols. New aspirations have exposed the current absence of community sanctions to manage the negative and often short-sighted consequences of these aspirations. In light of these changes, traditional governance is no longer workable so new structures and adaptations are required.
### Table 10 – Aspiration value framework – Indicators measuring impacts through traditional and current periods

<table>
<thead>
<tr>
<th>Indicators of values sought from aspirations</th>
<th>Traditional impacts</th>
<th>Current impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>To sustain resources from Tiwi land</td>
<td>Governance structures designed for primary value to manage and sustain resources from the entire Tiwi estate. Dependence of between 1,000 and 2,000 Tiwi people isolated on their islands for at least 6,000 years, relied upon sustaining these resources. [Discussion Chapter 2]</td>
<td>Traditional resources no longer a primary value. Money’s worth of resources a new primary value, attainable as entitlement without active participation [e.g. harvesting]. Elevates personal economic interests that support fractured Group decision making. Declining dependence on actual resources erodes knowledge of and interest in landscape sustainability. However, educational and social benefits and advantages are promoted. [Discussion Chapter 3]</td>
</tr>
<tr>
<td>Land Manager Status</td>
<td>Aspirations to acquire these values required extensive training and skills developed internally and integral to established governance structures. Status and prestige assured and rewarded through these structures. [Chapter 2]</td>
<td>Aspirations to acquire status as a land manager decline in value. Multiple organisations compete for skills and train for own skill interests separated and unrecognised by the community as assets to sustain land (Buchan 2014; Farmer, Kerinaua and Kalippa 2013; Hadden 2013).</td>
</tr>
<tr>
<td>For Rewards and Benefits</td>
<td>Rewards and benefits valued as status and prestige secured. Values sought to increase community influence; establish own law making authority; extend marital and family opportunities to further increase prestige and influence over others. Performance verified ensured continuing rewards and benefits. [Chapter 2]</td>
<td>Values of status and prestige remain significant but now obtainable as rewards and benefits through corporate structures. Rather than sanctioned by the wider Tiwi community; local group influences provide these satisfactions largely independent of sanctions or monitored performance. Immature governance at local levels is vulnerable to local influences and actions without developed sanctions, transparency or independent oversight. Value priorities shift from those achievable through verifiable land management and monitoring skills to personal and family monetary entitlements (Hart, Pilling and Goodale 1988; Venbrux 1995; Kalippa et al 2008; Fernando, Puruntatameri and Kerinaua 2014).</td>
</tr>
<tr>
<td>Overcoming sanctions and barriers to personal aspirations</td>
<td>Short cuts to achieve personal aspirations were restricted by severe capital punishments. These sanctioned through community forums where arguments and debates concluded community findings and punishments. Aspirations, both personal and those responsive to accepted Tiwi regulations were managed within governance systems that directed resource access and controlled breaches. [Chapter 2]</td>
<td>The value of aspirations to evade sanctions is increasing as monetisation of resources displaces direct harvest and participation in land management. Those with literacy and numeracy skills not shared by the majority are better able to promote their interests. Intimidation of those illiterate and less economically aware is now possible within a culture valuing non-confrontation. Access to resources now a right of beneficial group membership without land management skills or obligations. Community problem solving forums give way to external conciliation and superior authority beyond community knowledge or reference. Increasing use of social media as a tool for personal agenda setting and recriminations. (Pilling 1958; Cook 1994; Venbrux 1995; Fernando, Puruntatameri and Kerinaua 2014). [See also Chapter 2 and 3.]</td>
</tr>
<tr>
<td>Indicators of values sought from aspirations</td>
<td>Traditional impacts</td>
<td>Current impacts</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Ownership legitimacy and identification with land</td>
<td>The value of ownership and identity with the land a primary qualification of membership through direct mother and father Tiwi blood lines. Clear ownership and identity with land recorded from 1928 (Hart 1930). Identity and ownership verified, legitimised and managed through established governance systems. [Chapter 2]</td>
<td>Ownership and identification with land remains a significant aspiration and value. Although significant, the primary value has eroded as direct land use and participation in that use lessens. Ownership qualifications also changing as entitlements through Tiwi Father that have prevented children without a Tiwi Father from land ownership (some with Tiwi Mothers’) is being discussed (Tipungwuti et al 2008). Over 400 are seeking ownership and identity. The Land Council has authority to make these decisions but has resisted doing so. Tiwi land values and growing corporate assets are increasing these pressures. Some attempt to address these issues in recent years (Tipungwuti et al 2008). Many of these 400 have superior education to the majority of Tiwi. Resource access through group membership entitlements relieves responsibilities of ownership and changes identity with land (Fernando, Puruntatameri and Kerinaiau 2014).</td>
</tr>
<tr>
<td>To be a decision-maker</td>
<td>Aspirations a high value with clear pathways – superior land knowledge and managerial performance embedded within cultural rituals and protocols. Values sought included law making authority; but requires abilities to memorise and comply with accepted behavioural responses. Includes the ability to create metaphors containing messages of risks to sustainable landscapes through dance and song rituals publicly performed. [Chapter 2]</td>
<td>Remains an aspiration of value with more opaque and Group centred pathways. Land management skills no longer elevated as a requirement for decision making. Group corporate benefits from land use focus their own decisions on their own benefits (Kallipa et al 2008). Local Government, Health, Education, Art Centres, Clubs, Stores and commercial organisations all attract decision-making interests and satisfactions. Diminishing cultural memory and compliance as land use elevates decision-makers seeking economic benefits (Fernando, Puruntatameri and Kerinaiau 2014).</td>
</tr>
</tbody>
</table>
Good Governance framework

In Table 11, traditional and current Tiwi responses are presented against eight recognised principles [see page 13] of sustainable good governance (Ostrom 1990). The responses confirm sustainable qualities of traditional governance and the risks now being exposed in the current period. Unlike the traditional period, many risks facing current landowners are beyond their control. Those within their control are a recent experience with developing adaptive responses to manage them.

Figure 8 – Tiwi Islands – Map of the surveyed boundaries of the eight Tiwi land owning groups
<table>
<thead>
<tr>
<th>Indicators of sustainable good governance</th>
<th>Traditional</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internally developed principles</td>
<td>All internally developed principles. [Chapter 2, Table 1] Leaders' skills and authority accepted, known and proven by performance. [Chapter 2, Table 1] Note: Tiwi physical assets [Land] a male authority. [Spiritual] assets female.</td>
<td>A mix of internal and externally developed. Free hold title granted 1978 subject to Commonwealth (Aboriginal Land Rights (NT) Act 1976). Some allowance in the title and supporting legislation for aspects of internal governance [methods of representation and choice]. These continue to be subject to social trends and changing customs and attitudes influencing Australian society generally. For example: pressure to have women representatives on the Land Council (Macklin 2010); insistence that Land Council representation be elected rather than nominated by their land groups (Leitch 2010). Advice to change Chairman election processes of Tiwi designed exhaustive ballot and adopt preferential voting (Roper 2009).</td>
</tr>
<tr>
<td>Distinct boundaries of jurisdiction</td>
<td>Distinct boundaries of Tiwi Islands managed and defended over entire 800,000 ha landscape and adjacent waters. [Chapter 2] Recorded and conveyed through generations by memory and identification of internal group boundaries, reinforced by rituals and ceremony. [Chapter 2]</td>
<td>Boundaries declared and title conveyed in 1978. But subject to Federal and Territory Legislation in dealing and managing land and sea (Aboriginal Land Rights Act (NT) 1976; Environment Protection and Biodiversity Conservation Act 1999). Group boundaries of the entire estate recognised in memory have been internally re-defined and surveyed in 1995 as Group boundaries. [See Map.]</td>
</tr>
<tr>
<td>Resource access rules – monitored and able to be modified</td>
<td>Access a fundamental permission principle of Tiwi governance. [Chapter 2, Table 1]. Resource access monitored and controlled throughout entire estate through ceremonial protocols involving all groups.</td>
<td>Resource access rules weakened by strengthening group and individual interests and external relationships. The ability to implement modified rules is still maturing through fragmented estate comprising eight land groups each with own trustee corporation reliant upon own elected Directors and their aspirations independent of other groups. Developed structures to monitor access rules exist at Land Council level only (Kelly 2012).</td>
</tr>
<tr>
<td>Ability to impose sanctions for violations</td>
<td>A strong ability [Chapter 2, Table 1]</td>
<td>A weak ability internally among groups. External abilities through Group corporations subject to Corporations Law and litigation in the Australian Courts. An example of external litigation: Munupi Wilderness Lodge v Tiwi Land Council 2014 (NT Supreme Court) for illegal fishing access. Revenues able to be recovered for landowners but no imposed sanctions for violations that were acceptable to all landowners.</td>
</tr>
<tr>
<td>Indicators of sustainable good governance</td>
<td>Traditional</td>
<td>Current</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>Simple and speedy conflict resolution forums</td>
<td>Over 100 forums documented annually able to resolve conflicts. (Pilling 1958). [Chapter 2, Table 1]</td>
<td>Not at this time. (See sanctions indicator above). Group corporations may develop this capacity as they mature (Kalipps, Tipakalppa and Warapinni 2009).</td>
</tr>
<tr>
<td>Recognised authority not menaced by external authorities</td>
<td>No menace from external authority. [Chapter 2 and Table 1]</td>
<td>External authorities provide some support but do menace existing and developing structures either through patronage or extended interests in compliance with their authority. Discussion above.</td>
</tr>
<tr>
<td>Capacity to manage resilient and sustainable landscapes</td>
<td>Demonstrated and proven. [Chapter 2]</td>
<td>Capacity exists at Tiwi Land Council (entire estate) ownership level with environmental staff and developed, endorsed and monitored environmental management operations and audits, with policies and protocols open to scientific collaboration. Untested at Group levels. They have limited resources and undeveloped interests. Conflicting aspirations possible between Groups and Land Council determinations for resilient and sustainable landscapes. Land Council agrees maximum development area at 10 percent of total estate (Hadden 2013).</td>
</tr>
<tr>
<td>Nested common enterprises</td>
<td>Fisheries and land resources provided common benefits subject to Tiwi laws and sanctions for common use.</td>
<td>This indicator of sustainable good governance is becoming relevant as enterprises develop. Fisheries, tourism, forestry are managed by beneficial trusts with beneficiaries that include all Tiwi landowners. Enterprise governance is developing as group interests mature (Kelly 2014).</td>
</tr>
</tbody>
</table>
Findings

Traditional structures that were developed entirely by the Tiwi Islanders within a closed economy were vulnerable to new aspirations, which has led to fractured decision making [Tables 10 and 11]. Current aspirations to use land and benefit from resources are manifest at both personal and group levels. The Tiwi Land Council, which draws its membership from the eight land owning groups [five representatives from each group], retains legislative authority and has managed the entire Tiwi estate since 1978 (Aboriginal Land Rights (NT) Act 1976). However, since the boundaries of individual land owning groups were surveyed in 1995, the Tiwi Land Council has often typically endorsed the decision of individual land owning groups, despite the fact they have often made decisions for their own benefit without consideration for wider Tiwi interests (Tipungwuti et al. 2013). These boundaries are illustrated in Figure 8.

Aspiration values and governance [Tables 10 and 11] invite the question: are there enabling characteristics for adaptive governance and management for social-ecological resilience? Studies (Holling 2001; Folke et al. 2005; Berkes and Folke 2002) suggest that transformational opportunities can establish organisational flexibility and shared management for improved governance. Transformational opportunities are illustrated in Chapter 3. What then are the “critical attributes…to be reinvented and re-established from residual [traditional memory]…to recreate a new, sustaining panarchy [governance structure]?” (Holling 2001, p. 400).

An Adaptive governance framework

Table 12 records two classes of critical attributes. First, attributes of traditional management that are able to be recreated in sustaining modern structures. Second, recommended attributes that were identified from empirical research to facilitate resilient adaptive governance (Folke et al. 2005; Holling 2001). Column two of Table 12 records their significance for adaptive governance. Column three contains actions suggested by earlier discussion throughout this thesis.
Table 12 – Adaptive governance framework - Attributes enabling Tiwi adaptive governance for landscape system sustainability

<table>
<thead>
<tr>
<th>Attributes from traditional memory</th>
<th>Importance in adaptive governance from literature presented and findings of this thesis</th>
<th>Embedding attributes for new sustainable governance from traditional principles and findings of this thesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rewards and status for land management knowledge, skills and performance [Chapter 2]</td>
<td>Aspirations achieved through acquired skills and monitored performance re-engages community participation and promotes participatory excellence limiting short cuts to monetary satisfactions from resources.</td>
<td>Principles respecting and rewarding Land Managers skills and performance be drafted and resolved by Land Council endorsed for adoption by eight land-owning groups. Performance monitored at Group level; exposed and rewarded by Land Council.</td>
</tr>
<tr>
<td>Sanctions controlling access to resources [Chapter 2]</td>
<td>Direct harvesting of resources now replaced by money’s worth from resources. Sanctions for access to money’s worth required for resource and landscape sustainability. Re-establish sanctions exercised by trusted and skilled leaders in transparent framework capable of being monitored.</td>
<td>Changed community governance structures once centred on ownership rights and obligations now those of shareholders and beneficiaries reflective of Trust entities. Sanctions exist for national corporations. Design governance to enhance transparency and promote land management skills inseparable from money management skills at Group level. Recognise and reward these skills.</td>
</tr>
<tr>
<td>Monitoring and ownership of resources [Chapter 2]</td>
<td>Traditional governance managed and recognised ownership of distinct land area assets through social structures now weakened by an open economy and expanded aspirations. Distinctions between public and private assets required. For example: Port Melville on Munupi land provides public infrastructure to all Groups. Airstrips and roads on various Group land also. Groups seeking to protect and expand their own assets (and ownership claims) over public infrastructure may threaten Tiwi landscape resilience and sustainable management.</td>
<td>The Land Council has legislative authority as trustee of the entire Tiwi estate. Public asset distinctions require definition and acceptance by all Groups. Negotiation and disclosure of income and distributions from Public assets is required between Land Council, Groups and Local Government authorities. Supportive national and state legislation may be required for these distinctions and for management of them.</td>
</tr>
</tbody>
</table>
Discussion and final comments

Aspirations motivate landowners and managers of all landscapes. Containing the impact of these aspirations and apportioning their values is a major research focus (Gregory et al. 2012; Gould et al. 2014; Walker et al. 2004). There is general agreement in the literature that landowner and other stakeholder engagement opportunities be provided in order for these groups to enunciate their aspirations (Fagerholm et al. 2012; Gregory et al 2012; Ramos et al 2013; Schwilch et al. 2012). Having facilitated these opportunities to express landowner and stakeholder interests and aspirations, a goal of facilitators is then to direct or modify aspirations towards landscape sustainability (Weiland et al. 2011; Gould et al 2014; Gregory et al 2012). Modifying aspirations for sustainable land management behaviours is a goal of interview protocols designed to reveal what management aspirations are (Gould et al. 2014). A similar goal is sought from intervention frameworks managing behaviour promoted by aspirations (Morrison 2014). Good governance requires rules to temper aspirations and confine their impacts (Ostrom 1986). Researchers are broadly
concerned with the real or likely outcomes generated by land owner, stakeholder and manager aspirations.

Traditionally, Tiwi people sustained their landscape differently. Rather than contain aspirations and manage conflicting ambitions, Tiwi captured and embedded aspirations within governance structures stipulating the pathways, sanctions and verifications possible to achieve them. Outcomes of aspirations became predictable through design of their content and sanctioned pathways to their attainment. Accepting the pervasiveness of human aspirations in society, Tiwi exploited this characteristic to sustain their land and its resources.

Current Tiwi managers are exposed to risks in the transition from traditional aspirations, which managed land sustainably; to new aspirations, which primarily motivate the seeking of monetary benefits from resources. Millennia of management experience has promoted Tiwi own rules of resource access [pages 20 to 22 and pages 30 to 37] within Tiwi governance. Relying upon imposed rules, for example those developed by national bodies regulating corporate affairs or sanctions of the courts, may not contain new aspirations as effectively as internally developed rules (Berkes and Folke 1998, Ostrom 2009; Cumming et al. 2013).

Tiwi techniques admitting aspirations and designing and controlling their pathways and sanctions to fulfilment have been proven through a long history confined to their Islands. They are techniques of managing aspirations that remain part of Tiwi traditional memory in the present.

A challenge for flexible new Tiwi governance may be the capacity of that governance to establish rules and sanctions for aspirations within a money economy that proved capable of managing and sustaining resilient landscapes in the past.
References


Clark, L., D. Dixon and A. Monk 2013. Sovereign Wealth Funds legitimacy, governance and global power, Princeton University Press. USA.


Swaardecroon, H.K., C.S. Chastelijn, and J.S. Craine 1705. A written detail of the discoveries and noticeable occurrences in the voyage of the Fluyt Vossenbosch, the sloop D’Waijer and the Patsjallang Nova Hollandia. In Early voyages to Terra


Appendices

APPENDIX A.

TIWI PLANTATIONS CORPORATION FINANCIAL MODEL

1.0 General

<table>
<thead>
<tr>
<th></th>
<th>[%]</th>
<th>WACC [%]</th>
<th>2.70%</th>
<th>Plantation NPV</th>
<th>(1,915)</th>
<th>Rehab</th>
<th>(8,591)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>USD BDMt⁻¹</td>
<td>132.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currency Exchange</td>
<td>AUD USD⁻¹</td>
<td>0.93</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price Growth</td>
<td>[%]</td>
<td>3.00%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Cost</td>
<td>$ Ha⁻¹</td>
<td>99.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camp Cost</td>
<td>$ Ha⁻¹</td>
<td>57.98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Administration Cost</td>
<td>$ Ha⁻¹</td>
<td>157.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exetion Wharfage Fee</td>
<td>[% Gross Revenue]</td>
<td>5.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landholder Stumpage</td>
<td>[% Gross Revenue]</td>
<td>5.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.0 Growth Site Factors

|                | [v]       | 10       |       |                |         |       |         |
| Harvest Age    |           |          |       |                |         |       |         |
| Productivity   | [TRV m³ ha⁻¹] | 115     |       |                |         |       |         |
| Haul Distance  | [km]      | 45.41    |       |                |         |       |         |

3.0 Conversion Factors

|                | [BDMt m⁻³] | 0.50     |       |                |         |       |         |
| Basic Density  |           |          |       |                |         |       |         |
| Moisture Content | [w/w]   | 46%      |       |                |         |       |         |
| Dry Fibre Content | [w/w] | 54%      |       |                |         |       |         |
| Conversion Factor | [Gt m⁻³] | 0.93     |       |                |         |       |         |
| Stockpile Losses | [w/w]   | 3.0%     |       |                |         |       |         |

4.0 Supply Chain

|                | [$ GMt⁻¹] | 33.27    |       |                |         |       |         |
| Harvest Cost   |           |          |       |                |         |       |         |
| Haulage Cost   | [$ GMt⁻¹] | 10.35    |       |                |         |       |         |
| Roading Cost   | [$ GMt⁻¹] | 1.10     |       |                |         |       |         |
| Port Handling Costs | [$ GMt⁻¹] | 3.79     |       |                |         |       |         |

**NOTE:** The TPC Financial model is extensive. A general outline only is provided above for the purposes of both space and commercial in confidence. The model includes charts, cash flows nominal and real; stumpage, volumes; CAI v MAI charts; yield, harvest and haul analysis; OPEX profile; establishment; maintenance; basic density; rehabilitation; MAI; Estate model real and employment.
APPENDIX B.

CENSUS DATA

Consolidated extracts: Report on 2011 Census of Population, Employment and Housing
Tiwi Islands (Australian Bureau of Statistics 2012)

Demographics.

The total population of the three major communities on the Tiwi Islands is 2,347. Less than 100 live elsewhere on the Islands. 2000 are landowners. The number of persons under 15 years of age is 658 or 28.0% of the population.

The number of people between 15 and 64 years of age on the Tiwi Islands is 1,618 or 68.9% of the population.

The median age of Tiwi landowners is 28 contrasted with an Australian median age of 37. Tiwi life expectancy has risen from 47 years at 1990 to 67 years today. (Hoy, W. 2012. Kidney Disease in Aboriginal Australians. University of Queensland. Brisbane.)

Education.

Approximately 780 children on the Tiwi Islands are attending an educational institution. Rates of attendance at school differ among communities and range from 60% to over 80% at Tiwi College. Completion rates by staying at school through to year 12 are less than half the Australian average as reflected below.

![Students from the three Tiwi communities staying at School until Year 12, compared to those elsewhere.](image-url)
Employment.
The labour force on the Tiwi Islands totals 589 and consists of persons over 15 years. The remaining 1029 over 15 year olds are not looking for work. 250 of them are at school. 71 are over 65. 708 unemployed Tiwi are considered employable. Of the workforce itself 80% are in the over 25 year cohort. Less than 6% of 15 to 24 year olds are at work.

Median Income.
Weekly personal income is illustrated below. Wurrumiyanga is the township on Bathurst Island. The other Townships named are on Melville Island – central to plantations and to the Tiwi private economy. Median weekly family income averages $602. Landowners identify within approximately 100 traditionally structured families. Census expands family composition to 521 nuclear Tiwi families.

![Median personal incomes from the three Tiwi communities, compared to those elsewhere.](image)

The basic 2012 Centrelink payments for the Newstart allowance are $244.85 per week for a single person with no children, plus $64.90 per week for a single person with dependent children and $221 per week for each partnered person. This amount varies depending on individual circumstances. (Department of Human Services 2012. Canberra. Newstart Allowance. [http://www.human services.gov.au/customer/services/centrelink/newstart-allowance](http://www.human services.gov.au/customer/services/centrelink/newstart-allowance), accessed 31 August 2012.)
Author/s:
Hicks, John Sydney

Title:
Management structures of Tiwi indigenous landowners and responses to changing resource values

Date:
2015

Persistent Link:
http://hdl.handle.net/11343/91533

File Description:
Management Structures of Tiwi Indigenous Landowners and responses to changing resource values