



Martuwarra (Fitzroy River) Values and Valuation

Knowledge, Gaps, and Needs

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Note on Terminology

The terminology adopted when referring to First Nations people in this report reflects the author’s understanding of current usage and the literature reviewed.

The terms ‘First Nations’, ‘Indigenous’ and ‘First Peoples’ are used interchangeably when referring to First Nations people generally. The term ‘Aboriginal’ is often used in relation to Western Australian First Nations people and the term ‘Aboriginal and Torres Strait Islander’ is sometimes used when referring to Australian First Nations people.

The term Traditional Owner(s) (TOs) is used when referring to the First Nations people of particular Country, as this is the terminology adopted in native title law and land-related policy generally. I acknowledge that some people prefer the use of the term Traditional Custodians in recognition that their relationship to Country is more complex and quite different to ownership in a western sense.

Acronyms and abbreviations

| | |
|---------------|---|
| ANU | Australian National University |
| COAG | Council of Australian Governments |
| IPBES | Intergovernmental Platform on Biodiversity and Ecosystem Services |
| MDB | Murray Darling Basin |
| MEA | Millennium Ecosystem Assessment Framework (2005) |
| MFRC | Martuwarra Fitzroy River Council |
| NGO | Non-Government Organisation |
| NWC | National Water Commission |
| NWI | National Water Initiative |
| PC | Productivity Commission |
| TO(s) | Traditional Owner(s) |
| WA | Western Australia |
| WA Government | Western Australian Government |
| WJH | Water Justice Hub |

Words in language other than English

| | |
|-------------|---|
| jaminyjarti | a cultural mourning ritual (in several Fitzroy language groups) |
| jila | a term meaning waterhole or source of water in many Kimberley languages |
| liyan | a term meaning holistic wellbeing (West Kimberley language groups) |
| Mangala | First Peoples of Western desert, West Kimberley |
| Nyikina | First Peoples of western Martuwarra (Fitzroy River), West Kimberley |
| Yawuru | First Peoples of the Broome area, West Kimberley |

Summary

This report, undertaken to inform the Water Justice Hub (WJH) at the Australian National University (ANU) and the Martuwarra Fitzroy River Council (MFRC), reviews the coverage of the Martuwarra (Fitzroy River WA) region values and valuation in the academic and grey literature. The report extends to suggesting ways that further research and projects related to particular threats or risks could inform development decisions and address the gaps in the literature.

Professor Quentin Grafton, Director of the Water Justice Hub, was awarded an Australian Laureate Fellowship in 2019. One aim of the 5-year ARC research project is to value water, in particular to provide the missing socio-cultural-environmental values of First Peoples' water to overcome the problem that Indigenous demands for water justice are frequently ignored. Martuwarra is one of the Australian sites included in the research.

Proposed development of water and other resources in the Martuwarra region has given rise to concerns for appropriate governance and regulatory controls to protect the ecological, cultural and economic values of the River. National and state government regulatory frameworks for water are currently being reviewed or developed. The MFRC, which represents Traditional Owners (TOs) from six native title holding bodies along the River, seeks to work with governments and other stakeholders to form an inclusive governance framework for managing the catchment.

Much of the research reported in the literature was undertaken by multidisciplinary teams of researchers to inform governments and other stakeholders' consideration of potential development of the Martuwarra as a water resource. Several papers raised the need for increased First Nations involvement in governance of Martuwarra, in order to protect and monitor impacts on values. First Nations people's involvement in the research and literature was found to have increased and changed, becoming more central as authors and co-authors as well as informants, over time.

The review focused on *values* as the importance or worth of something, described or quantified, as distinct from values as beliefs or principles that guide and motivate people's behaviour. Cultural values are often expressed as beliefs that are integral to First Nations ways of being and doing. Economic values are more commonly expressed in monetary terms, as a common basis for comparison.

Assessment of cultural, ecological, economic, and relational values across the literature reviewed found:

- Despite excluding literature that only dealt with *cultural values* as beliefs, most of the literature acknowledged these underlying beliefs. In some cases, the cultural values were contrasted with non-Indigenous perspectives and values of the River as a water source. Several studies identified harvest and catch values as cultural values of ecosystem services.
- *Ecological values*, assessed in most of the literature, were often one of multiple values related to the river catchment. Many papers examined these in relation to water flows, connection of water sources across the catchment, and associated food webs.
- *Economic values* in relation to the potential development of the water resource, including secondary impacts, were identified in about half of the reviewed literature. These were often identified as one of multiple values.
- *Relational values*, while rarely explicitly identified, are particularly relevant for First Nations peoples where the relationships between people and Country are central to cultural identity.

The strong link between ecological and cultural values was a common theme in literature that dealt with multiple values, often pointing to the need to maintain water flows and water bodies across the catchment.

Valuation is a process of assessing or evaluating the value or worth of something, generally in monetary, spatial or time terms. It is often undertaken to inform a decision. Approaches to assessment and valuation in

the literature include qualitative description of cultural values, spatial mapping of multiple values along with physical and geological features, conceptual modelling of values relationships and responsibilities, and quantitative valuation in dollar terms. Valuation results are generally conveyed in absolute rather than relative terms, although the latter may inform the former.

The key advantage of valuation in dollar terms is that it enables all values to be included and compared in decision-making by government and industry. As many of the values that need to be taken into account are non-market values, different valuation approaches can be used depending on the types of values being considered. Importantly, valuing non-market ecological or cultural values in dollar terms does not commodify them or place them in a market.

The complexity of linkages and interdependencies of individual components underlie the trend towards mapping and modelling of multiple values. Literature reporting research that mapped cultural and ecological values identified their strong spatial relationship. Mapping projects generally had a high level of engagement of TOs and local First Nations people, while protecting and restricting access to sensitive cultural information. The conceptual models generally mapped the relationship between water and ecological and cultural values, demonstrating the importance of water flows and connectivity for the ecosystem and to people.

The most significant gap in the literature relates to quantification of values in monetary terms, in particular cultural values. Cultural valuation approaches ranged from use of harvest data to assess a market equivalent value in dollar terms to the use of choice modelling (a non-market preference valuation technique) to assess value to Indigenous people. Harvest values reflect the instrumental value, whereas preference techniques encompass instrumental, intrinsic, and intangible values, which are likely to exceed market value.

Ecological values were generally assessed scientifically using count, distribution, and temporal data, sometimes linked with hydrogeological data. Commercial viability of potential water resource developments relied on assessment of economic values using a range of cost data, data relating to potential economic activities as well as estimated secondary impacts for the region including employment. Alternate approaches looked at pathways for economic development for Indigenous people, including land-based Indigenous-owned enterprises.

While spatial mapping of values can inform decisions about where development could and should not occur, and conceptual models can assist in understanding the consequences of particular actions, valuation in monetary terms can support direct comparison of options. However, a holistic valuation that seeks to capture all non-market values can be complex and costly, and not without challenge. This report makes a critical distinction between the total value of the River and catchment, and the marginal value of the impact of a particular development, which is relevant for considering whether that development should proceed.

As highlighted in much of the literature reviewed for this report, TOs need to be central to the governance frameworks for determining and managing the balance between development and conservation in the catchment.

The report suggests that the MFRC, in conjunction with the Water Justice Hub, adopts a pragmatic approach, targeting the assessment and valuation of scenarios relating to a particular development that poses the greatest threat. Using the hydrogeological, spatial, and conceptual modelling of previous research, the MFRC could embark on a deliberative process involving key researchers and stakeholders to identify the scenarios that reflect potential impacts of development options, and assess values affected and rank preferences between them. This ranking of preferences could inform valuation in monetary terms, if required, to translate values for comparison with economic values relating to the project.

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Introduction

This project aimed to identify gaps in existing literature relating to Martuwarra (Fitzroy River) water values and valuation, in particular quantitative studies that are requisite for a comprehensive assessment of values. In doing so, it informs the Water Justice Hub (WJH) at the Australian National University (ANU) and the Martuwarra Fitzroy River Council (MFRC).

The approach taken was a desktop systematic examination of a wide range of academic and grey literature relating to values associated with the Martuwarra (Fitzroy River) catchment, the development of an annotated bibliography, and a synthesis of the approaches taken to the types and categories of values and their valuation in the literature examined. This report analyses gaps in the literature and suggests possible pathways forward for more inclusive and just valuations.

The three parts in this report are:

1. Background, including a brief discussion of the Martuwarra context, water reform processes as they apply to Martuwarra, and definitions and framing of values and valuation.
2. The literature review, including the search and assessment process, and the characteristics and treatment of values and valuation in the literature.
3. A conclusion, including the identification of gaps and considerations for future research.

Background

The Water Justice Hub

The Water Justice Hub's mission is to respond to water injustice and to promote both 'voice' and truth-telling about water. While the Hub has a primary focus on Australia, especially justice for First Peoples, it also responds to the global challenges of delivering 'water for all' or Sustainable Development Goal (SDG) 6.

The Water Justice Hub brings together several initiatives including a five-year Australian Research Council (ARC) funded Laureate research program¹ on water justice, water valuation and resilient decision-making. This five-year research program seeks to provide missing socio-cultural-environmental values of First Peoples' water to support resilient decision-making for water justice, with two Australian case studies in New South Wales (NSW) and Western Australia (WA). Identifying these important missing socio-cultural-environmental values is the key to a comprehensive assessment of values.

Martuwarra

The Martuwarra (Fitzroy River) is a major river system in the Kimberley facing increasing water extraction demands from the agricultural and mining sectors. For Traditional Owners (TOs) along this river system, Martuwarra is regarded as a living ancestral being, central to their identity and culture, as well as supporting the environment that supports their lifeways and wellbeing (RiverOfLife, Poelina, Alexandra, et al., 2020).

Established in 2018, the MFRC brings together six TO groups along the Martuwarra as a united voice to ensure that the Fitzroy River catchment is managed and cared for in line with its spiritual, cultural and environmental interests (Poelina et al., 2019; RiverOfLife, Poelina, Alexandra, et al., 2020). The Council acts as a voice for the River and its First Nations peoples, working with governments and other stakeholders to form an inclusive governance framework for managing the catchment.

¹ See <https://www.waterjusticehub.org/initiatives/arc-laureate/>

Martuwarra values

To date, significant research related to First Nations peoples' values in Martuwarra has focused on the need for inclusive governance arrangements and engagement with governments and stakeholders that are critical for protecting cultural and environmental interests (Moggridge & Thompson, 2021; RiverOfLife, Poelina, Alexandra, et al., 2020).

Experience with the Murray Darling Basin (MDB) has highlighted the limited capacity for existing water allocation mechanisms to adequately quantify and protect cultural, social and environmental values (Birckhead et al., 2011; MacKenzie et al., 2017). Supporting an inclusive governance arrangement with hydro-ecological modelling and an integrated assessment of environmental, social and cultural values is crucial to ensuring water justice in determining water allocation decisions (Akter et al., 2014).

Multiple values have been associated with Martuwarra, including market economic values of the land and water as well as the environmental, social and cultural values (Connor et al., 2019). Accounting for First Nations peoples' worldviews in value assessments remains a critical challenge for water management (Finn & Jackson, 2011; Jackson, 2005).

Water regulation reform

The significant reforms of water management at a national and state level, particularly the shift to water trading and market-based regulation, are key drivers of a broader and more inclusive valuation approach. This section outlines the national level reforms and the WA Government reform process, including specific plans for the Fitzroy River catchment.

Before the 1980s, water management regimes were generally State and Territory administrative approaches involving area-based water rights. By then it was evident that Australia's surface water and groundwater systems, particularly in the multijurisdictional MDB, were fully or overdeveloped. This led to the introduction of limited water trading, volume-based water rights and embargoes on new water diversions (National Water Commission (NWC), 2011, p. 36; Productivity Commission (PC), 2017, p. 68).

The adoption of a nationally agreed water reform framework in 1994 (Council of Australian Governments (COAG), 1994), followed by ongoing reviews, led to reform with the National Water Initiative (NWI) (COAG, 2004) that expanded water markets and established secure tradable water entitlements designed to enable water to flow to higher-value uses. The NWI is subject to regular reviews, and the Productivity Commission (PC) has recommended that the overarching goal be "modernised through reference to adaptation to climate change and recognition of the importance of water in the lives of Aboriginal and Torres Strait Islander people" (PC, 2021, p. 45). As well as highlighting the need for access to safe and reliable drinking water, and monitoring and reporting of water quality and service outcomes in remote Aboriginal and Torres Strait Islander communities, specific recommendations relating to Aboriginal and Torres Strait Islander people's interest and involvement in water management include:

- a new co-designed element involving a newly established Committee on Aboriginal Water Interests;
- improving cultural outcomes by explicitly identifying cultural objectives in existing frameworks, monitoring and reporting on progress and ensuring environmental water holders and natural resource managers incorporate and deliver on these outcomes; and
- improving access for economic development by sourcing water within existing water entitlement frameworks and ensuring adequate support to enable Aboriginal and Torres Strait Islander communities to maximise the value of the resource.

The Government of Western Australia (WA Government) signed the 2004 NWI agreement in 2006, releasing a final draft of its Implementation Plan for the NWI the following year (Department of Water (Western

Australia) (DoW, 2007b). The Fitzroy catchment does not feature in this draft implementation plan, other than being noted as part of the Timor Sea drainage division which has the most surface water resources in the state.

In its most recent review of the NWI (PC, 2021, p. 27), the PC found that WA lags behind most other jurisdictions in enacting legislation to create secure, NWI-consistent water access entitlements for consumptive users, and ensuring adequate independent economic regulation. In its submission to the PC, the WA Government indicated that the NWI measures are better suited to large, interconnected surface water systems such as the MDB, rather than providing the flexibility and tools to meet WA's unique water management challenges (PC, Minister for Water; Forestry; Innovation and ICT; Science; Youth (Western Australia) (MWFISY), 2020; 2021, p. 62). The WA Government submission noted its support for "the proposal to consider the needs of Indigenous Australians in water access planning and management" and argued for the refreshed NWI to "place a stronger focus on consideration of water for cultural continuity and economic development" (MWFISY, 2020, p. 6).

Around the same time as it was developing its NWI Implementation plan (DoW, 2007b), the WA Government was considering water reform processes, with its response to 'A Blueprint for Water Reform in Western Australia' (DoW, 2007a). This was followed by a discussion paper on water reform options (DoW, 2009). After consultation with stakeholders (excluding First Nations representative organisations), the WA Government released its position paper on reforming water resource management (DoW, 2013) which informs a water reform bill. This paper was not publicly available at the time of writing.

Without seeing the draft bill, it is difficult to assess how the overriding objective of providing certainty to industry stakeholders by reducing red tape sits with the need for best practice engagement with TOs as part of the regulatory approval process articulated in the recent Fitzroy discussion paper (DWER 2020). Among the aims of the new legislation² is "support attainment of Closing the Gap targets by supporting the Aboriginal community's access to water resources". However, a principle that water resource allocation will reflect the range of economic, environmental, social, and cultural values, and acknowledgement of flows and timing affecting cultural values, appears as the only explicit or implicit reference to First Nations peoples or values in water in the 2013 position paper (DoW, 2013, pp. 2, 25).

While expressing reservations about the relevance of the NWI to WA in its 2020 submission to the PC, the WA Government has pledged to protect and manage the Fitzroy. This 2017 election commitment included the creation of a new national park; supporting the protection and development of a management plan to ensure the health of the River and provide a basis for sustainable economic development; and not to allow the River or its tributaries to be dammed. This commitment and a process for planning were outlined in 2017 (Department of Primary Industries and Regional Development (Western Australia) (DPIRD), 2017), revised in 2019 (DWER, 2019), and followed by a discussion paper released in late 2020 (DWER, 2020).

The recent discussion paper includes these approaches for discussion and feedback:

- An adaptive management approach to protect the health of the Fitzroy River that would involve establishing an advisory group, monitoring of water resources, environmental and cultural values, and support for future investigations to build shared knowledge.
- Consistent with current policy, no dams or other infrastructure that would impact river flow, but off-stream storage infrastructure for run-off, drainage or flood water could be allowed.

² As listed on the Water Reform Bill website: <https://www.wa.gov.au/service/building-utilities-and-essential-services/water-supply/water-reform-bill>

- Staged allocation of any surface water to enable monitoring of impacts on river values.
- Requirement for the proponent to engage with TOs to identify and assess potential impacts and avoid and protect areas with significant heritage, cultural and environmental values.
- Establishment of a Fitzroy Aboriginal Water Reserve for native title holders to use under a water license for economic development on native title lands.
- Groundwater extraction is to be limited by volume (108.5 GL) and to specific aquifers to avoid adverse effects on significant cultural, environmental, geological and heritage values. A portion of the groundwater allocation could be available through a Fitzroy Aboriginal Water Reserve.
- Two options for allocations: (i) groundwater only (108.5 GL); and (ii) groundwater (108.5 GL) plus surface water (up to 300GL, with an initial release of 100GL for general licensing and 90GL for Fitzroy Aboriginal Water Reserve).

The draft management plan that was expected to be released for public comment in 2021 is not yet available. However, the WA Government recently announced³ the creation of the Warlibirri National Park, the first step in establishing a series of national parks in the Fitzroy Valley, as part of the election commitment to protect and manage the Fitzroy River.

Groundwater allocation plans for regions across WA are being progressively developed, released for consultation, refined, and implemented. The Derby Groundwater Allocation Plan⁴ was released in November 2020 and open for feedback until May 2021. Recommendations in the MFRC submission (RiverOfLife, Poelina, et al., 2021) in response to the plan included increasing use of scientific evidence on the links between the Martuwarra and the groundwater bodies affected by the plan, as well as engagement with the MFRC to ensure that cultural values and impacts are adequately addressed.

Value, Values, Worth and Valuation

Discussion of values across the reviewed literature varied widely, reflecting the purpose and type of paper and disciplinary backgrounds of the authors. Before assessing approaches to valuation of Martuwarra in the literature, it is important to define value and values and outline the approaches to valuation, given the diversity of perspectives and objectives in the literature.

Values and Value

The terms ‘values’ and ‘value’ have multiple meanings, dependent on the context and sometimes the disciplinary perspective.

Values can be defined as the beliefs or principles that guide and motivate behaviour. This definition is particularly common when cultural values are discussed, as beliefs and values are central to any culture.

Three alternative noun form definitions of ‘value’, and corresponding plural form ‘values’, are relevant to this research:

1. the importance or worth or utility or regard in which something is held;
2. a numerical quantity assigned or calculated (through a process of valuation);
3. the fair return in goods, services or money for something exchanged.

Building on this definition, the term ‘values’ is often used to describe attributes or things that have such value, measured or otherwise, since they are held in high regard. For example, the cultural and biodiversity

³ See Media Release of 29 April 2022 <https://www.mediastatements.wa.gov.au/Pages/McGowan/2022/04/Warlibirri-National-Park-created-in-Plan-for-Our-Parks-milestone.aspx>

⁴ <https://consult.dwer.wa.gov.au/water-policy/derby-groundwater-allocation-plan/>

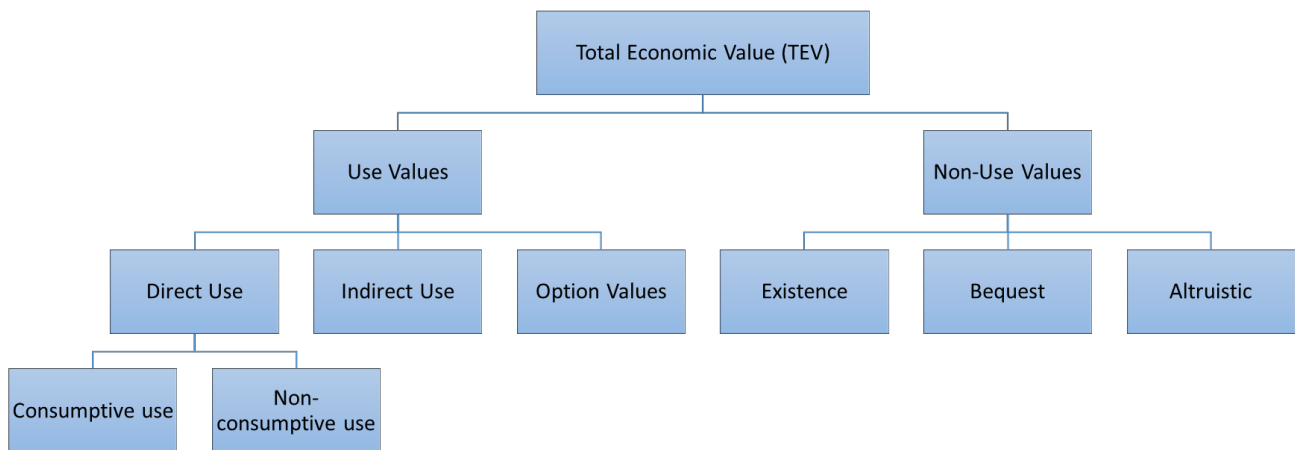
values of Martuwarra are recognised and held in high regard, as reflected in much of the literature reviewed for this report.

The verb form to ‘value’ something is generally taken as meaning to consider that thing as important or having worth, and in some circumstances to attribute a monetary or numerical value to it through a process of valuation.

Value types

Classifying values by the way they benefit people, *value types* include use and non-use values; direct and indirect (use) values; option values; and existence, bequest and altruistic (non-use) values. In some cases, use values are disaggregated further, according to the impact of their use, into consumptive or exploitative uses, such as harvesting, hunting, or extracting water, where goods are consumed, destroyed, or removed, and non-consumptive uses such as recreational or cultural uses that do not necessarily destroy or prevent other uses. Sometimes it is relevant to distinguish rivalrous values, where a benefit to one person or group means a benefit is not available to others, from non-rivalrous values. A simple diagram setting out the main value types making up TEV is shown in Figure 1 below.

Figure 1 Value types in Total Economic Value (TEV) in environmental economics



A similar value typology in cultural economics may use different terms including instrumental (use) and intrinsic (non-use) values. Intrinsic values are values in themselves or existence values, which can be intangible (e.g. relating to spirituality) or tangible but associated with goods that lie outside markets.

Much of the literature, in seeking to accommodate Indigenous perspectives, focuses on use or instrumental values rather than existence, intrinsic or relational values. This aligns with human centred instrumental approaches to ecosystem services valuation in the 2005 Millennium Ecosystem Assessment (MEA) framework. Some uses of Aboriginal culture may have both intrinsic and instrumental value (e.g. cultural tourism activity; ranger work on Country). Martuwarra provides instrumental value to Aboriginal people in the form of foods and medicines, while the River itself is intrinsically valued as an entity central to the identity and wellbeing of TOs. Examples of values by type are set out in Table 1.

Table 1 Value types and examples associated with the Martuwarra

| Value types | Example | |
|----------------|-----------------------------|---|
| Use Values | Direct Use: Consumptive | Extracting water for irrigation, fishing, aquaculture, bush foods and medicines |
| | Direct Use: Non-consumptive | Use for cultural identity and wellbeing, recreational use (e.g. swimming, boating) |
| | Indirect Use | Flushing of the River in the wet season, soil fertility |
| | Option Value | Value of water that might be used in the future e.g. for aquaculture |
| Non-Use Values | Existence | Value of the existence of cultures and ecosystems associated with Martuwarra |
| | Intrinsic | Values of the River, associated ecosystems and cultures, in themselves, rather than their instrumental value |
| | Bequest | Value of knowing future generations will have access to Martuwarra water and associated cultures and ecosystems |
| | Altruistic | Value placed on the existence of Martuwarra, its ecosystem and the culture it supports, by people who don't live near or use it |

Valuation

Valuation is a process of assessing, or evaluating, the value or worth of something, often expressing values in monetary, spatial or time terms. Generally, valuation is undertaken to inform a decision, such as an appropriate price for buying, selling, or insuring something, or whether, where or when a project will be worthwhile.

For example, if a government was deciding whether it was worthwhile to replace a dirt road to a remote community with a sealed all-weather road, it may try to value all the costs and benefits associated with this change for a benefit-cost analysis of the overall worth of the project. This would include the costs of building the road as well as the benefits, including improved safety, a better quality of life for people from improved access to education, healthcare and other services, improved food security, as well as any savings from reduced costs of maintaining the dirt road and servicing the community. While some of the costs and savings can be estimated using known market prices, some of the secondary impacts or benefits, such as improved wellbeing, are more difficult to measure and value.

Another type of valuation process might assess the value of a project or activity relative to spatial, time or other variables, yielding values relative to areas of land or periods of time rather than in dollar terms. For example, evaluating and mapping the cultural and ecological values relating to a particular area of land can identify areas of high value that need to be protected, and areas of land with lower value.

Ecological values are often biophysical and incorporate standard measures of biodiversity. Biodiversity assessments for a specific area of land consider a range of values, such as rarity, diversity, fragmentation, habitat condition, resilience, threats, and ecosystem processes. These generally yield a ranking or numerical score, and these 'values' might be mapped spatially, or on a timeline. In some cases, an overall conservation value might be calculated for an area. These approaches to valuation inform decision making about development, by comparing alternative scenarios and the differences in values between them.

So, for the community access road example, the government may consider two different options for improving all-weather access to the community. One option might be a sealed road replacing an existing dirt road, another option might be a new sealed road that takes a shorter route. In comparing these options, the spatial distribution of values, particularly the cultural and ecological values, is relevant. Assessing and mapping these values along the two route options would be appropriate. Areas of high cultural and/or ecological values might mean that the new route is not acceptable or needs to be adjusted to avoid sensitive sites of high value. In making its final decision, the government may want to compare the overall values

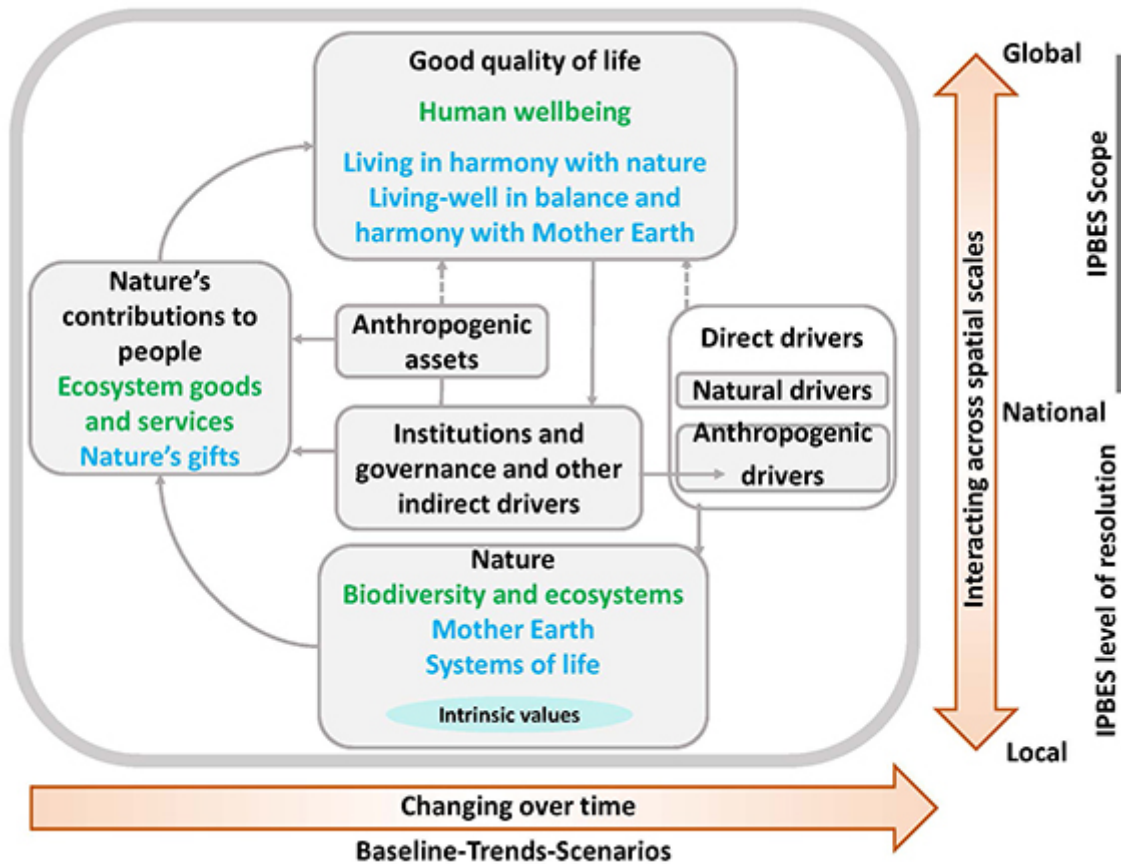
associated with the routes, including costs, benefits and the values associated with cultural and ecological impacts. Having all values expressed in monetary terms enables direct comparison between the options.

In the environmental economic literature (see for example Perman et al., 2011; TEEB, 2010), approaches to quantitative valuation of ecosystem services that yield overall values in monetary terms need to account for multiple values. Similar approaches are taken in other fields of economics, such as transport economics and cultural economics, where changes to policies or other decisions give rise to multiple values in the form of benefits and disbenefits (detriments or disadvantages) to people. These economic valuation approaches are essentially human-centred inasmuch as they assess instrumental value to people (Pascual et al., 2012, p. 189).

Building on the 2005 Millennium Ecosystem Assessment (MEA) Framework, a broader conceptual framework was developed by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al., 2015). The IPBES framework models the interactions between the natural world and human societies. It includes six interlinked elements constituting a social-ecological system that operates at various scales in time and space: nature; nature's benefits to people (also known as nature's contributions to people or NCPs); anthropogenic assets; institutions and governance systems and other indirect drivers of change; direct drivers of change; and good quality of life. The conceptual framework contextualises relational values as a contribution to people through desirable relationships among people and between people and nature. The framework seeks to include Indigenous and local knowledge, and to address concerns that economic valuation approaches may omit values that are intrinsic and hard to identify, or spiritual values, that are particularly relevant when considering the trade-offs between conservation and development.

The IPBES Conceptual Framework shown in Figure 2 shows the linkages between nature and people, and the contribution of governance, which is also considered in many of the reviewed papers.

Figure 2 IPBES Conceptual Framework



From <https://ipbes.net/conceptual-framework>

Economic impact or utility

While there are several valuation methodologies reflecting different perspectives, there are two general approaches to the economic analysis of values. The first is an impact evaluation approach that measures the economic impact in terms of direct and indirect market impacts and multiplier effects, and the second is a welfare theory approach that uses valuations of the effect on utility or wellbeing.

Impact evaluations seek to capture the instrumental values that are reflected in market or market equivalent impacts. This might involve estimation of the direct costs and benefits of an activity, as well as the indirect impacts, such as increasing employment and associated expenditure in local businesses. Sometimes flow-on benefits into the local economy are estimated using multipliers. Secondary impacts, while hard to attribute directly, can be considered in impact evaluations.

For example, culture is positively associated with physical health, social and emotional wellbeing (Bourke et al., 2018; Cairney et al., 2017; Dockery, 2010). Savings in primary health care costs for treatment of three common chronic conditions have been associated with greater participation in land management on Aboriginal land (Campbell et al., 2010). Despite this growing evidence of the link between culture and health and wellbeing, the challenges of quantifying these secondary impacts have meant they are rarely explicit in cultural impact evaluations.

Another approach to verification of the economic effects of a cultural event is to use ex-post econometric methods such as difference-in-differences, linear and dynamic panel models (Srakar & Vecco 2017). These

methods rely on the availability of large data sets, generally not available, to reveal the measurable economic effects of cultural activities.

Governments often rely on impact evaluations because the effects are perceived to be concrete and measurable.

A welfare theory approach assesses utility that captures instrumental as well as intrinsic value, including non-market values. This might involve testing people's preferences using contingent valuation or choice modelling to ascertain their willingness to pay (WTP) for a change. Such an approach can capture intrinsic and broader public values, including existence and option benefits for those not directly involved.

These two approaches, impact and utility, form the basis of many approaches to quantify cultural and ecological values.

Marginal or total value

While the total value of something indicates its overall worth, marginal values relating to differences between scenarios are relevant to decision making about proposed or potential changes. In updating previous estimates of the global value of ecosystem services, Costanza et al. (2014) highlight the magnitude of these ecosystem services, noting that although the total value has no specific decision-making context, the application of the underlying models to assess changes could inform decisions.

Frequently a valuation is undertaken to assess the impact of a proposed or actual change in policy or practice, or to determine the value of something that could be, or has been, lost. For example, to assess the impact of an increased allocation of water for irrigation from Martuwarra, the valuation could be based on the changes to different cultural, social, ecological, and economic attributes flowing from the increased allocation. This marginal valuation focuses on the marginal or incremental changes associated with the increase in the allocation rather than the total allocation.

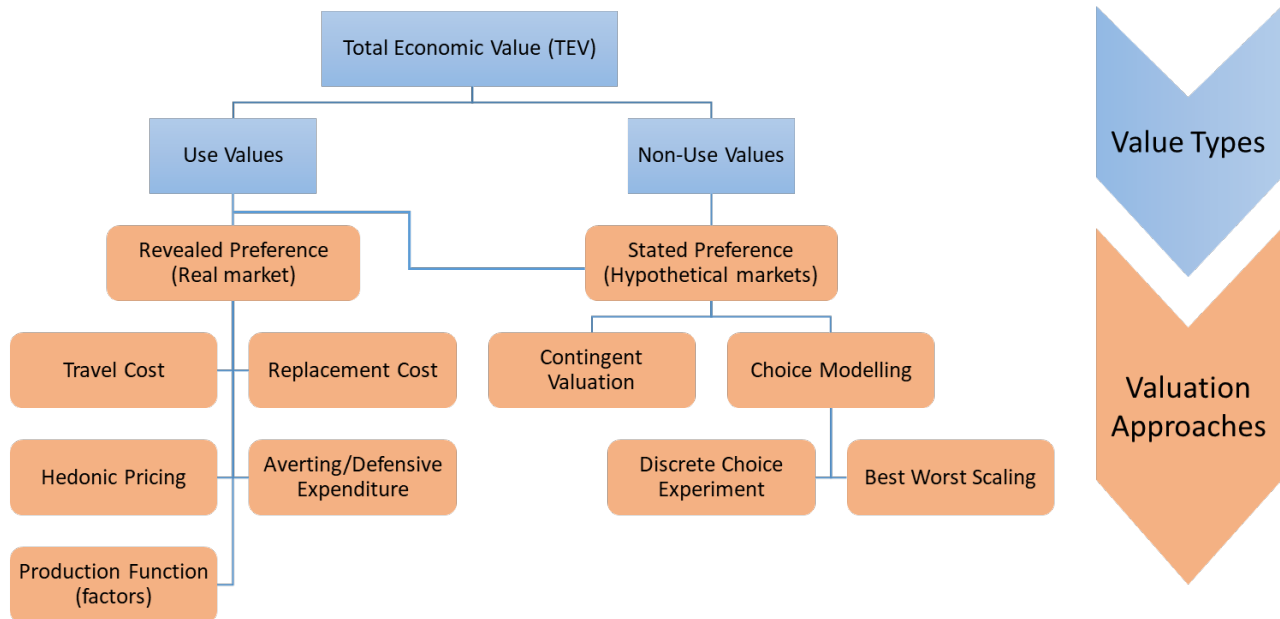
Before moving to consider how the valuation of Martuwarra has been dealt with in the literature reviewed in this report, it is worth setting out some of the value types and quantitative valuation approaches commonly adopted in the valuation literature. The human-centred basis for valuation and estimating Total Economic Value (TEV) in economic literature differentiates values according to their benefit (or disbenefit) to people, and the way values are assessed.

Monetary quantification

Quantification of values in dollar terms enables an understanding of values in terms that are readily understood and compared with other costs and benefits. While values could be related to land or time, this may not assist with communication and comparison with other values in a broader decision-making context. Mapping of values, for example, informs *where* development could minimise negative impacts, but quantifying values in dollar terms enables comparison with other costs and benefits. Importantly, the expression of values in dollar terms does not mean they are commodities that can be bought and sold.

Approaches to quantitative valuation in monetary terms generally differentiate market and non-market values. Market values reflect or relate to prices in a market, whereas non-market values cannot be assessed in markets, and instead are assessed using revealed preference or stated preference techniques. Revealed preference techniques use surrogate/constructed or hypothetical values, such as hedonic pricing or travel cost methods. These rely on the availability of appropriate data and relevance to the values being assessed. For example, the value of a national park might be assessed using data on the amount of money and time people will spend to enjoy it. The main valuation techniques for use and non-use values in TEV are shown in Figure 3 below.

Figure 3 Main valuation techniques for use and non-use values in TEV



Stated preference techniques, including contingent valuation and choice modelling, are survey-based (hypothetical) techniques that can be used to assess instrumental (use) and intrinsic (non-use) values, intangible values, and arguably relational values, including (but not exclusively) non-market values. Stated preference techniques are often described as welfare theory or utilitarian approaches to valuation because utility theory underpins them. Assessing the total value in social welfare terms requires the aggregation of individual values. These approaches are conceptually challenging, particularly when applied to cultural values that are sometimes considered to be so important that they are immeasurable.

In the Martuwarra context, the difference between market and non-market values is clear when considering the value of fishing. The market value of wild-caught fish, for example, might be assessed as the price of a similar fish in a market, with adjustments for the costs of catching them (travel, bait, effort). In a cultural context, however, it may be more appropriate to assess the value of fishing to First Nations people using stated preference techniques, because of the associated non-market cultural values arising in the process of harvest and distribution of the catch, and the cultural significance of the fish at certain times (Toussaint, 2014). The overall value of the fish incorporating this cultural value, which could be ascertained using stated preference techniques alone or in combination with revealed preference techniques, is likely to be higher than the market equivalent value.

An impact approach to this fishing example would attempt to assess the indirect or secondary values arising from the process of harvest and distribution, and the cultural significance of the fish. An improved sense of identity, connection and wellbeing arising from the cultural fishing activity may in turn improve health and reduce incarceration rates. Quantifying this impact in dollar terms may involve identifying the causal connection between fishing and health and incarceration rates and estimating the associated savings.

The differentiation between commodification and valuation is particularly important in the context of environmental and cultural values, where there are significant existence, intrinsic, bequest and relational values that cannot be bought and sold. Indigenous cultural values associated with the River include potentially marketable goods such as bush tucker or bush medicines. In these cases, the cultural value

includes a commodifiable good. However, as in the fishing example, the value to the people involved in or benefiting from the harvest process can exceed these market values.

Quantification of values in dollar terms where there is no market value enables comparison of values, enhancing the ability to take those values into account in decision making. There are technical and conceptual challenges associated with both impact and utilitarian approaches to estimating total value, particularly data for impact analysis, and defining attributes and aggregation in revealed preference techniques.

The literature

The core of this report is the review and analysis of literature that deals with values associated with Martuwarra. This part of the report outlines the search and preliminary assessment process used to identify relevant literature, the drivers and timelines and Indigenous involvement in research production, and then explores how values and valuation are dealt with across categories of values, including cultural and ecological.

Literature search

An initial systematic literature search and resulting annotated bibliography focused on Indigenous cultural values and valuation related to Martuwarra identified 33 articles and reports, termed ‘papers’ here. Of these, 17 papers were reviewed as especially pertinent. Following consultation with the Advisory Group, the scope expanded to include values more broadly, including ecological and economic values, as well as other relevant regional research on values and valuation.

This expanded systematic search identified 65 papers, which included a range of grey literature and related research. The iterative search process involved research databases, other literature reviews and known literature, with filtering and results outlined in **Attachment A**.

The literature identified included published peer-reviewed journal articles, grey literature including reports and supporting technical papers, conference papers, a doctoral thesis, and a widely cited unpublished report. A WA Government website about the values of waterways⁵ was excluded as it is essentially a general overview that links to relevant government information.

I use the term ‘papers’ as an inclusive term for the literature reviewed in this report.

Preliminary assessment

Of the 65 papers identified in the revised search, 14 were assessed as being outside the scope of this review focusing on values and valuation in the Martuwarra region. Many of those papers contribute to an understanding of the ecological, hydrogeological, or cultural context of Martuwarra, but do not address values directly. These papers, listed and briefly described in **Attachment B**, are:

- scientific studies of vegetation zones without discussion of associated cultural or biodiversity values (Freestone et al., 2021);
- assessments of scientific understanding that do not add to the understanding of values associated with Martuwarra (Hamilton & Gehrke, 2005);
- ethnographic studies that build understanding essential to assess values associated with the River, without addressing them directly (Toussaint, 2008, 2014);

⁵ <https://www.water.wa.gov.au/water-topics/waterways/values-of-our-waterways>

- papers dealing with processes for recognition of rights, water governance, and collaborative management - while important for a more holistic approach to water management, these papers did not explicitly address values and valuation (Dobbs et al., 2016; Pelizzon et al., 2021; Poelina, 2019; RiverOfLife, Poelina, Bagnall, et al., 2020; RiverOfLife, Taylor, et al., 2021; RiverOfLife, Unamen Shipu Romaine River, et al., 2021);
- approaches to the assessment of biodiversity management and planning processes (Simmonds et al., 2021; Stoeckl et al., 2016);
- papers that contained no material addressing values associated with Martuwarra or the region (Moggridge, 2021; Treloyn et al., 2016).

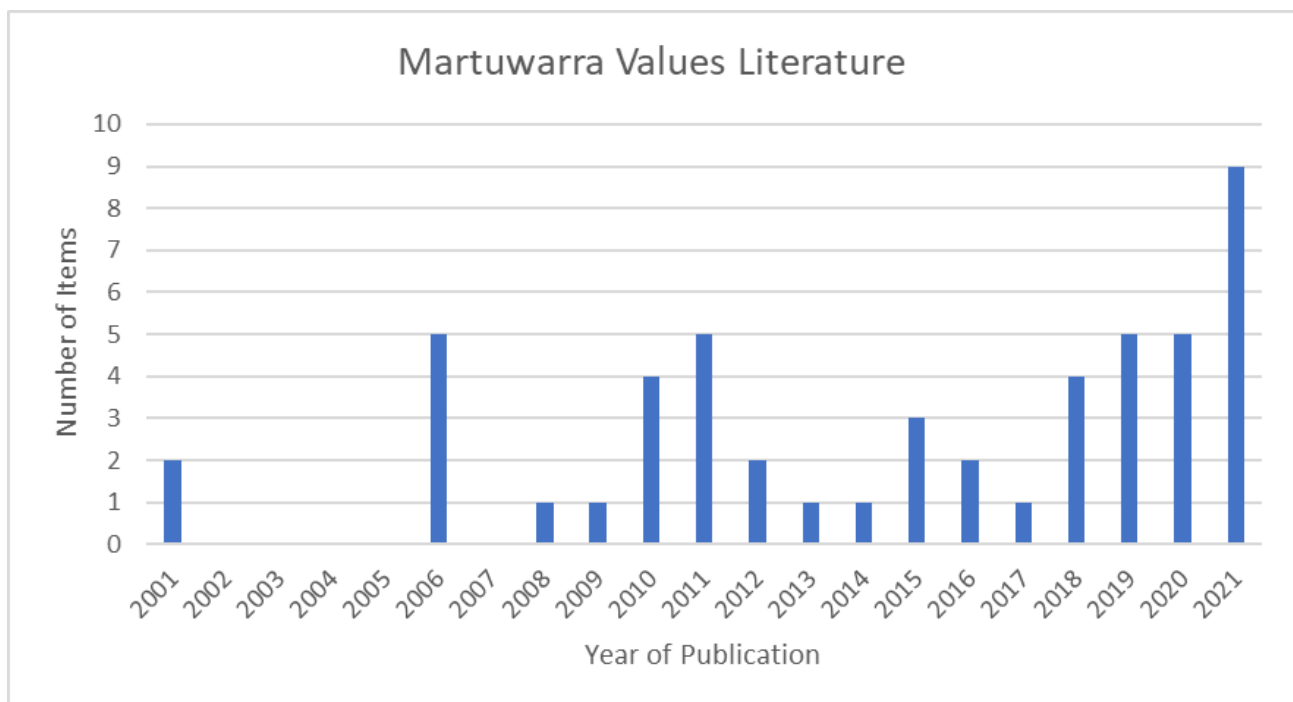
The remaining 51 papers were retained and reviewed further. These papers are listed, noting the values considered in each, at **Attachment C**, and are summarised in an annotated bibliography at **Attachment D**.

Research production

Timeline

Even though the systematic literature search did not limit the timeframe for publication, most of the identified literature relating to Martuwarra values is relatively recent. All the papers reviewed in this report were published since the year 2000, a minority (n=9) were published before 2010, about a quarter (n=13) were published in the period 2010 to 2014, and more than half (n=29) were published or completed since 2015. The increase in research activity is reflected in Figure 4 which shows the distribution of papers in this review by year of publication.

Figure 4 Reviewed literature by year of publication



This research effort is driven primarily by increased interest in the water resources of the Fitzroy River catchment and other development in the region. Proposals to extract water from the Kimberley have highlighted the limited understanding of the hydrogeology, ecology (including biodiversity) and cultural significance of the Fitzroy River Basin.

Development proposals involving water in the Fitzroy catchment have motivated governments and NGOs to support research projects that can inform assessments of feasibility and cost-benefit. These include renewed consideration by the WA Government in the early 2000s of sourcing and transporting water from the Kimberley to the south of WA, and increasing interest across governments in developing Australia’s north. Table 2 below shows a breakdown of the research type and major funding source.

Table 2 Literature by research type and major funding source

| Major funding support | Predominantly government funded | University funded | NGO funded | Government research scholarship | Other | Total |
|-----------------------|---------------------------------|-------------------|------------|---------------------------------|-------|-------|
| Grey literature | 14 | 8 | 6 | 1 | 0 | 29 |
| Journal article | 18 | 0 | 1 | 2 | 1 | 22 |
| Total | 32 | 8 | 7 | 3 | 1 | 51 |

More than half (n=28) of the papers considered in this literature review was grey literature. Half of the grey literature (n=14) was produced by research organisations, such as CSIRO, and research collaborations between governments and universities, such as the Northern Australia Environmental Resources Hub. Major funding for the latter comes from the Australian Government’s National Environmental Science Program, with the involvement of universities, CSIRO, state and territory governments, industry, NGOs and Indigenous organisations and people. University auspiced research (n=8), NGO supported research (n=6), and a scholarship supported thesis made up the balance of the grey literature.

Most of the journal articles (18 of 22) reviewed were largely funded by governments, with many of these arising from the major research projects that generated the reviewed grey literature. The small number of other journal articles acknowledge the support of postgraduate Australian Government Research Training Program (RTP) Scholarships (n=2) and an anonymous foundation (n=1). One journal article, while acknowledging the in-kind support of an Indigenous organisation, did not mention any funding support.

First Nations involvement

Another important consideration in this review is the degree of involvement of First Nations people in the research, particularly where it pertains to their cultural, environmental, and economic interests in water. Historically, Aboriginal involvement in research was limited to being the subjects of research, rather than being integrally involved in the research (Martin, 2003). There is increasing recognition of the importance of the ‘cultural interface’, described by Nakata (2002) as the intersection of the Western and Indigenous domains, in a wide range of research.

While not all the research reviewed explicitly identified the indigeneity of authors or co-authors, many acknowledged the contribution of First Nations groups or individuals where applicable. Using my knowledge of Aboriginal people and groups involved in research, I assessed their level of involvement and found that most papers at least acknowledged the contributions of First Nations people. The degree of involvement of First Nations people in the research, ranging from ‘lead author(s)’ to ‘no noted Indigenous involvement’, across the categories of literature (grey, journal and other) is tabulated below.

Table 3 Indigenous authors and involvement by reviewed literature type

| Literature type | Indigenous lead author(s) | Indigenous co-author(s) | Indigenous involvement | No Indigenous involvement noted | Total |
|-----------------|---------------------------|-------------------------|------------------------|---------------------------------|-------|
| Grey literature | 2 | 3 | 22 | 2 | 29 |
| Journal article | 3 | 4 | 14 | 1 | 22 |
| Total | 5 | 7 | 36 | 3 | 51 |

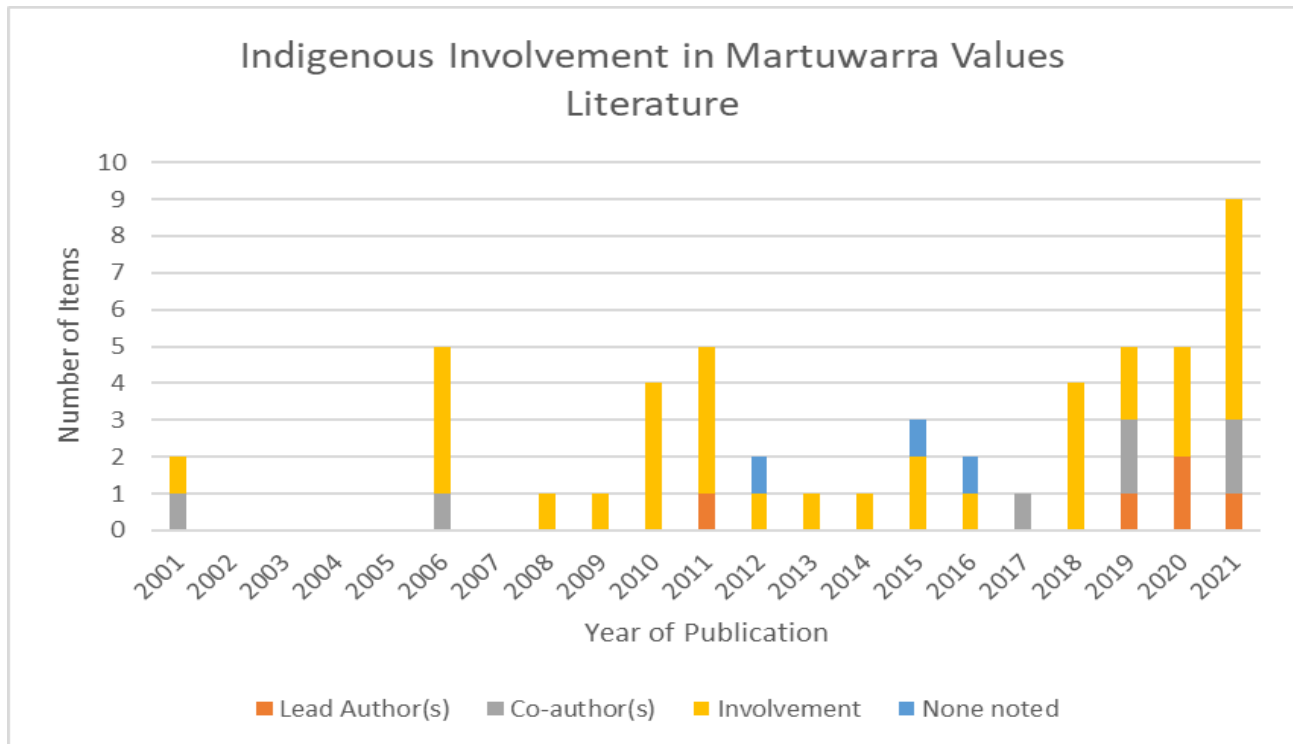
Only three papers appeared to have no Indigenous involvement (Hermoso et al., 2012; Kragt et al., 2016; Pusey & Kath, 2015). These were either generalised high level or technical in nature, as described below.

- In a review of the state of play in scientific knowledge of ecosystem responses to flow and water regime changes and interactions between flow-dependent phenomena, Pusey and Kath (2015) identified gaps and proposed further scientific research. While no attempt was made in this paper to assess the availability or otherwise of sociocultural information, it acknowledged the importance of traditional ecological knowledge and sociocultural information necessary for a considered water strategy.
- A scientific paper by Hermoso et al. (2012) focused on scientific assessments of lateral connectivity between water habitats.
- A technical conference paper presenting a novel methodology with spatial choice experiments, by Kragt et al. (2016), refers to an extensive stakeholder consultation process to identify attributes that include Aboriginal Rangers for the subsequent online survey, without specific mention of Aboriginal people or TOs being involved. This process was described in underlying research, including one paper (Spencer-Cotton et al., 2016) stating that stakeholder consultation did involve Aboriginal people but noting that "It is potentially difficult to engage with Aboriginal people for choice experiment research" and concluding that, "It is therefore acknowledged that the community preferences reported in this study may not include the values held by Aboriginal people." This suggests that any involvement of Indigenous people in the online choice modelling survey analysed in the technical conference paper was incidental rather than intentional.

The representation of Indigenous authors and co-authors is proportionally higher for the journal articles (32%) than the grey literature (18%) reviewed in this report. This may be explained by the broad scope of grey literature generated by major multi-disciplinary research projects covering multiple aspects of research, including 'cultural' aspects often covered by Indigenous authors. Another factor may be that non-Indigenous researchers are over-represented in these large research projects and organisations. Many of the Indigenous authors and co-authors are TOs who juggle several roles, including cultural roles, making large projects less suitable for their circumstances.

Despite limited representation in the grey literature, the emergence of some notable First Nations authors and increased co-authorship of papers in the area of Martuwarra protection and water justice is reflected in the graph below that shows the distribution of Indigenous involvement, by year.

Figure 5 Timeline of Indigenous authorship and involvement in the reviewed literature



Value categories

Taking the definition of values as things of value or worth held in high regard, many values associated with Martuwarra were identified in the literature reviewed for this report. These can be categorised broadly as economic, ecological, cultural, and relational values.

The larger, more comprehensive assessments in the grey literature, and papers that dealt with multiple aspects of water management and were produced by multidisciplinary teams (e.g. Álvarez-Romero et al., 2021; Douglas et al., 2019; Petheram et al., 2018), addressed most values. Associated supporting reports and journal articles often focused on one aspect of value, or relationships between values (e.g. Barber & Woodward, 2018; Pettit et al., 2016; Stokes & Jarvis, 2018). Grey literature documenting Fitzroy River region plans (Cook, 2010; Watson et al., 2011) identified the most important values to TOs and other stakeholders.

Approaches to values across the 51 papers reviewed can be summarised as follows:

- All of the papers (n=51) mentioned values as related to worth;
- About half the papers (n=25) discussed a process for recognition of values, with many of these (n=17) canvassing the need to consider governance;
- One paper identified the need for improved governance processes to protect multiple values, without discussing processes to recognise these values in the face of development pressures;
- Most papers (n=46) referenced or explored cultural values as beliefs or as aspects of the River that are important or are of worth;
- A large majority of the papers (n=44) referenced ecological values, including papers with a science and ecology focus that contribute to an understanding of values;
- Of those papers that referenced ecological values, nearly all (n=41) referenced both ecological values and cultural values, with many noting or exploring the interaction and connection between ecology and culture;

- A small number of papers (n=4) explicitly mentioned relational values, where the relationship between Indigenous people and Country is recognised as going beyond the unidirectional nature of ecosystem services to people;
- Around half the papers (n=25) dealt with economic values (market or market equivalent) associated with water and water rights, including the customary economy; and
- Of 19 papers that dealt with valuation, 13 addressed quantitative valuation.

The complexity and interconnectivity of the values of the Fitzroy River catchment identified in the literature are highlighted by the high proportion of papers that address more than one value (n=43), as shown in **Attachment C**.

The following thematic analysis discusses the approaches to the different values considered in the reviewed literature, starting with papers that focused on cultural values and ecological values, then economic value, before moving to relational values and multiple values.

Cultural values

Cultural values in terms of worth often stem from values as principles or beliefs. While this review focuses on values in terms of worth, a majority of papers reviewed also addressed values in terms of principles or beliefs (n=33). The importance of values as principles was demonstrated in a participatory study where TOs were critical of the exclusion of values as principles from the categories of wellbeing used to assess scenarios (Kim, Álvarez-Romero, Wallace, Pannell, Hill, & Pressey, 2021; Kim, Álvarez-Romero, Wallace, Pannell, Hill, Adams, et al., 2021).

Apart from three papers (Barber & Woodward, 2018; Jackson, 2015; Woods, 2020), most papers that dealt with cultural values also canvassed other values. The assessment of knowledge gaps by Jackson (2015) indicated that further research on Indigenous water values should be built around two elements. Firstly, a socio-ecological component that identifies and quantifies flow links that might enable the prediction and mitigation of negative impacts from water resource development. Secondly, a water governance component that empowers Indigenous people in their relationship to water, and supports the maintenance and restoration of Indigenous practices that transmit and affirm cultural values and supports caring for Country.

A report for the Fitzroy Water Resource Assessment (Barber & Woodward, 2018), focused on Indigenous values, defined value as “what people consider important, worthy, of merit and significance. It can also refer to underlying principles or beliefs that drive estimations of importance” (Barber & Woodward, 2018, p. 9). Water values familiar to non-Indigenous Australians, including the physical sustenance it provides, were compared with its significance for Indigenous Australians encompassing mythology, identity, and connection. Poelina et al. (2021) contrasted the local perspective of the River and its ecological and cultural values with the coloniser perspective of the River as merely a water source.

My doctoral thesis (Woods, 2020) explored how to quantify cultural values for First Nations people. Working with Nyikina and Mangala people residing in several locations in the Fitzroy River catchment and region, the research privileges their viewpoints in the design of the choice model and broader survey. Multiphase fieldwork started with qualitative research to build trust and inform the selection of attributes and levels for the choice model. The cultural values assessed as most important were: access to Country; spending time with other Aboriginal people; and cultural activities. In order to yield maximum information about preferences with minimum cognitive load, a Best-Worst Scaling Profile Case model with a supplementary question about profile acceptability, a discrete choice experiment, was developed and incorporated into a survey. The relative preferences expressed by people demonstrated the importance of accessing Country, echoing the qualitative findings that stressed the importance of relationships with Country.

Ethnographic approaches to values

Most of the literature reviewed acknowledged the importance of Indigenous cultural values, informed largely by a body of ethnographic research and involvement of Indigenous researchers. These approaches generally do not extend to quantitative valuation but are critical in framing any quantitative analysis.

Harvest activities

Building on established anthropological economic approaches to cultural valuation and the concept of ecosystem services providing instrumental values, harvest and catch values are frequently identified as cultural values. In Altman's hybrid economy model (Altman, 2005) these values arise in what is termed the customary economy. Alternatively, as instrumental values that substitute for, or contribute to, household income, they could be considered to be economic values. Many of the papers using this approach were authored by Jackson and others (Finn & Jackson, 2011; Jackson et al., 2012; Jackson et al., 2014; Jackson et al., 2011; Jackson et al., 2008). A study of catfish abundance, size and condition relative to variations in environmental flow and habitat, was contextualised in the tangible economic and cultural values of catfish as a food source for Indigenous people (Beesley et al., 2021)

The value of certain aquatic species to First Nations people may differ from an ecological value that considers biodiversity, or a valuation by a recreational fisher. Catfish is an example where the question of 'values to whom' is pertinent. In this context, cultural values inherently are values for First Nations people.

Ecological values

Ecological values are the values relating to ecology, the interrelationships of organisms and their environment. I use the term ecological values here as inclusive of the biodiversity values that relate to the biological variety, often used concerning threatened species, at the ecosystem level.

The knowledge of hydrogeology and ecology of the Fitzroy River catchment has increased markedly in recent years. This review excludes scientific water studies or biological studies limited to particular species that do not extend to consider their ecological or other value. Most of the literature reviewed considers ecological value as one of multiple values, with only three papers that link hydrology to ecological values not extending to consider other values.

While many hydrological studies do not consider values, Hermoso et al. (2012) demonstrated the importance of understanding water flows and lateral connectivity between different components of waterways, such as lakes and wetlands, in maintaining biodiversity and ecological processes in freshwater environments.

Using carbon and nitrogen isotope analysis to determine the influence of waterhole type and persistence on the local energy resources for aquatic food webs in Nyul Nyul Country, Pettit et al. (2016) found that groundwater-fed riverine waterholes appeared to have more complex food webs than lacustrine waterholes. This also points to the importance of the frequent connection of water sources in supporting ecosystem values.

A major assessment of existing hydrogeological and biological knowledge of the Fitzroy catchment, and gaps in that knowledge (Pusey & Kath, 2015), recommended a range of research projects that would provide an integrated research program on the flow ecology of the Fitzroy River and its aquifers. While focused on (western) scientific knowledge, it noted the importance of traditional ecological knowledge and sociocultural information in the development of a water strategy.

Economic values

Economic values most frequently relate to market values, such as the cost of a good or the return on an asset. Economic value can also include secondary impacts, such as regional stimulation of the economy arising from a particular development. In terms of a water resource development, such as irrigated agriculture, economic values can include water market values, the cost of infrastructure, the cost of inputs and value of outputs, and impacts on the regional economy from increased employment and supply chain activity.

Economic values and benefits were identified in several reports that considered multiple values, with only two papers focused solely on economic values (Appleyard et al., 2006; Stokes & Jarvis, 2018).

Several papers considered economic values in terms of direct or indirect costs and benefits, in commercial or market terms, related to the potential development of water resources in the Fitzroy Basin. The water resource assessment for the Fitzroy catchment (Petheram et al., 2018) considered existing economic values (Merrin et al., 2018) and potential water resource development (Stokes & Jarvis, 2018), with the latter drawing on a report that assessed the conditions required for potential irrigated agriculture to succeed financially (Stokes et al., 2017). Two papers that considered the costs and benefits of water resource development (Appleyard et al., 2006; Connor et al., 2019) found that the costs of development exceeded the costs of alternative sources of water or benefits from the development of irrigated agriculture.

The potential costs and benefits of, and attitudes to, water markets in northern Australia were discussed in reports from a project exploring the feasibility of using market-based mechanisms for water delivery in northern Australia (Nikolakis & Grafton, 2011; Nikolakis et al., 2010). Uncertainty over Indigenous rights and interests in water, the need to integrate customary and ecological values in any assessment of efficiency, as well as equity issues, were identified as challenges, and the report suggested that non-market approaches might be more appropriate to meet ecological or equity objectives.

The Nyikina and Mangala Mardoowarra Wila Booroo Natural and Cultural Heritage Plan (Watson et al., 2011) considered economic values in terms of traditional subsistence as well as commercial use of plants and aquatic life. It identified management priorities for the Fitzroy basin, including an Integrated Asset Management Assessment to identify social, human, cultural, landscape and economic values in the Nyikina and Mangala native title area.

The Fitzroy Catchment Management Plan (Cook, 2010) also took an assets-based approach to the valuation of the water, biodiversity, agricultural, cultural, recreational and tourism assets, with comparative values assigned to each asset using the Investment Framework For Environmental Resources (INFFER) process. Economic values associated with these assets were derived from Kimberley wide data, where available, to inform these assessments.

Spatial mapping of landscape features associated with social and economic values preceded the participatory scenario planning in a major research project reported by Álvarez-Romero et al. (2021) and in associated reports (Kim, Álvarez-Romero, Wallace, Pannell, Hill, & Pressey, 2021; Kim, Álvarez-Romero, Wallace, Pannell, Hill, Adams, et al., 2021). This research project considered values as the potential benefits associated with natural assets, and the capacity of the landscape to support different economic activities.

Relational values

Relational values are defined as ‘preferences, principles, and virtues associated with relationships’ (Chan et al., 2016; Chan et al., 2018). Relational values are highly relevant in First Nations society, particularly relationships of people with other people and with Country (including water). Considering relational values arising from the relationship of people with Country, they can be differentiated from instrumental values

(what Country provides to humans) or intrinsic values (the value of Country in itself), as the reciprocal and fundamental relationship between people and Country. Relational values include eudaimonic values - those associated with a good life or wellbeing. Some West Kimberley languages (including Nyikina, Yawuru) use the term 'liyan' to talk about a sense of wellbeing, reflecting eudaimonic value.

While the concept of relationality is not new, the use of the term 'relational values' in valuation literature is relatively recent and is included in the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) Conceptual Framework (Díaz et al., 2015). Relational values were explicitly mentioned in four reviewed papers. Only one considered quantitative valuation approaches for relational values as part of the IPBES framework, while the others focused on qualitative aspects.

In their study of the contributions of nature to people within the Yawuru IPA, Newman et al. (2019) used the IPBES 'nature's contribution to people' (NCP) framework to assess and quantify NCPs, including context-specific perspectives (CSPs) that incorporate relational values to the Yawuru IPA management objectives. That paper suggested five potential valuation methods that could be applied to measuring NCPs for one of the eight targets, with stated preference methods the most common.

Exploring relational values and thinking in Nyikina custodial and hydro-ecological relationships, Milgin et al. (2020) argued that relationality should be seen not only as a value concept to improve assessments of the benefits to humans, but also as an overarching framework for human-environment relations with a basis in the ethics of care. In a similar vein, Stoeckl et al. (2021) suggested the existing ecosystem services assessments framework does not adequately address broader relationships to nature, particularly the connectivity, reciprocity and transcendental values, in Indigenous and other non-western societies. They stressed the complexity of the relationship between people and place, noting the longer temporal scale, physical connections to strengthen spiritual connection, and the need for reciprocal caring to be done the right way by the right people.

In conceptualising hydro-socio-ecological relationships, Douglas et al. (2019) discussed legal processes supporting Indigenous peoples to assert their water management responsibilities, acknowledging the people's relational values and the global trend for rivers to be conferred rights and legal agency.

Multiple values

The majority of papers mentioned both ecological and cultural values (n=41), most specifically linking them. Of these papers, about half mentioned ecological, cultural values and economic values (n=21). Only eight papers focused exclusively on one value (3 on ecological, 3 on culture, 2 economic).

The overarching theme of the Kimberley Appropriate Economies Roundtable Forum report (Hill et al., 2006; Jackson, 2006) was the importance of considering all values – cultural, ecological, and economic – in development. There was much greater focus on developing and sharing understandings of cultural and ecological values rather than simply the economic benefits of development.

The larger, more comprehensive research projects undertaken in the region generated literature that addressed cultural, ecological, and economic values. These include reports from major research projects including TRaCK (Jackson et al., 2011; Nikolakis & Grafton, 2011; Nikolakis et al., 2010; Straton & Zander, 2009), CSIRO Water Resource Assessments (Merrin et al., 2018; Petheram et al., 2018), and the National Environmental Research Programme's (NERP) Northern Australia Hub (Álvarez-Romero et al., 2021; Kim, Álvarez-Romero, Wallace, Pannell, Hill, & Pressey, 2021). Several journal articles also reported on these research reports.

Ecological, cultural and economic values are addressed in community-led research supported by NGOs, including the report from the Kimberley Appropriate Economies Roundtable Forum (Hill et al., 2006), the

Fitzroy River Catchment Management Plan (Cook, 2010), and the Nyikina and Mangala natural and cultural heritage plan (Watson et al., 2011).

Linkages between values

A preliminary qualitative assessment of the Fitzroy River system environmental values (Storey et al., 2001) used the term eco-cultural values to recognise the strong linkage between ecological values and cultural values. The values discussed include places of cultural significance on the River that are linked to culture and creation stories that are often associated with the River. Permanent pools called ‘living waters’ are culturally significant and need to be flushed and restocked by flooding to support important aquatic species targeted for harvesting. Similarly, many riparian species are used for foods and medicines, as well as shade, demonstrating the inextricable relationship between ecological and cultural values of specific freshwater habitats (Storey et al., 2001).

Several papers discussed the importance of water flow and water bodies, including floodplains, wetlands, and permanent pools, to ecological and cultural values (Finn & Jackson, 2011; Heiner et al., 2019; Jackson, 2015). Studies exploring carbon (food web) movement in the Fitzroy River assessed the likely impacts of water flow alteration on ecological and cultural values (Beesley et al., 2020), and then extended focus to the economic value of fish to Aboriginal people (Beesley et al., 2021). A similar study on nearby Nyul Nyul Country stressed the importance of groundwater for maintaining aquatic habitats that support ecological and cultural values (Pettit et al., 2016). A study of the riparian vegetation pointed to the effects of water extraction on cultural values associated with particular species (Canham et al., 2021).

Assessment and valuation

The assessment of values evident in the literature generally reflects the nature of the value, the information available for assessment, and the disciplinary approach of the authors. Several papers highlighted the challenge of valuation and raised questions about the appropriateness of quantitative valuation.

Cultural values, for example, are often described qualitatively, particularly in ethnographic research. Cultural heritage sites are sometimes mapped to inform development decisions, often with large buffers and protection of information by limiting access to TOs. This mapping is often layered with other information, including physical land features and ecological values.

Structured assessment techniques, particularly where multiple values are involved, were utilised in several papers. These techniques included spatial mapping of multiple values or modelling the hydrological, ecological, and cultural values, relationships and responsibilities.

Most of the mapping and models were developed collaboratively with TOs and researchers, enabling co-production from cultural and scientific viewpoints. The results reflect the relationality of cultural and ecological values.

Spatial mapping

Mapping of geological, hydrological, ecological, cultural, social, and economic data is particularly useful in informing decisions about where development and protection are appropriate or maximise value. Mapping of hydrogeological, surface geological, soil and water and flood was included in the major water resource assessment for the Fitzroy catchment (Petheram et al., 2018).

Mapping of species distribution in the riparian zone was linked to flood inundation to support predictive modelling of the impacts of water extraction on ecological values (Canham et al., 2021).

Spatial mapping of cultural heritage values and sites with other cultural significance, with TOs exercising control over access to that information, can be used to inform decision making about the development and

protection of sites. Six papers reported applying spatial mapping techniques to cultural values (Álvarez-Romero et al., 2021; Heiner et al., 2019; Hill et al., 2021; Jackson et al., 2012; Jackson et al., 2011; Laborde & Jackson, 2021).

Importantly, the cultural information mapped by TOs was not shared with researchers, except by Heiner et al. (2019), who incorporated 663 sites identified in surveys, mapped by the count of sites in a grid of 3x3km cells. This paper demonstrated the strong spatial association of cultural heritage sites and ecological values with freshwater places in the catchment. Mapping of significant places that are part of the River story was reported (Laborde & Jackson, 2021), with data restricted to the native title holders.

Spatial mapping of cultural/heritage sites and significant habitats for biodiversity values in Heiner et al. (2019) showed a strong thematic and spatial link with freshwater features in the catchment, reflecting how social, cultural and biodiversity values can reinforce each other.

A recent study focused on governance and co-production of knowledge (Hill et al., 2021), using spatial and non-spatial participatory mapping and co-production of scientific and Indigenous knowledge to map ecological values, and using the information on their occurrence and importance to TOs. Notably, the cultural values were discussed and recorded by TOs but were not shared with the non-Indigenous researchers or mapped. This exercise focused on improving processes for environmental planning and management by remote Indigenous peoples.

A study of aquatic resource use by Indigenous people in both the Fitzroy and Daly River catchments used participatory river use mapping to understand the spatial and temporal distribution of species availability, and how river flows might affect these habitats (Jackson et al., 2012; Jackson et al., 2011).

Modelling and (non-spatial) mapping of related values

The conceptual models reviewed in this literature generally involved the relationships between Indigenous people, water, and ecological values. An initial hydro-socio-ecological conceptual model published in Douglas et al. (2019) explored the influences of water flows and water abstraction with ecological values and cultural values to demonstrate the importance of hydrological connectivity for maintaining hydro-ecological and cultural values.

Building on that initial conceptual model, Laborde and Jackson (2021, pp. 19–21) presented a living waters model informed by Aboriginal collaborators. The model represents a customary system of management handed down over generations – a paradigm that depicts the relationships between people, other beings, and the waters of the Martuwarra/Fitzroy River catchment. The reciprocity and linkages of values and responsibilities were contrasted with the modern water resource model where water is seen purely as a resource.

Stoeckl et al. (2021) developed an Aboriginal model of the nature-people relationship which stresses the importance of stewardship (caring for Country), activities being done the right way by the right people, thereby improving the environment and directly improving wellbeing.

Cultural values

Across the literature reviewed, cultural values were predominantly discussed and presented in qualitative terms.

Cultural values related to the use of natural resources by Aboriginal people were assessed by examining harvest data for key species that are targeted by Aboriginal people (Finn & Jackson, 2011; Jackson et al., 2012; Jackson et al., 2014; Jackson et al., 2011). Quantification of cultural values in dollar terms in Two of

these papers (Jackson et al., 2014; Jackson et al., 2011) used economic data and replacement cost (market equivalent) values for harvest.

Broadening the concept of cultural value from physical heritage and resource use to include intrinsic, existence and, more recently, relational values and connection, presents a greater valuation challenge. Essentially this entails revealed preference techniques. Choice modelling of ecosystem services for the Fitzroy and two other rivers, with both Indigenous and non-Indigenous respondents, provided estimates of willingness to pay, aggregate willingness to pay, and compensating surplus (Straton & Zander, 2009; Zander et al., 2010). A choice modelling approach was also used to quantify cultural values held by the Nyikina and Mangala people of the Fitzroy River region (Woods, 2020). This research sought to identify and quantify cultural values from a First Nations viewpoint, rather than limit valuation to a western market equivalent approach. While the non-market valuation method used to quantify value may itself have limitations, the essential approach of privileging First Nations perspectives, and framing the quantitative assessment in grounded qualitative research with First Nations people, is critical to any valuation of cultural values.

Ecological values

Scientific assessment of ecological values generally involves collation of count, distribution, and temporal data, supporting assessments of the status of significant or threatened species. The assessment of ecological values was supported by hydrogeological data linked to species-specific data (Beesley et al., 2021; Canham et al., 2021). The collation of hydrological data, and data on plant and animal species dependent on water, contributed to assessment of the ecological and cultural values of a region (Storey, 2006; Storey et al., 2001).

Economic values

Economic values are generally assessed using direct or estimated commercial cost and return data, along with estimation of secondary impacts – the benefits or harms. In the context of Martuwarra, economic values can include those relating to water resource development and associated industries, such as irrigated agriculture, mining, aquaculture, tourism and recreation, and traditional harvest activities.

Feasibility and economic analysis of options to transport water from the Kimberley to the south of WA (Appleyard et al., 2006) involved costing of options and comparison with desalination. It separately quantified the energy consumption and greenhouse gas emissions, assessed risks, and explored the relative environmental and social impacts of the options.

In the final Water Resource Assessment for the Fitzroy catchment, Merrin et al. (2018) provided a profile of the living and built environment of the Fitzroy catchment. In profiling the current and potential development of industries and land use, the assessment drew together data on the economics of the agriculture and fisheries industries, including irrigation schemes, tourism, and the mining industry.

A later chapter of the same report assessed the commercial viability of potential irrigated agriculture developments (Stokes & Jarvis, 2018). While acknowledging this was not a full economic analysis, the authors considered the costs of building new infrastructure, the financial viability of different types of schemes, and regional economic impacts. Regional impacts were estimated using regional economic multipliers, derived from input-output tables that summarise expenditure flows between industry sectors and households within the region. A subsequent chapter addressed a range of risks associated with greenfield agriculture or aquaculture development that would need to be considered in determining viability.

The more traditional economic analysis reviewed above focuses on economic analysis from a general perspective, rather than a context-specific Indigenous perspective. An Indigenous approach might consider

alternative development pathways such as those identified in Watson et al. (2011), or build in valuations from an Indigenous perspective.

A benefit-cost analysis (BCA) of allocating water for irrigated agriculture in the Fitzroy catchment was compared with alternate economic pathways for TOs by Connor et al. (2019). The economic assessment of three alternative irrigation developments utilised data of past regional irrigation projects to assess profitability, noting but not quantifying the associated additional social and environmental costs, including externalities such as carbon emissions, and natural and cultural asset degradation. This was contrasted with a scenario where Indigenous-owned enterprises are developed in carbon farming, bush foods, traditional medicine, tourism, partnerships in science and education, and arts and crafts.

Relational values

Much of the recent research used qualitative methods to identify and assess relational values, and has suggested that relational values cannot be captured and quantified using existing quantitative techniques. While there are few quantitative studies on relational studies in the literature, Schulz and Martin-Ortega (2018) suggested three benefits of quantifying relational values, namely contributing to the empirical evidence base testing hypotheses and assumptions, enhancing global dialogue on relational values, and improving the political legitimacy of environmental decision-making.

None of the literature reviewed in this project explicitly quantifies relational values, although Newman et al. (2019) indicated methods that could be used to do so, based on the IPBES framework. NCPs were used to assess Yawuru IPA conservation objectives including eight targets relating to cultural, ecological and economic values (Newman et al., 2019). By assessing context-specific perspectives and generalising perspectives (regulating, non-material and material), and mapping these against established NCPs, the study then assessed a single target for wetlands, and identified several valuation methods, including stated preference (SP), revealed preference (RP), production-based (PB), cost-based (CB), and benefits transfer (BT), that could be used. While the paper did not attempt an overall valuation of NCP provided by the Yawuru IPA, the mapping of NCPs against targets and identification of potential valuation methods provides significant insight into the challenges and limitations of such an approach.

Having worked with an Aboriginal group to explore how its conceptualisation of the Country-people system related to the ecosystem services concepts, Stoeckl et al. (2021) highlighted the need to allow for the interconnections that differentiate Aboriginal views from atomistic descriptions of ecosystem services. The reciprocity of not only gaining benefits from Country but looking after Country the right way enhanced wellbeing, as well as benefitted the environment, a clear example of relational value. Stoeckl et al. (2021) are critical of the MEA and IPBES frameworks as inadequately addressing relational values.

The reciprocity inherent in relationality means that it encompasses more than what nature provides to people, as suggested by the IPBES model. Given the improvement in wellbeing associated with the reciprocated human-nature relationship of caring for Country, acknowledged in the literature (Campbell, 2011; Stoeckl et al., 2021), it seems likely that wellbeing measures based on preference elicitation techniques or impact data may incorporate relational value.

The bigger challenge with quantification of relational values using choice modelling is the requirement for independence of irrelevant alternatives (IIA) in attributes being assessed (see for example Woods, 2020, p. 286). Adaptation of multi-attribute utility theory in a participatory scenario planning process (Gregory et al., 2020; McDaniels & Trousdale, 2005) may support a valuation of instrumental, intrinsic, and relational values.

Innovation in valuation

In one paper, spatial characteristics were incorporated in an innovative choice modelling approach to assess marine and coastal management in the Kimberley, enabling differentiated valuations of geographical zones (Kragt et al., 2016). This research did not explicitly consider cultural values from a First Nations perspective, instead focusing on management regimes, increased sanctuary zones, recreational facilities, Aboriginal rangers, and visible coastal development.

Application of the IPBES ‘nature’s contribution to people’ approach, and identification of possible valuation objectives for a subset of the management objectives in the Yawuru IPA, were suggested as a means of communicating the economic, social and cultural benefits of an IPA (Newman et al., 2019). However, that paper noted that the potential cost of an accurate valuation for all NCPs in a protected area is potentially prohibitively expensive, and only likely to be pursued if there is significant economic potential in alternative development.

Governance

A key message in many of the papers is that ecosystem assessment of the Martuwarra needs to involve TOs as central actors. While some of the research did not address processes for Indigenous engagement beyond the research itself, planning documents and most of the literature mapping or modelling multiple values explicitly recognise the need for TOs to be involved in the assessment and decision making to protect the cultural and ecological values of the River.

The need for reform of governance to involve Indigenous people was asserted to varying degrees across the papers reviewed. For example, a lower threshold suggests acknowledging that ‘formalising and refining water values and water planning ... may require ... [r]efinement of Indigenous governance rights, roles and responsibilities’ (Petheram et al., 2018, p. 131). Greater Indigenous involvement in governance is more strongly recommended in other reports, including those with TO authors. Governance recommendations in these include: advocating for a statutory authority, inclusive of all stakeholders, to ‘monitor and regulate potential cumulative impacts from development’ and ‘ensure that there is informed consent in decisions regarding development’ (Poelina et al., 2019); and, embedding plurality into knowledge production, management and governance (Milgin et al., 2020).

In his paper for the Global Water Forum, Samnakay (2020) argued for new governance and legal settings to protect the natural and cultural values of the Fitzroy in the face of growing demands to exploit the water and mineral resources of the Fitzroy catchment.

Conclusion

The literature reviewed in this project addressed cultural, ecological, economic and relational values and valuation approaches associated with the Martuwarra (Fitzroy River) catchment and region. Few of the papers addressed only one of the values, with most considering cultural and ecological values and the linkages between them. Several papers by multidisciplinary teams addressed multiple values.

The review found a trend away from the quantitative valuation of ecosystem services toward mapping and modelling of values. Modelling demonstrates the complexities of linkages and interdependencies and the challenge of identifying components of the system independently.

Two significant themes arise in the literature that dealt with multiple values. Firstly, papers demonstrated the strong linkages between ecological and cultural values. Secondly, by both discussion and omission, papers demonstrated the challenges inherent in the valuation of multiple values in an eco-cultural system.

The relationship between ecological and cultural values was shown in the modelling of relationships between the River, ecology, and people, and mapping of values and linkages between elements of the eco-cultural system. These models go some way towards showing the relational, or reciprocal, relationships that people have with other people and with Country, relationships that Aboriginal people in the region have expressed for some time. These relationships reinforce the crucial role of TOs in assessing and managing values in the catchment.

While values and valuation, rather than governance, were the focus of this project, most of the literature points to the need to ensure that TOs are directly involved in the governance of the catchment to protect cultural and ecological values, as well as the assessment and management of values. Governance reforms, including co-design and co-management, are, to varying degrees, established in principle in both the Australian Government and WA Government First Nations policy frameworks. The MFRC, representing TOs along the River, is well situated to play a key role in reformed and inclusive governance of the catchment.

It is important to recognise that First Nations governance and cultural valuation are not mutually exclusive. Arguably, valuation, particularly in quantitative and monetary terms, can play an important part in broadening recognition and inclusion of First Nations values in policy and legal frameworks.

Gaps

The major gaps evident in the literature reviewed relate to the quantification of values in monetary terms. For good reason, none of the more comprehensive assessments of values attempts to quantify all values associated with the River. Arguably, a holistic quantification of all values associated with the River could be likened to estimating the global value of ecosystem services (Costanza et al., 2014). Such a holistic valuation, while providing a basis to communicate the importance of Martuwarra, would not assist with the assessment of development proposals or other changes to the river basin.

Economic values flowing from some proposed developments involving water extraction, including regional economic benefits, have been quantified using commercial and cost-benefit analysis. The quantitative valuation of ecosystems is limited to biodiversity assessments, including aquatic and listed threatened species, with limitations on economic and biodiversity data noted in several studies. None of the comprehensive assessments of values associated with Martuwarra quantifies cultural values.

Economic values in private development

Assessment of the economic values associated with major public infrastructure developments to support transporting water from the Fitzroy River to southern WA, or water extraction for irrigated agriculture, did not provide an economic valuation framework for assessing other development, such as extraction of mineral or gas resources in the Fitzroy River catchment.

While major private sector developments may require economic analysis to underpin applications for government approval or support, the true costs and returns are privatised and not necessarily transparent. Secondary benefits, such as socioeconomic gains through employment, are often misrepresented or overstated. The total number of new jobs to be created by a project may be interpreted as full time and ongoing but may relate primarily to the construction phase of a project. The political appeal of job creation encourages a generous interpretation to attract government support. Ecological and cultural impacts of water extraction - riverine or groundwater, pollution, or changes to water quality - may not be independently assessed or fully understood, and the cultural values of First Nations people may not be adequately assessed or taken into account.

Cultural valuation

The rationale for not fully quantifying cultural values in many studies relates to the underlying challenges of applying quantitative valuation techniques to cultural values (especially the non-market values), and the focus on instrumental values in MEA framework based ecosystem services assessments. There are three main challenges raised in the literature. Firstly, preference elicitation techniques can be seen as utilitarian and individualistic and therefore not applicable to First Nations communities. Secondly, the relational and non-atomistic nature of cultural values means they are harder to separate from other values for valuation. The other main challenge relates to concerns about monetary valuation leading to the commodification of culture.

Both approaches used in the reviewed literature to quantify cultural values in dollar terms - market equivalent values of harvest and choice modelling - have limitations. Harvest valuation only captures instrumental or use value based on western market values, rather than the full cultural value to First Nations people. This means any estimates of cultural value could be significantly understated given the secondary benefits flowing from harvest processes. The main challenges and limitations of the choice modelling approach used (Straton & Zander, 2009; Woods, 2020) include:

- ensuring methods (design and conduct) privilege First Nations perspectives (not aggregating results using the same approach for Indigenous and non-Indigenous people);
- specifying attributes that reflect First Nations perspectives but are sufficiently independent;
- aggregation of individual utility, if these do not accommodate values that extend beyond individualistic ideals, to produce a higher level of social utility;
- generalisability of the model or results beyond the specific context and First Nations group involved.

A recent review of peer-reviewed literature (Manero et al., 2022) identified challenges associated with non-market valuation of Indigenous peoples' values. They recommended bespoke approaches to Indigenous non-market valuation using seven questions to guide best practice non-market valuation that address some of these challenges. The seven questions are:

1. What is the purpose?
2. How does Indigenous knowledge inform non-market valuation?
3. Who benefits?
4. What ethical frameworks are followed?
5. Whose values are being considered?
6. What is the expected change and how is it perceived by Indigenous peoples?
7. How are limitations handled?

Alternative approaches

Despite the challenges of undertaking and incorporating cultural valuation from a First Nations perspective, there may be scope to build or adapt multi-objective planning frameworks for assessing nature's contributions to people in a way that accommodates First Nations values, including relational and eudaimonic values. Combining these grounded multi-objective planning frameworks with choice modelling could provide an opportunity for First Nations peoples' values to be built into planning processes, as well as providing rigorous preference modelling and quantitative valuations if required.

The wellbeing-based multi-attribute participatory planning approach (Álvarez-Romero et al., 2021) supported assessments of scenarios by First Nations and other participants. Adapting this approach to privilege First Nations viewpoints on attributes of scenarios and wellbeing measures would address some of its shortcomings. The inclusion of an economic trade-off could support valuations of scenarios and their

attributes, including the cultural values. Splitting of First Nations and other participants may still be required to protect cultural information that was not shared with non-Indigenous participants.

Multi-attribute ranking approaches that accommodated community rather than individual assessments of cultural values were used to assess the multiple dimensions of loss associated with exclusion from, or damage to, traditional lands (Gregory et al., 2020; Gregory & Trousdale, 2009; McDaniels & Trousdale, 2005). Important elements of this approach to assessing loss for compensation involve: privileging First Nations viewpoints in identifying significant values; including an economic loss category as a comparator; determining relative importance in small groups to enable discussion (a deliberative process); and, independent calculation of dollar values for categories of loss to avoid strategic bias. Adapting this type of approach to suit the Martuwarra context would need to focus on existing values and potential rather than actual losses associated with scenarios being compared. The decision and preference expression techniques are not dissimilar to a choice modelling approach, such as a multi-profile case Best-Worst Scaling method.

Approaches that adopt deliberative processes, generally involving groups of key stakeholder representatives including elders and leaders, provide a means for understanding the benefits of ecosystems and facilitating exploration of the values at stake in different scenarios. As well as the examples specifically targeting cultural values mentioned above, other literature explores methodological frameworks that address intangible dimensions of cultural services and benefits (see for example Chan, Guerry, et al., 2012; Chan, Satterfield, et al., 2012). Further research on such alternative approaches could inform an approach for Martuwarra.

A way forward

This report analyses literature relating to Martuwarra values and valuation. The biggest gap in the valuation literature relates to the inclusion of cultural values in monetary valuations. Unless cultural values are included in valuations there is a risk that they will be overlooked in decisions, and thereby be adversely affected. An inclusive governance regime, while providing a voice for TOs to assert the importance of these values, cannot provide a comparative valuation with economic and other values.

While not intending to recommend a particular approach to valuation, this report can inform consideration and discussion by TOs, and the Water Justice Hub, of what, if any, valuation or further research for Martuwarra is worthwhile.

Valuation is complex and costly to undertake, and potentially contestable given the limitations of valuation approaches and multiple values that may be affected by development in the Fitzroy Basin.

A holistic valuation of all values associated with the entire Fitzroy Basin would not enable the assessment of specific development proposals or other changes to the basin. It would also be an expensive, time consuming and lengthy process.

Instead, a suggested approach is to develop a small research project related to a recent or imminent development proposal. This could enable the demonstration and testing of preferred valuation approaches, which might incorporate deliberative, multi-attribute and/or choice methods. As well as the questions to guide best practice in non-market valuation recommended by Manero et al. (2022), MFRC and the Water Justice Hub may wish to consider the following points in the design of a valuation project.

1. The extensive mapping of values that has already been undertaken in previous research could inform spatially targeted valuations.
2. Engaging all stakeholders, including governments and development proponents, in any research and valuation process is more likely to ensure acceptance and use of any results. Involving relevant researchers may also assist with acceptance of results.

3. A high degree of support among locals, and engagement of local researchers in research, is important. This includes strong representation in workshops and high participation rates in surveys, which is critical to statistical validity given the low population density in the region.

The assessment and decision making about development projects affecting Martuwarra, including mineral resource extraction, must involve affected Aboriginal people and include evidence of potential impacts on all the values (including ecological and cultural values). TOs and affected Aboriginal people need to be central in governance frameworks for determining and managing the balance between development and conservation in the catchment. Valuation informing decision making needs to incorporate First Nations peoples' values to be a just representation of all the values affected by any proposed development. These two features, governance and valuation, would address the underrepresentation of First Nations peoples and their values that has impacted so negatively on water resource management elsewhere.

Attachment A: Summary of search and selection process

Original search and review

Original searches focused on published literature relating to Martuwarra (Fitzroy River) water values and valuation, primarily Indigenous values and valuation, with a particular focus on quantitative studies.

To do this, the following steps were taken:

1. defining the scope of the literature
2. searching literature databases
3. identifying supplementary literature from other literature reviews and the author's own database
4. reviewing the literature identified and removing literature that did not advance the objective.

The search and review of literature was conducted through literature databases (SCOPUS, JSTOR, and Web of Science core collection). The literature search was not time-limited. The following terms were used in searches: Martuwarra OR Mardoowarra OR "Fitzroy River", value OR valuation. The review's scope focused on Indigenous values and excluded water resource assessments and hydrogeological assessments reviewed elsewhere.

A draft Annotated Bibliography by Adjunct Professor John Williams, and the author's collection of other related literature, including grey literature, were then compared to, and supplemented, the search results.

Results of searches and preliminary assessments

| Database/collection | Raw | Excluded | Remainder |
|---|-----------|-----------|-----------|
| SCOPUS | 32 | 26 | 6 |
| JSTOR | 9 | 7 | 2 |
| Web of Science | 28 | 14 | |
| - excl. duplicates | | 6 | 8 |
| Other sources: | | | |
| Williams (draft Annotated Bibliography) | 6 | - | 6 |
| Woods (author's collection) | 11 | - | 11 |
| TOTAL SEARCH RESULTS | 86 | 53 | 33 |

Each item identified in this search process was reviewed to consider whether it:

1. considered value in terms of philosophical principles and beliefs or in terms of worth
2. addressed valuation
3. addressed quantitative valuation
4. considered a process for recognition of values
5. considered governance requirements.

Most papers explicitly or implicitly considered value, particularly Indigenous values and cultural values, in terms of beliefs or principles (n=28), while a slightly smaller number (n=26) considered value in terms of worth.

A valuation was either referred to or undertaken in n=23 of the papers. Of these, in one case there was a reference to an approach for incorporating qualitative data, and two papers undertook some form of scaling assessment for translation to spatial data. Quantitative approaches to valuation were undertaken in several papers (n=8), although two of these did not attempt to incorporate sociocultural values.

Much of the literature considered processes for recognition of the sociocultural values held by Indigenous people (n=18). Future governance arrangements to protect or recognise values were discussed in several papers (n=11).

Eliminating those papers that did not deal directly with some form of valuation or use of quantitative or qualitative assessments of worth, the annotated bibliography here briefly discusses n=17 of the remaining papers, focusing on the stated objective of the initial annotated bibliography.

Expanded search and review

Following discussion of the initial annotated bibliography with the Water Justice Hub Advisory Group, the review's scope was expanded to include values more broadly, including ecological and economic values, as well as other relevant regional research, including grey literature, on values and valuation.

Further searching of databases used in the original search, as well as Google Scholar, government and relevant research organisation websites, and revisiting known research yielded an additional 31 papers that were likely to be relevant. The water resource assessments and related reports undertaken by research organisations in response to acknowledged limits of research in the Fitzroy River region were a significant addition, both in the breadth of values and volume of research. The table below sets out the sources of additional literature.

| Database/collection | Original | Expanded Raw | Excluded | Additional | Final |
|------------------------------|-----------|--------------|------------|------------|-----------|
| SCOPUS | 6 | 57 | 47 | 4 | 10 |
| JSTOR | 2 | 38 | 34 | 2 | 4 |
| Web of Science | 8 | 16 | 8 | 0 | 8 |
| Google Scholar* | - | 200 | 196 | 4 | 4 |
| <i>Other sources</i> | | | | | |
| Williams | 6 | 6 | 0 | 0 | 6 |
| Woods | 11 | 21 | 0 | 10 | 21 |
| Governments (WA, Australian) | - | 2 | 0 | 2 | 2 |
| Research Organisations | - | 10 | 0 | 10 | 10 |
| TOTAL SEARCH RESULTS | 33 | 350 | 285 | 32 | 65 |

* The first 200 of approximately 3240 Google Scholar search results were assessed

Attachment B: Papers excluded from further review

| Reference | Brief Outline |
|--|--|
| Dobbs et al. (2016) | This paper discussed the importance of collaboration between scientists and Nyul Nyul rangers at Beagle Bay to inform monitoring and management of aquatic ecosystems. Not addressing values and valuation per se. |
| Freestone et al. (2021) | This report presents a synthesis of plant surveys, and describes the vegetation species composition and structure of four broad vegetation zones along the lower Fitzroy River. Not addressing values. |
| Hamilton and Gehrke (2005) | This paper outlines the scientific knowledge of tropical rivers in Australia presented at the 2004 forum on Sustainable Futures for Australia's Tropical Rivers, with a focus on hydrological uncertainty and the need for further research. The paper acknowledges the uneven geographical coverage of research, with the majority relating to the rivers draining into the Great Barrier Reef lagoon and waterways in and around Kakadu National Park. No research specifically addressing values in the Fitzroy River. It acknowledges Indigenous cultural and social values, noting Aboriginal legal title to much of the land in the tropical north of Australia. |
| Moggridge (2021) | This editorial introduction for a journal special issue dealing with Indigenous water knowledge and values does not deal with values or valuation related to Martuwarra. |
| Pelizzon et al. (2021) | This paper deals with personhood for river and legal rights, not cultural valuation. |
| Poelina (2019) | This book chapter suggests how to promote remote Aboriginal people's wellbeing through a cooperative regional earth-centred governance model. |
| RiverOfLife, Poelina, Bagnall, et al. (2020) | This symposium article proposes a co-management governance model, premised on the right of the River as an entity and 'First Law', which provides enhanced water rights for the River and TOs. |
| RiverOfLife, Taylor, et al. (2021) | This paper presents the 'Living Waters, Law First' water governance framework that centres on Living Waters, First Law and the health/wellbeing of people and Country. The framework is based on a groundwater policy position developed by the Walalakoo Aboriginal Corporation (WAC), the Nyikina and Mangala peoples' native title corporation, in the West Kimberley, WA in 2018. This article explores the emerging conceptual challenges to the status quo by comparing the Living Waters, First Law framework to Australia's settler state water governance framework, represented by the National Water Initiative. |
| RiverOfLife, Unamen Shipu Romaine River, et al. (2021) | This paper presents a comparison of two rivers and the rights of the River. |
| Simmonds et al. (2021) | This paper explores the impacts of development on biodiversity and biocultural impacts of development and considers the limitations of project level as opposed to regional planning approaches. It examines how different approaches to impact assessment (IA) can contribute to, or detract from, sustainable development in northern Australia, given the extraordinary ecological value and human history juxtaposed against conflicting development |

| Reference | Brief Outline |
|-----------------------|--|
| | aspirations. The Northern Territory is the focus of the paper, but the paper notes that much would apply to northern WA and Queensland. |
| Stoeckl et al. (2016) | This paper reviews and assesses integrated decision support tools that might be used to support management and planning in Northern Australia. The empirical models assessed originate from the biophysical sciences, the social sciences, and computational/mathematical sciences. |
| Toussaint (2008) | This paper presents an ethnographic study of Indigenous and non-Indigenous connection to water places and engagement in protection that create place-based cultural attachments. The complexity of Indigenous peoples' relationships to water are contextualised in the cultural beliefs and the 'Dreaming', and the tensions that arise when developments are proposed, or occur, that disturb the ecological balance. The views of non-Indigenous people who live and work in the Kimberley are also discussed in the paper, noting that the Fitzroy River is a meaningful place to them - particularly for those involved in environmental and ecological protection. |
| Toussaint (2014) | This paper describes the importance of fishing as a cultural mourning ritual (jaminyjarti). Systematic and spatial analysis of jaminyjarti is an important factor in studies of fish and river flows, particularly given the high mortality rates in the region. While not explicitly dealing with value, the paper highlights the cultural value of fishing over and above the market value of the product, and demonstrates the interconnectedness of cultural and ecological values of water. |
| Treloyn et al. (2016) | This paper considers processes for repatriating song recordings, identifying their cultural significance. |

Attachment C: Values canvassed in reviewed literature

| Authors | Publication Year | Value(s) (as in beliefs) | Cultural values | Ecological values | Economic values | Relational values | Valuation | Quantitative valuation \$ | No. of values |
|---|------------------|-----------------------------|-----------------|-------------------|-----------------|-------------------|-----------|---------------------------|---------------|
| Álvarez-Romero et al. (2021) | 2021 | X | X | X | X | | X | | 2 |
| Appleyard et al. (2006) | 2006 | | | | X | | X | X | 1 |
| Barber and Woodward (2018) | 2018 | X | X | | | | | | 0 |
| Beesley et al. (2020) | 2020 | | X | X | | | | | 1 |
| Beesley et al. (2021) | 2021 | | X | X | X | | | | 2 |
| Canham et al. (2021) | 2021 | | X | X | | | | | 1 |
| Connor et al. (2019) | 2019 | | X | X | X | | X | X | 2 |
| Cook (2010) | 2010 | | X | X | X | | X | | 2 |
| Douglas et al. (2019) | 2019 | X | X | X | | X | | | 2 |
| Finn and Jackson (2011) | 2011 | X | X | X | X | | | | 2 |
| Heiner et al. (2019) | 2019 | X | X | X | | | X | | 1 |
| Hermoso et al. (2012) | 2012 | | | X | | | | | 1 |
| Hill et al. (2006) | 2006 | X | X | X | X | | X | | 2 |
| Hill et al. (2021) | 2021 | X | X | X | | | X | | 1 |
| Jackson (2006) | 2006 | X | X | X | X | | | | 2 |
| Jackson (2015) | 2015 | X | X | | | | | | 0 |
| Jackson et al. (2012) | 2012 | X | X | X | X | | | | 2 |
| Jackson et al. (2014) | 2014 | X | X | X | X | | X | X | 2 |
| Jackson et al. (2011) | 2011 | X | X | X | X | | X | X | 2 |
| Jackson et al. (2008) | 2008 | X | X | | X | | | | 1 |
| Kim, Álvarez-Romero, Wallace, Pannell, Hill and Pressey (2021) | 2021 | X | X | X | X | | | | 2 |
| Kim, Álvarez-Romero, Wallace, Pannell, Hill, Adams, et al. (2021) | 2021 | | X | X | X | | | | 2 |
| Kragt et al. (2016) | 2016 | | X | X | X | | X | X | 2 |
| Laborde and Jackson (2021) | 2021 | X | X | X | X | | | | 2 |
| Liedloff et al. (2013) | 2013 | X | X | X | | | X | | 1 |

| Authors | Publication Year | Value(s) (as in beliefs) | Cultural values | Ecological values | Economic values | Relational values | Valuation | Quantitative valuation \$ | No. of values |
|--|------------------|-----------------------------|-----------------|-------------------|-----------------|-------------------|-----------|---------------------------|---------------|
| Mathews et al. (2011) | 2011 | | X | X | | | | | 1 |
| Merrin et al. (2018) | 2018 | X | X | X | X | | X | X | 2 |
| Milgin et al. (2020) | 2020 | X | X | X | | X | | | 2 |
| Newman et al. (2019) | 2019 | X | X | X | X | X | X | X | 3 |
| Nikolakis and Grafton (2011) | 2011 | X | X | X | X | | | | 2 |
| Nikolakis et al. (2010) | 2010 | X | X | X | X | | | | 2 |
| Petheram et al. (2018) | 2018 | X | X | X | X | | | | 2 |
| Pettit et al. (2016) | 2016 | | | X | | | | | 1 |
| Poelina et al. (2021) | 2021 | X | X | X | | | | | 2 |
| Poelina et al. (2019) | 2019 | X | X | X | | | | | 1 |
| Pusey and Kath (2015) | 2015 | | | X | | | | | 1 |
| RiverOfLife, Poelina, Alexandra, et al. (2020) | 2020 | X | X | X | | | | | 1 |
| Samnakay (2020) | 2020 | X | X | X | X | | | | 2 |
| Stoeckl et al. (2021) | 2021 | X | X | X | | X | | | 2 |
| Stokes et al. (2017) | 2017 | | X | | X | | X | X | 1 |
| Stokes and Jarvis (2018) | 2018 | | | | X | | X | X | 1 |
| Storey (2006) | 2006 | X | X | X | | | | | 1 |
| Storey et al. (2001) | 2001 | | X | X | | | | | 1 |
| Straton and Zander (2009) | 2009 | X | X | X | | | X | X | 1 |
| Toussaint et al. (2001) | 2001 | X | X | X | | | | | 1 |
| Vogwill (2015) | 2015 | | X | X | | | | | 1 |
| Watson et al. (2011) | 2011 | X | X | X | X | | | | 2 |
| Woods (2020) | 2020 | X | X | | | | X | X | 0 |
| Yu (2006) | 2006 | X | X | X | | | | | 1 |
| Zander et al. (2010) | 2010 | | X | X | | | X | X | 1 |
| Zander and Straton (2010) | 2010 | | X | X | | | X | X | 1 |
| Total | | 33 | 46 | 44 | 25 | 4 | 19 | 13 | |

Attachment D: Annotated bibliography

Álvarez-Romero, J. G., Kim, M. K., Pannell, D., Douglas, M. M., Wallace, K., Hill, R., Adams, V. M., Spencer-Cotton, A., Kennard, M., & Pressey, R. L. (2021). *Multi-objective planning in northern Australia: co-benefits and trade-offs between environmental, economic, and cultural outcomes.*

This is the final report on a major research project that involved mapping landscape features associated with economic, social, and cultural values across the Fitzroy catchment, developing realistic scenarios under different development trajectories looking ahead to 2050, and participatory scenario planning (PSP).

While the mapping of values aimed to include landscape features associated with economic, social, and cultural values across the Fitzroy catchment, publicly available spatial data relating to Aboriginal cultural heritage was collected but not used or shared, and was not included in the mapping because of the process required to obtain prior informed consent from Aboriginal organisations. However, participants in the research were able to use and discuss the information, and were able to point out places that could be affected under the possible future scenarios.

A range of potential land uses was modelled, including aquaculture, irrigated agriculture, carbon farming, environmental management, resource extraction, and cultural and nature tourism. This informed the development of four scenarios incorporating these land uses and based on the primary drivers of policy and markets, with spatial configurations and diagrams representing significant features. Workshops considered the potential outcomes of the scenarios including identifying and assessing the positive and negative impacts of different future scenarios on environmental, socioeconomic, and cultural values associated with different areas of the water/landscape.

In the PSP, two groups - TOs and multi-stakeholders (pastoralists, governments, and mining, tourism, and environmental groups) - assessed the effects of the scenarios relative to the current state on nine wellbeing categories. The nine wellbeing categories included aspects of economic, cultural, social, and environmental wellbeing. Participants' ratings followed a similar pattern in both workshops, except for the scenario with increased large-scale irrigation, which was scored mostly positively by the multi-stakeholder group, and mostly negatively by TOs. This methodology is found to be more nuanced than focusing only on plants, animals, jobs, revenue, or water quantities.

Appleyard, R., Ronalds, B., Lowe, I., & Blackmore, D. (2006). *Options for bringing water to Perth from the Kimberley: An independent review.*

This report presents the findings of a review by an Expert Panel, commissioned by the WA Government, of the feasibility of transporting water from the Kimberley region for use in the WA Water Corporation's supply in the south of the State. The options considered water sourced from the Ord and/or the Fitzroy basin, supplied by pipeline, canal or ocean transport, and how that water would be integrated into the water supply for towns and or irrigation en route south, as well as the ultimate destination.

The report is essentially a feasibility study and economic analysis of the options, and finds that while several methods of transporting water are technically feasible, the cost of water would be at least five times that of desalination.

The Fitzroy River is identified as the preferred source for pipeline and canal options, although the variability of source flow meant options including damming the Margaret River, with water flowing to a modest dam near Willare Crossing, off-stream storage of water pumped during high flow, and ground water extraction

from a bore field to off-stream storage. The construction of a dam on the Margaret River is determined to be the most economical solution.

The report notes the environmental impacts of any modification of the Fitzroy River, especially damming and run of river options, including the impact of changes in seasonal flow on the floodplain and its ability to support endemic and endangered species.

Social impacts were assessed through the Kimberley Appropriate Economies Roundtable held at Fitzroy Crossing during October 2005, and other consultations. Through this forum, the panel found that all the Aboriginal communities were critical if not hostile to the concept of taking water from the Fitzroy River because of their cultural connection and dependence on the River for food, and other landholders and residents would be directly affected.

Barber, M., & Woodward, E. (2018). *Indigenous water values, rights, interests and development objectives in the Fitzroy catchment. A technical report to the Australian Government from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments.*

This report, part of the suite of reports for the Northern Australia Water Resource Assessment, deals specifically with Indigenous water values, rights and interests in the Fitzroy catchment, Indigenous perspectives on natural resource development generally, and local Indigenous development opportunities and objectives.

In terms of value, the report defines this as “what people consider important, worthy, of merit and significance. It can also refer to underlying principles or beliefs that drive estimations of importance” (Barber & Woodward, 2018, p. 9). Water values familiar to non-Indigenous Australians, including the physical sustenance it provides, are compared with its significance for Indigenous Australians encompassing mythology, identity, and connection

Beesley, L. S., Pusey, B. J., Douglas, M. M., Gwinn, D. C., Canham, C. A., Keogh, C. S., Pratt, O. P., Kennard, M. J., & Setterfield, S. A. (2020). *New insights into the food web of an Australian tropical river to inform water resource management.*

This study investigates possible sources of carbon supporting the food web, particularly in the lowlands, of the Fitzroy River, as well as potential vectors for transporting carbon around the system. Altered flow due to water resource development can change the food web and impact riverine energetics. This in turn affects the ecological and cultural values associated with the River.

Finding seasonal variations in sources of energy for fish, and no evidence to support the transport of remote carbon around the system by large-bodied fish, the report recommends a precautionary approach to water resource development policy until more food web evidence is available.

Beesley, L. S., Pusey, B. J., Douglas, M. M., Keogh, C. S., Kennard, M. J., Canham, C. A., Close, P. G., Dobbs, R. J., & Setterfield, S. A. (2021). *When and where are catfish fat fish? Hydro-ecological determinants of energy reserves in the fork-tailed catfish, *Neoarius graeffei*, in an intermittent tropical river.*

Recognising the cultural, economic (food), and ecological value of the fork-tailed catfish, this paper reports on an investigation of the influence of flow and habitat on the energy reserves of fork-tailed catfish during the dry season. Investigations assessed body condition and fat levels in the fish in different habitats and seasonal times. Predictive models showed fish were fatter in years after moderate to high wet-season flow,

smallest after low-flow years and decreased as the dry season progressed. Essentially this evidence points to how flow variation can impact biota.

Canham, C. A., Beesley, L. S., Gwinn, D. C., Douglas, M. M., Setterfield, S. A., Freestone, F. L., Pusey, B. J., & Loomes, R. C. (2021). *Predicting the occurrence of riparian woody species to inform environmental water policies in an Australian tropical river.*

This paper reports on a study of the impact of water resource development and changes to the natural flow regime on riparian vegetation, with ecological and cultural value, in the lower Fitzroy River. The researchers undertook a plant survey and applied a joint species distribution model to determine the likelihood of occurrence for 26 woody riparian plant species, mapping species occurrence and assessing the change in species distribution under two water-take scenarios. Essentially the predictive model showed a greater species loss under the higher water-take scenario. This approach can inform management to protect ecologically and culturally important species.

Connor, J., Regan, C., & Nicol, T. (2019). *Environmental, cultural and social capital as a core asset for the Martuwarra (Fitzroy River) and its people.*

Using benefit-cost analysis, this report argues that protection and preservation of the Martuwarra catchment, with alternative investment in Aboriginal-led enterprises in the region, could result in economic and social values over those associated with increased water extraction. The report notes the literature pointing to methodological challenges, in natural resource management studies, associated with the valuation of social and cultural goods that Aboriginal people derive from Country. For these reasons, the authors note that there are significant environmental cultural and Indigenous use externalities that have not been included in their benefit-cost analysis.

Cook, P. A. (2010). *Fitzroy River Catchment Management Plan.*

This report, undertaken for Rangelands NRM, develops a risk assessment plan by assessing the relative values of assets and a management plan identifying appropriate investment needed to maintain significant values of the Fitzroy Catchment. The risk assessment involved the identification and prioritisation of assets through stakeholder workshops, and visits to some key stakeholders unable to attend.

The workshops identified 122 assets, including water resources and cultural, ecological, agricultural, and tourism/recreational assets. Comparative values were assigned to assets (other than cultural assets that were all classified as high value due to their subjectivity). The valuation of each asset type was assessed by significance (Exceptional, Very High, High, Moderate, Low) and current state (Very High, High, Moderate, Low).

The risks to these assets were assessed by type and level of threat. Threat levels were categorised as Very High, High, Moderate, or Low. Risk types include: uncontrolled fire; damage to vegetation and aquatic ecosystems through invasive species (plants and animals); over-grazing / overharvesting; siltation, sedimentation, flooding and erosion impacts on waterways; dams and potential future water extraction; uncontrolled tourism, vandalism and recreational access to sites; mining; loss of Indigenous and/or non-Indigenous knowledge and the associated languages; exclusion of TOs from sites; climate change; lack of NRM capacity; and legislation.

Catchment targets specified the desired conditions at a future specified time, management action targets identified actions required to address the identified threats to the specified assets within a 5-year period, and investment strategies were prioritised.

Douglas, M. M., Jackson, S., Canham, C. A., Laborde, S., Beesley, L., Kennard, M. J., Pusey, B. J., Loomes, R., & Setterfield, S. A. (2019). *Conceptualizing Hydro-socio-ecological Relationships to Enable More Integrated and Inclusive Water Allocation Planning*.

Building on field research with TOs and government landowners, this paper presents a hydro-socio-ecological model around the four distinct flow phases of the Fitzroy River. Ten principles for water planning and associated essential considerations for water planning are set out, five with a focus on the water allocation planning process and five focusing on the ecological and indigenous relationships with key flow components. It notes a global move towards an acknowledgement of relational values conferring rights to rivers as an agent.

Finn, M., & Jackson, S. (2011). *Protecting Indigenous values in water management: A challenge to conventional environmental flow assessments*.

This article demonstrates how environmental flow assessments and allocations in Australia have failed to incorporate Indigenous values, drawing on examples from northern Australia including the Fitzroy Valley. Recognising the need to adapt flow assessments, the authors propose three challenges that need to be met to overcome this failure. These are:

1. the recognition that species use and importance may vary relative to other stakeholders;
2. the need to accommodate different levels of customary use for socially and economically sustainable; and
3. to take account of Indigenous worldviews and the importance of people-place relationships.

Drawing on data from other studies, the article demonstrates the economic importance of aquatic resource use to Indigenous peoples. In doing so, it demonstrates how a better understanding of the *use* of resources by Indigenous users can address the first two challenges.

In relation to the social and cultural values, the paper points to limited guidance to planners, given the difference in approaches of qualitative ethnographic sociological and cultural studies to the technical scientific approach that dominates the resource management approach. The paper suggests that qualitative data that link flow regimes and water landscape qualities could identify components of a flow regime that are socially and culturally important. In doing so, it points to a multidisciplinary, mixed-methods approach involving cross-cultural engagement to inform and adapt water allocation in ways that address Indigenous water requirements.

Heiner, M., Hinchley, D., Fitzsimons, J., Weisenberger, F., Bergmann, W., McMahon, T., Milgin, J., Nardea, L., Oakleaf, J., & Parriman, D. (2019). *Moving from reactive to proactive development planning to conserve Indigenous community and biodiversity values*.

Using the Nyikina Mangala native title determination area as a case study, this project maps cultural/heritage sites, freshwater features, common native animals and plants (represented by biophysical habitat types), and legally protected threatened and migratory species (represented by potential habitat models given limited observation data). This shows both cultural/heritage sites and threatened species habitats show a strong thematic and spatial link with freshwater features, particularly the Fitzroy River wetlands.

Significant values were defined by TOs through a Healthy Country Planning process, resulting in seven targets. Spatial datasets for cultural social and biodiversity values for four of these targets include cultural and heritage sites, freshwater places, native animals and bush tucker, and bush medicine plants. These were mapped by density (e.g. number of sites) on grids, along with social and physical access (roads and communities), and the results were compared.

While the research provides TOs with a tool for considering what development they want and where, this is not a quantitative valuation per se.

Hermoso, V., Kennard, M. J., & Linke, S. (2012). *Integrating multidirectional connectivity requirements in systematic conservation planning for freshwater systems.*

The paper considers the importance of lateral connectivity between river channels and aquatic habitats on the adjacent floodplain, using systematic conservation planning analyses. The paper considers biodiversity and population dynamics of organisms to demonstrate the importance of connectivity, both longitudinally and laterally.

The research paper covers northern Australia, including the Kimberley. There is no consideration of Indigenous cultural or social values.

Hill, R., Golson, K., Lowe, P., Mann, M., Hayes, S., & Blackwood, J. (2006). *Kimberley Appropriate Economies Roundtable Forum Proceedings.*

This volume draws together papers presented to the roundtable, as well as the principles and recommended actions developed in the roundtable. Papers presented by Andrew Storey (2006), Sarah Yu (2006) and Sue Jackson (2006), considered separately in this review, are particularly relevant to this research on the values and valuation related to the Fitzroy River. The wide range of topics included scientific studies, reflections on past development, and international models. Common themes are the connection between ecology, culture and economies for Indigenous people, and the desire for development to be framed in strong culture and healthy Country.

Hill, R., Harkness, P., Raisbeck-Brown, N., Lyons, I., Álvarez-Romero, J. G., Kim, M. K., Chungalla, D., Wungundin, H., Aiken, M., Malay, J., Williams, B., Buisseret, R., Cranbell, T., Forrest, J., Hand, M., James, R., Jingle, E., Knight, O., Lennard, N., Lennard, V., Malay, I., Malay, L., Midmee, W., Morton, S., Nulgit, C., Riley, P., Shadforth, I., Bieundurry, J., Brooking, G., Brooking, S., Brumby, W., Bulmer, V., Cherel, V., Clifton, A., Cox, S., Dawson, M., Gore-Birch, C., Hill, J., Hobbs, A., Hobbs, D., Juboy, C., Juboy, P., Kogolo, A., Laborde, S., Lennard, B., Lennard, C., Lennard, D., Malay, N., Malay, Z., Marshall, D., Marshall, H., Millindee, L., Mowaljarlai, D., Myers, A., Nnarda, T., Nuggett, J., Nulgit, L., Nulgit, P., Poelina, A., Poudrill, D., Ross, J., Shandley, J., Skander, R., Skeen, S., Smith, G., Street, M., Thomas, P., Wongawol, B., Yungabun, H., Sunfly, A., Cook, C., Shaw, K., Collard, T., & Collard, Y. (2021). *Learning Together for and with the Martuwarra Fitzroy River.*

Co-production of scientific and Indigenous knowledge, using 3D mapping of Martuwarra, was undertaken and assessed. It was found that the co-production improved accessibility of knowledge, and experiences of users, and strengthened collective identity and partnerships and Indigenous-led institutions. Ecological values were mapped by a grid, based on probabilities of occurrence for local plants and animals and importance values (determined by TOs). Cultural knowledge was discussed, but not transmitted to or included in the model. The project also assesses influence and power through influence mapping, leading to the development of six building blocks for cultural governance and management.

Other than the calculation of probabilities and importance scales for important plants and animals, this paper does not discuss the quantitative assessment of values.

Jackson, S. (2006) (11-13 October 2005). *Indigenous Economic Opportunities and Water Resource Planning.*

This conference paper presents important contextual information about water resource demands, water regulation and management, and water reforms applicable to the Fitzroy and Ord systems in the Kimberley. These include WA Government regulation of water, national-level agreements, and water reforms.

It then presents issues for roundtable participants to consider. These issues include: the different values held by Aboriginal people; how Indigenous people's special relationship to land and waters can be recognised and protected in these contexts; gaps in scientific knowledge and understanding of social and cultural values; the opportunities that might be available for all Kimberley people; and questions of where efforts should be focused to ensure Indigenous people have the capacity to determine their own water use.

Jackson, S. (2015). *Indigenous social and cultural values relating to water in the Fitzroy Valley, Kimberley (WA): Information availability, knowledge gaps and research needs.*

This literature review was undertaken to inform the development of project ideas for the Northern Environmental Resources Hub of the National Environmental Science Program. It presents literature and background about Indigenous interests in water and values associated with water, noting the predominantly qualitative nature of many of the studies. It highlights the gap in the literature about the effect of flows on Indigenous use of rivers and water resources, and the challenges in quantifying values and relationships in this context. It suggests that qualitative analysis of links between flow regimes and water landscape qualities could identify components of the flow regime that are socially valuable. The paper also points to the water governance challenges that address Indigenous aspirations for self-determination. It suggests that research on Indigenous water values should focus on socio-ecological and water governance components.

Individual papers relevant to Martuwarra values that are reviewed by Jackson are considered in this review.

Jackson, S., Finn, M., & Featherston, P. (2012). *Aquatic resource use by Indigenous Australians in two tropical river catchments: The Fitzroy River and Daly River.*

This paper reports on research undertaken (Indigenous Socio-economic Values and River Flows project of the Tropical Rivers and Coastal Knowledge (TRaCK) program) over a three year period into customary aquatic resource use in the Daly River, NT, and the Fitzroy River, WA. It uses qualitative and quantitative methods to understand the spatial and temporal use of aquatic resources and their social cultural and economic importance. The results are presented in terms of the distribution of harvest of key species over time, and the sharing of the harvest. The paper does not seek to convert these data to market equivalent values.

Jackson, S., Finn, M., & Scheepers, K. (2014). *The use of replacement cost method to assess and manage the impacts of water resource development on Australian indigenous customary economies.*

Drawing on research from the project reported in Jackson, S. et al (2011), this paper seeks to quantify, using the replacement cost method, the direct consumptive value of aquatic species and sites for Indigenous subsistence in three tropical river systems, including the Fitzroy River catchment. The purpose was to establish a baseline for assessing and monitoring the socio-economic impact of hydrological and ecological changes from water resource development. The impact of cultural protocols on the location of wild harvest and species selection are discussed, highlighting the importance of valuations being culturally contextualised and informed.

Jackson, S., Finn, M., Woodward, E., & Featherston, P. (2011). *Indigenous Socio-economic Values and River Flows: A Summary of Research Results: 2008-2010.*

This booklet presents the main findings from the final report from the Indigenous Socio-economic Values and River Flows project of the Tropical Rivers and Coastal Knowledge (TRaCK) program. As well as high-level catch data, it incorporates market equivalent replacement values for the five top species of aquatic resources in the two catchments (Daly and Fitzroy), calculating household consumption as a proportion of median income to demonstrate the importance of aquatic resources and the customary economy.

Jackson, S., Stoeckl, N., Straton, A., & Stanley, O. (2008). *The changing value of Australian tropical rivers.*

This paper presents the results of a focus group conducted in Mount Isa (Qld), Derby (WA), and Katherine (NT), during the 2005-06 wet season. This qualitative research resulted in the identification of values including the intrinsic value of waterways and the human interactions. The paper explicitly distinguishes between the term value as used in this study as something that has merit, importance or worth, rather than any numerical or financial estimate of the magnitude of worth.

Kim, M. K., Álvarez-Romero, J., Wallace, K., Pannell, D., Hill, R., & Pressey, R. (2021). *Assessment of the potential changes in wellbeing of key interest groups in the Fitzroy River catchment under alternative development scenarios: Traditional Owners' workshop.*

This paper discusses the objective, methods, and results of a workshop with TOs in Fitzroy Crossing that set out to identify and assess the positive and negative effects of different scenarios on the wellbeing of residents across the Fitzroy catchment. The four scenarios, developed in previous workshops, reflected variations in two key drivers, namely market investment and demand, that affected natural landscapes and policy strength.

Kim, M. K., Álvarez-Romero, J. G., Wallace, K., Pannell, D., Hill, R., Adams, V. M., Douglas, M., & Pressey, R. L. (2021). *Participatory multi-stakeholder assessment of alternative development scenarios in contested landscapes.*

This paper discussed a participatory scenario planning (PSP) developed with a multi-stakeholder, cross-cultural group in the Fitzroy River (Martuwarra) basin. Participants considered and discussed the current situation and how well nine dimensions of wellbeing were satisfied, and then considered how wellbeing changed under different scenarios that change two main drivers – policy strength and markets. There was no valuation involved, although the quantitative assessments reveal preferences about the potential development of the catchment.

Kragt, M. E., Spencer-Cotton, A., & Burton, M. (2016) (July 10–14, 2016). *Spatial choice experiments to support environmental management of the Kimberley coast.*

This paper, while focused on marine and coastal environmental management in the Kimberley, provides a novel methodological approach to assess values with a spatial characteristic, as well as attributes reflecting environmental management and cost. No specific mention is made of efforts to engage Indigenous people in the preliminary research or the choice modelling, or any differentiation of results. One of the attributes in the choice model is the number of Aboriginal rangers in each zone. The choice modelling presents scenarios of five attributes at different levels in different zones against the status quo. Such a spatially explicit non-market valuation approach can be compared to spatially defined scenario planning, with monetary valuation results, which can assist in decision making.

Laborde, S., & Jackson, S. (2021). *Indigenous water requirements in the Martuwarra/Fitzroy River catchment, Western Australia.*

This text reports on the Indigenous water requirements in the Martuwarra/Fitzroy catchment project of the National Environmental Science Program's Northern Australia Environmental Resources (NAER) Hub. The project initially set out to develop a methodology based on the framework by Finn and Jackson (2011), which is an adaptation of environmental flow approaches to water management, with an emphasis on the inclusion of Aboriginal custodians' objectives. Through the collaborative research process, the focus of the research shifted from quantifiable water requirements to the secondary objective of assessing governance requirements. The project also sought to update the hydro-socio-ecological model (Douglas et al., 2019) as

the living waters model in collaboration with TOs. The report concludes that the foundational problem identified by the living waters framework cannot be resolved by incorporating Indigenous cultural values into a water plan within the government's modern water framework.

Liedloff, A. C., Woodward, E. L., Harrington, G. A., & Jackson, S. (2013). *Integrating indigenous ecological and scientific hydro-geological knowledge using a Bayesian Network in the context of water resource development.*

This paper outlines an approach taken in the Fitzroy River demonstrating how indigenous knowledge can contribute to water planning. In particular, it shows how Indigenous ecological knowledge can inform cause and effect relationships between species and aquatic habitats to promote broader ecosystem understanding.

While the value and effort involved in species harvest is a factor in the Indigenous knowledge captured in the model, there was no intention or attempt to quantify values.

Mathews, D., Semeniuk, V., & Semeniuk, C. (2011). *Freshwater seepage along the coast of the western Dampier Peninsula, Kimberley region, Western Australia.*

The paper discusses the hydrological processes of freshwater seepage and the cultural, ecological, and hydrological value of the seepage from Jila and other freshwater sources to the shore zone. It points out that the resultant coastal wetlands support biodiversity unique to the otherwise arid coastal zone, and are of national significance.

Merrin, L., Addison, J., Austin, J., Barber, M., Bruce, C., Ebner, B., Higgins, A., Horner, N., Jarvis, D., Kenyon, R., Lau, J., Macintosh, A., Philip, S., Pollino, C., Ponce Reyes, R., Stokes, C., Stratford, D., Waschka, M., Woodward, E., & O'Sullivan, J. (2018). *Living and built environment of the Fitzroy catchment.*

This chapter of the water resource assessment for the Fitzroy catchment (Petheram et al., 2018) provides information on the living and built environment, including information about the people, the ecology, the infrastructure, and the institutional context of the Fitzroy catchment. It also examines the values, rights, interests, and development objectives of Indigenous people. In essence, it provides a snapshot of the catchment, with a discussion of a range of values, with some dollar quantification of economic values.

Milgin, A., Nardea, L., Grey, H., Laborde, S., & Jackson, S. (2020). *Sustainability crises are crises of relationship: Learning from Nyikina ecology and ethics.*

This article, by three Nyikina and two non-Indigenous authors, seeks to shift the focus of environmental sustainability to focus on relational thinking in models of hydro-ecological and social dynamics. It notes that while quantitative indicators of ecological or value of human life or wellbeing may help assess processes, the focus should shift from assessing benefits to people to instead focus on relational assessments by TOs, given 'ecological' is taken to include people. Three models articulate Nyikina ecology, namely: a seasonal model of hydro-ecological and social dynamics; a model of habitats in terms of belonging; and a model of reciprocal relationships essential for sustainability. The article points to limitations of utilitarian ecosystem services valuation, instead focusing on relational values to improve assessments.

Newman, B., Wilson, K. A., Melbourne, J., Mathews, D., Wysong, M., & Iacona, G. D. (2019). *The contributions of nature to people within the Yawuru Indigenous Protected Area.*

This paper examines how benefits to people (nature's contributions to people or NCPs) from IPAs could be measured using approaches to valuation benefits, using Yawuru IPA as a case study. It appears that the

research was largely desk-based using existing data held by Yawuru. While not specifically Martuwarra, the approach to using valuation to identify benefits may be relevant.

Nikolakis, W., & Grafton, R. Q. (2011). *Assessment of the potential costs and benefits of water trading across northern Australia.*

This report is the third in a series examining the feasibility of establishing water markets in northern Australia, and provides an assessment of the potential costs and benefits of water markets across northern Australia with consideration of efficiency, equity, and effectiveness criteria. The second report from the project focuses on analysing stakeholder attitudes and values relating to water trading, and the implications of establishing water markets.

This report highlights the challenge of integrating customary or ecological values, due to their intangible nature, in assessment of the efficiency of water markets. It also points out that Indigenous involvement is essential to ensure that issues of equity are upheld. In conclusion, it notes that non-market approaches to water allocation may be more suitable than market-based mechanisms across the north of Australia, suggesting markets in combination with collaborative governance are more likely to support ecological and equity outcomes.

Nikolakis, W., Grafton, R. Q., & To, H. (2010). *Stakeholder values and attitudes towards water markets across northern Australia.*

This report is the second in a series examining the feasibility of establishing water markets in northern Australia. It analyses the attitudes and values of a range of stakeholders about water markets, identified through a survey.

The findings highlight that sustainability, environmental protection, social justice and equity, and economic development, were important values for respondents in relation to water markets. Respondents emphasised the importance of robust water planning frameworks that support ecological values and irrigator and Indigenous livelihoods, and respondents overwhelmingly disagreed with the trade of environmental and cultural flows. There was also significant support for the preservation of certain catchments and aquifers for their unique values (particularly among Indigenous respondents). Social justice and equity were important to respondents, with a sentiment to include Indigenous people in water reform and water markets.

Petheram, C., Bruce, C., Chilcott, C., & Watson, I. (2018). *Water resource assessment for the Fitzroy catchment. A report to the Australian Government from the CSIRO Northern Australia Water Research Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments.*

This is the main report for the Fitzroy catchment from water resource assessments for three catchments in northern Australia, conducted for the Australian Government. The objective of these assessments was to evaluate the feasibility, economic viability, and sustainability of water resource development in each of the catchments. Individual chapters relevant to the question of water values in the Fitzroy are Chapter 3 (Merrin et al., 2018) and Chapter 6 (Stokes & Jarvis, 2018), discussed separately in this review.

Pettit, N. E., Warfe, D. M., Close, P. G., Pusey, B. J., Dobbs, R., Davies, C., Valdez, D., & Davies, P. M. (2016). *Carbon sources for aquatic food webs of riverine and lacustrine tropical waterholes with variable groundwater influence.*

This study investigated the influence of waterhole type and persistence on the strength of consumer reliance on local energy resources for aquatic food webs. Food web studies integrate ecological information and provide an understanding of ecosystem function. Aquatic ecosystems of the Kimberley region have high

conservation significance as hotspots for maintaining local and regional biodiversity. In a region where groundwater is influential in maintaining aquatic habitats, future development of groundwater reserves will likely affect the ecological and cultural value of freshwater wetlands, by either reducing their permanence or size, or indirectly through possible alteration to the role of periphyton in supporting the food web.

Poelina, A., Brueckner, M., & McDuffie, M. (2021). *For the greater good? Questioning the social licence of extractive-led development in Western Australia's Martuwarra Fitzroy River region.*

This paper applies a social licence lens to current water extraction proposals for Western Australia's remote Martuwarra Fitzroy River region. It highlights differences between Indigenous and non-Indigenous value systems, where the orthodox colonial development paradigm views the River system as an underutilised resource, effectively an irrigation channel, while the local ontological view of the River sees the water as fully utilised for the maintenance of vital ecological and cultural values. The paper advocates for the 'greater good' to be redefined and to articulate 'socially licenced' just development alternatives for the region without the ecological and cultural trade-offs typical of orthodox development.

Poelina, A., Taylor, K. S., & Perdrisat, I. (2019). *Martuwarra Fitzroy River Council: An Indigenous cultural approach to collaborative water governance.*

This paper discusses issues relating to different values of the River, including cultural and economic values. It promotes the Fitzroy River Declaration and the Martuwarra Fitzroy River Council as a cultural solution and collaborative long term planning mechanism in which TOs play a critical role, and First Law is respected and culture strengthened.

Pusey, B. J., & Kath, J. (2015). *Environmental Water Management in the Fitzroy River Valley: Information availability, knowledge gaps and research needs.* Unpublished report to the Department of Water, Western Australia.

This report reviews available information that could guide management strategies aimed at maintaining existing environmental values. It explicitly excludes socio-cultural values, despite acknowledging their significance.

The knowledge gaps identified were in five areas. (1) The nature of aquatic habitats and their relationship to the flow regime and groundwater. (2) Responses of riparian, floodplain, and groundwater-dependent vegetation to changes in the water regime. (3) Response of individual biotic elements and assemblages to changes in water regime and habitat structure, and ecological interactions between elements and within assemblages. (4) The nature of the food web sustaining assemblages in different water bodies and its relationship to the flow regime, habitat structure and dependency on ground water inputs during the dry season. (5) The absence of information concerning interactions between flow-dependent phenomena and other non-flow related factors that may either exacerbate flow-related impacts or obscure changes in environmental values in response to water regime change, and thus lessen the capacity to evaluate the efficacy of environmental water management plans.

The report proposes 22 distinct and separate research projects to address these gaps and provide an integrated research program on the flow ecology of the Fitzroy River and its aquifers. Each proposed project is assessed for potential in addressing socio-cultural and ecological values, as well as contributing to information for management, and establishing baseline data.

RiverOfLife, M., Poelina, A., Alexandra, J., & Samnakay, N. (2020). *A conservation and management plan for the National Heritage listed Fitzroy River Catchment Estate (No. 1.)*

While the focus of this document is the planning and governance of Martuwarra, it discusses the values associated with the River and asks: 'How are existing values of the riverine system understood and measured?' The thrust of the report is to document position statements relating to heritage conservation and management planning agreed by Martuwarra Fitzroy River Council.

Samnakay, N. (2020). *The multiple values of the Martuwarra – Fitzroy River (Australia) – new governance required to protect free-flowing rivers.*

This article argues for improved water governance, which recognises rivers beyond a simplistic lens of extractive economic opportunity. It notes values that include 'unique cultural and heritage values', 'many heritage and conservation values', and 'Aboriginal cultural, spiritual and heritage values', and it argues for new governance and legal settings based on multiple and complex competing values that present governance and legal challenges.

Stoeckl, N., Jarvis, D., Larson, S., Larson, A., Grainger, D., & Ewamian Aboriginal Corporation.(2021). *Australian Indigenous insights into ecosystem services: Beyond services towards connectedness – People, place and time.*

This paper starts from an acknowledgement of reciprocal flows from humans to nature, and growing recognition of the need to better incorporate insights from other cultures. In a workshop with Aboriginal people which developed an (Aboriginal) model of the nature-people relationship, ecosystem services were a component of the model, but the Aboriginal model was not 'atomistic' and instead focused on connections between and within the human and natural systems. Temporal dimensions were considerably longer than those commonly considered by Western scientists, feelings and spirituality were central, and stewardship activities were highlighted as not only improving the environment but also directly improving wellbeing. The paper found that Country needs to be looked after the 'right way'; it is not enough to simply account for the ES values that are generated, or the stewardship activities that are undertaken (e.g. controlling weeds); one also needs to record *how* this is done (e.g. with respect) and *by whom* (e.g. TOs).

Stokes, C., Addison, J., Macintosh, A., Jarvis, D., Higgins, A., Doshi, A., Waschka, M., Jones, J., Asmi, W., & Horner, N. (2017). *Costs, benefits, institutional and social considerations for irrigation development. A technical report to the Australian Government from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments.*

This report is an important contributor to the overall Northern Australia Water Resource Assessment, including the assessment for the Fitzroy catchment (Petheram et al., 2018). It seeks to identify the social, institutional, and economic conditions that would be required for the potential irrigated agriculture in the Assessment areas to succeed.

It concludes that it would be difficult to find opportunities for new irrigation development that meet regulatory requirements, and gain stakeholder support, while also providing a financial rate of return to investors commensurate with the level of risk involved. Instead, justifying any development would rely on secondary benefits beyond the farm gate, such as through processing or other value-adding or indirect benefits to local communities.

The report finds that different stakeholder groups value northern Australia differently, with diverse and sometimes conflicting interests and values, affecting the ability of developers to gain and maintain a social licence. In particular, it notes the limitations of the broad top-down assessment of stakeholders given the

risk of identifying the ‘usual suspects’ and ‘experts’ without understanding the views of those with less power. It suggests a more robust bottom-up approach to engagement. It also notes that TO groups could hold both cultural obligations and development aspirations that would lead them to identify as partners rather than stakeholders. This report notes that Indigenous values, rights, and objectives, are covered in companion reports, including for the Fitzroy (Barber & Woodward, 2018).

The study also sought to increase the understanding of potential investors, other than Indigenous organisations, by developing a typology that reflected their access to natural capital and human/financial/social capital, and by interviewing a small number of investors. These investors expressed highly consistent views and clarified their expansion aspirations and perceived constraints, including institutional uncertainty and complexity, economy of scale, poor infrastructure, and training of a skilled workforce. Each of these constraints affects the economic viability of development.

A major component of the report provides information on the costs and benefits of developing new irrigated agriculture, identifying investments in infrastructure required for large-scale irrigated development, a financial analytical framework to assess the commerciality of irrigation schemes, and regional input-output analysis to quantify regional costs and benefits. Assessment of new infrastructure costs and options covers different irrigation schemes, processing costs, transport costs, domestic and export markets, energy infrastructure costs, and community infrastructure. The scheme-scale financial evaluations of irrigated development used a discounted cash flow framework that considered the lifetime costs and benefits, taking account of water supplier and irrigator investments across generic models with off-farm and on-farm water sources, risk assessments, and value-adding beyond the farm gate.

Regional-scale economic impacts of irrigated development are considered to be a critical determinant of overall economic viability that would warrant investment. Regional benefits from the construction and ongoing phases were assessed through input-output analysis, showing that the size of total economic benefit is dependent on the scale of development, the type of agriculture, and the source of supply. Case studies of the impacts of water extraction on the fishing and tourism industries discussed the potential co-benefits and costs.

The overall conclusion of this report is that it would be challenging to find opportunities for new irrigated agriculture in the Assessment area that met regulatory requirements and gained stakeholder support, while also providing a financial rate of return to investors commensurate with the level of risk involved.

Stokes, C., & Jarvis, D. (2018). *Overview of economic opportunities and constraints.*

This chapter of the Water Resource Assessment for the Fitzroy catchment (Petheram et al., 2018) deals with the commercial viability of irrigated agriculture development. This is limited to normal market transactions, rather than extending to non-market impacts and risks that would be expected in a full economic analysis.

The chapter draws on the previous more detailed report (Stokes et al., 2017). Essentially, it demonstrates that returns from broad acre agriculture would be unlikely to cover the development costs of irrigation schemes, although value-adding through processing can assist with commercial viability but would introduce risk. Public investment could be justified with regional economic impacts, including jobs, although these would be reduced by leakage of extra expenditure outside the catchment.

Storey, A. (2006) (11-13 October 2005). *Ecological values of the Fitzroy River with links to indigenous cultural values.*

This paper presented to the Kimberley Appropriate Economies Roundtable draws heavily on the unpublished report (Storey et al., 2001). It demonstrates, through several studies, the strong linkage between ecological

values and cultural values. In doing so, it argues for the importance of a natural flow regime, involving the natural frequency of floods and dry periods, with floodplain inundation, and permanent riverine pools. Drawing on lessons from the Ord and Camballin, it argues for the adoption of a precautionary approach to water resource development that aims to maintain the natural flow regime.

Storey, A., Froend, R., & Davies, P. M. (2001). *Fitzroy River system: Environmental values*. Unpublished report prepared for Water and Rivers Commission.

This reports on a preliminary qualitative assessment of the environmental values of the Fitzroy River and tributaries, undertaken by field and desktop studies. It assessed the possible effects of potential flow regulation regimes, such as dams, and identified gaps in knowledge that require additional studies. This study was undertaken in association with the TOs through a parallel study assessing the cultural values of the Fitzroy River (Toussaint et al., 2001).

A significant finding of this study is the strong linkage between ecological values and cultural values. The importance of a natural flow regime, involving the natural frequency of floods and dry periods, with floodplain inundation and flushing of permanent riverine pools, termed “living water” to “cleanse the country” (Storey et al., 2001, p. 111). Drawing on lessons from the ecological impacts of the Ord and Camballin, it argues for the adoption of a precautionary approach to water resource development that aims to maintain the natural flow regime.

Straton, A., & Zander, K. (2009). *The value of Australia’s tropical river ecosystem services*.

This detailed report assesses the impact of development scenarios and estimates the economic value of particular ecosystem services. It uses choice modelling of scenarios for three Australian river systems (Fitzroy WA, Daly NT, and Mitchell Qld) with Indigenous and non-Indigenous people. The results of this modelling include estimates of willingness to pay, aggregate willingness to pay, and compensating surplus from a series of models.

The research also assessed the impact of potential development using resilience analysis, which brings together information about the processes, interactions, and thresholds for the sustainability of ecosystem services. It reflects on the history of tropical rivers and the cycles of change, and what they may mean for existing development trajectories.

Toussaint, S., Sullivan, P., Yu, S., & Mularty Jr, M. (2001). *Fitzroy Valley Indigenous cultural values study (a preliminary assessment)*.

This report undertaken for the Water and Rivers Commission is a preliminary assessment of Fitzroy Valley cultural values documents, drawing on ethnographic research with several language groups, and demonstrating cultural values attached to the Fitzroy River and associated waterways. In discussing Indigenous concepts of land and waters in a cultural framework, where mythic beings play a role in the reproduction of water and associated species, the report considers how beliefs and practices continue to be central to how people live their lives, and their responsibilities to look after the lands and waters. In documenting historical and present-day ideas and practices, including fishing, food and medicines, rituals, explanations and stories about water cycles, the report illustrates a wide range of cultural values.

The report also stresses the importance of consulting with Fitzroy Valley communities about water regulation and planning to avoid damage to Indigenous cultural beliefs, practices, and systems. Specific recommendations about governance and decision making include establishing an MOU between the Water and Rivers Commission and local Fitzroy Valley Indigenous organisations and communities.

Vogwill, R. (2015). *Water resources of the Mardoowarra (Fitzroy River) catchment.*

This report presents an overview of the understanding of the Fitzroy River catchment, and gaps in this knowledge, to consider the potential impact of the development of water resources flagged in government projects, and allocating large amounts of water before obtaining sufficient information. The WA Government Water for Food initiative identified a potential 200GL/year allocation, a significant increase from the current allocation of 2GL/year mostly for Aboriginal community bores, pastoral bores and limited horticulture. It presents information on the physical and human geography, ecology and natural environment, Indigenous value and cultural significance, climate and hydrology, hydrogeology, surface water and ecohydrology.

The main thrust of the report is the need for a better understanding of the significant interactions between groundwater and surface water, and the seasonal and interannual variability inflows. It concludes that the potential for impacts requires a more rigorous assessment before any significant water allocation in the Fitzroy Basin.

Watson, J., Watson, A., Poelina, A., Poelina, N., Watson, W., Camilleri, J., & Vernes, T. (2011). *Nyikina and Mangala Mardoowarra Wila Booroo Natural and Cultural Heritage Plan.*

This report, prepared by Nyikina and Mangala TOs and the WWF, guides actions and decisions to protect natural and cultural values, including in decisions about the use and conservation of the River and traditional lands and future enterprise developments. For four priority management areas in the Nyikina and Mangala native title determination area, three of which are directly related to the River, it details the natural and cultural values, community enterprises, issues and threats, and management strategies. The river-related issues and threats identified include irrigated agriculture, taking water, erosion resulting from changed river flows, and ownership of water.

Woods, K. (2020). *Culture Counts: A choice modelling approach to quantifying cultural values for First Nations People.*

This doctoral thesis explored methods to quantify cultural values for First Nations people. The research was conducted with Aboriginal people residing in the West Kimberley with connection to Nyikina and Mangala people, including in communities and towns along the Fitzroy River. While water values were not the explicit focus of the research, in identifying aspects of culture that were most important to people, access to Country, including the River and its surrounds, was consistently identified as highly valued. The choice method used, Best-Worst Scaling Case 2, was selected to identify the most important attributes, and lessons from this research are highly relevant to the consideration of the value of water to First Nations people.

Yu, S. (2006) (11-13 October 2005). *Cultural studies of the Fitzroy River, WA.*

This paper presents a summary of the ethnographic research undertaken with Nyikina, Mangala, and Ngarinyin people and scientists as part of the Fitzroy River Cultural Values Study (Toussaint et al., 2001). It provides a brief overview of the cultural view of the River and its creation stories, the history that led to the development of relationships between the desert people and the River, and the role of the River in the cultural and economic lives of people traditionally. It also touches on the history of environmental change caused by the Camballin irrigation project of the 1960s and the building up of the Willare Bridge crossing road, as documented by local TOs. Finally, it points toward culture-based economies, working on Country, that could provide livelihoods and engage young people while maintaining the integrity of cultural management systems.

Zander, K. K., Garnett, S. T., & Straton, A. (2010). *Trade-offs between development, culture and conservation - Willingness to pay for tropical river management among urban Australians.*

This paper builds on the research reported in Straton, A., & Zander, K. (2009), further exploring the characteristics of respondents. By modelling the urban respondents by environmental/development preference category ('environmentalists', 'developers' or 'neutral'), and connection to tropical rivers, the analyses showed that 'green' thinking Australians had a higher WTP for river ecosystem services, and respondents with some connection showed higher WTP for environmental, recreational and cultural values. Modelling of respondents by city showed Darwin residents were more willing to pay for environmental, recreational, and cultural values, than residents of other cities.

Zander, K. K., & Straton, A. (2010). *An economic assessment of the value of tropical river ecosystem services: Heterogeneous preferences among Aboriginal and non-Aboriginal Australians.*

Building on the research reported in Straton, A., & Zander, K. (2009), this paper compares the valuation of ecosystem services for the three river systems by local Indigenous and non-Indigenous respondents. It finds that the WTP of Indigenous Australians was significantly higher than that of non-Indigenous Australians for some of the attributes, particularly those related to cultural values.

References

- Akter, S., Grafton, R. Q., & Merritt, W. S. (2014). Integrated hydro-ecological and economic modeling of environmental flows: Macquarie Marshes, Australia. *Agricultural Water Management*, 145, 98–109. <https://doi.org/10.1016/j.agwat.2013.12.005>
- Altman, J. C. (2005). Economic futures on Aboriginal land in remote and very remote Australia: hybrid economies and joint ventures. In D. Austin-Broos & G. M. Macdonald (Eds.), *Culture, Economy and Governance in Aboriginal Australia* (pp. 121–134). University of Sydney Press, <http://metisportals.ca/MetisRights/wp/wp-admin/images/Economic%20Futures%20on%20Aboriginal%20Land.pdf>
- Álvarez-Romero, J. G., Kim, M. K., Pannell, D., Douglas, M. M., Wallace, K., Hill, R., Adams, V. M., Spencer-Cotton, A., Kennard, M., & Pressey, R. L. (2021). *Multi-objective planning in northern Australia: co-benefits and trade-offs between environmental, economic, and cultural outcomes. Final report*. James Cook University. <https://www.nespnorthern.edu.au/wp-content/uploads/2021/11/Multi-objective-planning-in-northern-Australia-final-report.pdf>
- Appleyard, R., Ronalds, B., Lowe, I., & Blackmore, D. (2006). *Options for bringing water to Perth from the Kimberley. An Independent Review*. WA Department of the Premier and Cabinet. https://www.water.wa.gov.au/_data/assets/pdf_file/0007/4966/64772.pdf
- Barber, M., & Woodward, E. (2018). Indigenous water values, rights, interests and development objectives in the Fitzroy catchment. A technical report to the Australian Government from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments. CSIRO.
- Beesley, L. S., Pusey, B. J., Douglas, M. M., Gwinn, D. C., Canham, C. A., Keogh, C. S., Pratt, O. P., Kennard, M. J., & Setterfield, S. A. (2020). New insights into the food web of an Australian tropical river to inform water resource management. *Scientific Reports*, 10(1), 1–12. <https://doi.org/10.1038/s41598-020-71331-0>
- Beesley, L. S., Pusey, B. J., Douglas, M. M., Keogh, C. S., Kennard, M. J., Canham, C. A., Close, P. G., Dobbs, R. J., & Setterfield, S. A. (2021). When and where are catfish fat fish? Hydro-ecological determinants of energy reserves in the fork-tailed catfish, *Neoarius graeffei*, in an intermittent tropical river. *Freshwater Biology*, 66(6), 1211–1224. <https://doi.org/10.1111/fwb.13711>
- Birckhead, J., Greiner, R., Hemming, S., Rigney, D., Rigney, M., Trevorrow, G., & Trevorrow, T. (2011). *Economic and cultural values of water to the Ngarrindjeri people of the Lower Lakes, Coorong and Murray Mouth*. River Consulting Pty Ltd Townsville. https://data.environment.sa.gov.au/Content/Publications/CLLMM_417_Ngarrindjeri%20economic%20and%20cultural%20values%20article_2010.pdf
- Bourke, S., Wright, A., Guthrie, J., Russell, L., Dunbar, T., & Lovett, R. (2018). Evidence review of Indigenous culture for health and wellbeing. *International Journal of Health, Wellness & Society*, 8(4), 11–27. <https://doi.org/10.18848/2156-8960/CGP/v08i04/11-27>
- Cairney, S., Abbott, T., Quinn, S., Yamaguchi, J., Wilson, B., & Wakerman, J. (2017). Interplay wellbeing framework: a collaborative methodology ‘bringing together stories and numbers’ to quantify Aboriginal cultural values in remote Australia. *International Journal for Equity in Health*, 16(1). <https://doi.org/10.1186/s12939-017-0563-5>
- Campbell, D. (2011). Application of an integrated multidisciplinary economic welfare approach to improved wellbeing through Aboriginal caring for country. *The Rangeland Journal*, 33(4), 365–372. <https://doi.org/10.1071/RJ11025>
- Campbell, D., Burgess, C. P., Garnett, S. T., & Wakerman, J. (2010). Potential primary health care savings for chronic disease care associated with Australian Aboriginal involvement in land management. *Health Policy*, 99(1), 83–89. <https://doi.org/10.1016/j.healthpol.2010.07.009>

- Canham, C. A., Beesley, L. S., Gwinn, D. C., Douglas, M. M., Setterfield, S. A., Freestone, F. L., Pusey, B. J., & Loomes, R. C. (2021). Predicting the occurrence of riparian woody species to inform environmental water policies in an Australian tropical river. *Freshwater Biology*, 66(12), 2251–2263. <https://doi.org/10.1111/fwb.13829>
- Chan, K. M., Balvanera, P., Benessaiah, K., Chapman, M., Díaz, S., Gómez-Baggethun, E., Gould, R., Hannahs, N., Jax, K., & Klain, S. (2016). Opinion: Why protect nature? Rethinking values and the environment. *Proceedings of the National Academy of Sciences of the United States of America*, 113(6), 1462–1465. <https://doi.org/10.1073/pnas.1525002113>
- Chan, K. M., Guerry, A. D., Balvanera, P., Klain, S., Satterfield, T., Basurto, X., Bostrom, A., Chuenpagdee, R., Gould, R., & Halpern, B. S. (2012). Where are *cultural* and *social* in ecosystem services? A framework for constructive engagement. *BioScience*, 62(8), 744–756. <https://doi.org/10.1525/bio.2012.62.8.7>
- Chan, K. M., Satterfield, T., & Goldstein, J. (2012). Rethinking ecosystem services to better address and navigate cultural values. *Ecological Economics*, 74, 8–18. <https://doi.org/10.1016/j.ecolecon.2011.11.011>
- Chan, K. M. A., Gould, R. K., & Pascual, U. (2018, 2018/12/01/). Editorial overview: Relational values: what are they, and what’s the fuss about? *Current Opinion in Environmental Sustainability*, 35, A1–A7. <https://doi.org/10.1016/j.cosust.2018.11.003>
- Connor, J. D., Regan, C., & Nicol, T. (2019). *Environmental, cultural and social capital as a core asset for the Martuwarra (Fitzroy River) and its people*. University of South Australia. https://assets.nationbuilder.com/likenowhereelse/pages/2425/attachments/original/1557294683/UniSA_FitzroyRiver.pdf?1557294683
- Cook, P. A. (2010). *Fitzroy River Catchment Management Plan*. University of Western Australia. <https://rangelandswa.com.au/wp-content/uploads/2017/01/FitzroyRiverCatchmentPlanV1.pdf>
- Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S., & Turner, R. K. (2014). Changes in the global value of ecosystem services. *Global Environmental Change*, 26, 152–158. <https://doi.org/10.1016/j.gloenvcha.2014.04.002>
- Council of Australian Governments (COAG). (1994). *Water Reform Framework*. <https://webarchive.nla.gov.au/awa/20041031073734/http://www.coag.gov.au/meetings/250294/index.htm>
- Council of Australian Governments (COAG). (2004). *Intergovernmental Agreement on a National Water Initiative*. <https://www.awe.gov.au/water/policy/policy/nwi>
- Department of Primary Industries and Regional Development (Western Australia) (DPIRD). (2017). *Fitzroy River Commitments*. www.drd.wa.gov.au/Publications/Documents/fittzroy_river_commitments.pdf
- Department of Water (Western Australia) (DoW). (2007a). *Government response to a blueprint for water reform in Western Australia*. Department of Water. https://www.water.wa.gov.au/_data/assets/pdf_file/0020/4394/73207.pdf
- Department of Water (Western Australia) (DoW). (2007b). *Western Australia’s Implementation Plan for the National Water Initiative (final draft)*. Department of Water. https://www.water.wa.gov.au/_data/assets/pdf_file/0019/4447/73203.pdf
- Department of Water (Western Australia) (DoW). (2009). *Discussion Paper. Water Resources Management Options: Looking after all our water needs*. Department of Water. https://water.wa.gov.au/_data/assets/pdf_file/0019/5581/89895.pdf
- Department of Water (Western Australia) (DoW). (2013). *Securing Western Australia’s water future. Position paper - reforming water resource management*. Department of Water. https://www.water.wa.gov.au/_data/assets/pdf_file/0019/1765/106021.pdf

- Department of Water and Environmental Regulation (Western Australia) (DWER). (2019). *Water planning in the Fitzroy River catchment*. Department of Water and Environmental Regulation. https://webarchive.nla.gov.au/awa/20190322054424/http://water.wa.gov.au/data/assets/pdf_file/0009/9666/water-planning-in-the-fitzroy-river-catchment.pdf
- Department of Water and Environmental Regulation (Western Australia) (DWER). (2020). *Managing water in the Fitzroy River Catchment: Discussion paper for stakeholder consultation*. Department of Water and Environmental Regulation. https://consult.dwer.wa.gov.au/water-policy/managing-water-in-the-fitzroy-river-catchment/user_uploads/115885-2.pdf
- Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J. R., Arico, S., Báldi, A., Bartuska, A., Baste, I. A., Bilgin, A., Brondizio, E., Chan, K. M. A., Figueroa, V. E., Duraiappah, A., Fischer, M., Hill, R., Koetz, T., Leadley, P., Lyver, P., Mace, G. M., Martin-Lopez, B., Okumura, M., Pacheco, D., Pascual, U., Pérez, E. S., Reyers, B., Roth, E., Saito, O., Scholes, R. J., Sharma, N., Tallis, H., Thaman, R., Watson, R., Yahara, T., Hamid, Z. A., Akosim, C., Al-Hafedh, Y., Allahverdiyev, R., Amankwah, E., Asah, S. T., Asfaw, Z., Bartus, G., Brooks, L. A., Caillaux, J., Dalle, G., Darnaedi, D., Driver, A., Erpul, G., Escobar-Eyzaguirre, P., Failler, P., Fouda, A. M. M., Fu, B., Gundimeda, H., Hashimoto, S., Homer, F., Lavorel, S., Lichtenstein, G., Mala, W. A., Mandivenyi, W., Matczak, P., Mbizvo, C., Mehrdadi, M., Metzger, J. P., Mikissa, J. B., Moller, H., Mooney, H. A., Mumby, P., Nagendra, H., Nesshover, C., Oteng-Yeboah, A. A., Pataki, G., Roué, M., Rubis, J., Schultz, M., Smith, P., Sumaila, R., Takeuchi, K., Thomas, S., Verma, M., Yeo-Chang, Y., & Zlatanova, D. (2015, 2015/06/01/). The IPBES Conceptual Framework — connecting nature and people. *Current Opinion in Environmental Sustainability*, 14, 1–16. <https://doi.org/10.1016/j.cosust.2014.11.002>
- Dobbs, R. J., Davies, C. L., Walker, M. L., Pettit, N. E., Pusey, B. J., Close, P. G., Akune, Y., Walsham, N., Smith, B., & Wiggan, A. (2016). Collaborative research partnerships inform monitoring and management of aquatic ecosystems by Indigenous rangers. *Reviews in Fish Biology Fisheries*, 26(4), 711–725. <https://doi.org/10.1007/s11160-015-9401-2>
- Dockery, A. M. (2010). Culture and wellbeing: The case of Indigenous Australians. *Social Indicators Research*, 99(2), 315–332. <https://doi.org/10.1007/s11205-010-9582-y>
- Douglas, M. M., Jackson, S., Canham, C. A., Laborde, S., Beesley, L., Kennard, M. J., Pusey, B. J., Loomes, R., & Setterfield, S. A. (2019). Conceptualizing hydro-socio-ecological relationships to enable more integrated and inclusive water allocation planning. *One Earth*, 1(3), 361–373. <https://doi.org/10.1016/j.oneear.2019.10.021>
- Finn, M., & Jackson, S. (2011, December 01). Protecting Indigenous values in water management: A challenge to conventional environmental flow assessments. *Ecosystems*, 14(8), 1232–1248. <https://doi.org/10.1007/s10021-011-9476-0>
- Freestone, F. L., Canham, C. A., Setterfield, S. A., Douglas, M. M., & Loomes, R. C. (2021). *Characterising vegetation zones along the lower Fitzroy River, Western Australia*. University of Western Australia. <https://www.nesppnorthern.edu.au/wp-content/uploads/2021/11/Characterising-veg-zones-along-the-lower-Fitzroy-River-WA-report.pdf>
- Gregory, R., Halteman, P., Kaechele, N., Kotaska, J., & Satterfield, T. (2020). Compensating Indigenous social and cultural losses: a community-based multiple-attribute approach. *Ecology and Society*, 25(4). <https://doi.org/10.5751/ES-12038-250404>
- Gregory, R., & Trousdale, W. (2009). Compensating aboriginal cultural losses: An alternative approach to assessing environmental damages. *Journal of Environmental Management*, 90(8), 1–11. <https://doi.org/10.1016/j.jenvman.2008.12.019>
- Hamilton, S. K., & Gehrke, P. C. (2005). Australia's tropical river systems: Current scientific understanding and critical knowledge gaps for sustainable management. *Marine Freshwater Research*, 56(3), 243–252. <https://doi.org/10.1071/MF05063>

- Heiner, M., Hinchley, D., Fitzsimons, J., Weisenberger, F., Bergmann, W., McMahon, T., Milgin, J., Nardea, L., Oakleaf, J., & Parriman, D. (2019). Moving from reactive to proactive development planning to conserve Indigenous community and biodiversity values. *Environmental Impact Assessment Review*, 74, 1–13. <https://doi.org/10.1016/j.eiar.2018.09.002>
- Hermoso, V., Kennard, M. J., & Linke, S. (2012). Integrating multidirectional connectivity requirements in systematic conservation planning for freshwater systems. *Diversity and Distributions*, 18(5/6), 448–458. <http://www.jstor.org/stable/23258131>
- Hill, R., Golson, K., Lowe, P., Mann, M., Hayes, S., & Blackwood, J. (2006, 11-13 October 2005). Kimberley Appropriate Economies Roundtable Forum Proceedings. Kimberley Appropriate Economies Roundtable Forum, Fitzroy Crossing, WA.
- Hill, R., Harkness, P., Raisbeck-Brown, N., Lyons, I., Álvarez-Romero, J. G., Kim, M. K., Chungalla, D., Wungundin, H., Aiken, M., Malay, J., Williams, B., Buisseret, R., Cranbell, T., Forrest, J., Hand, M., James, R., Jingle, E., Knight, O., Lennard, N., Lennard, V., Malay, I., Malay, L., Midmee, W., Morton, S., Nulgit, C., Riley, P., Shadforth, I., Bieundurry, J., Brooking, G., Brooking, S., Brumby, W., Bulmer, V., Cherel, V., Clifton, A., Cox, S., Dawson, M., Gore-Birch, C., Hill, J., Hobbs, A., Hobbs, D., Juboy, C., Juboy, P., Kogolo, A., Laborde, S., Lennard, B., Lennard, C., Lennard, D., Malay, N., Malay, Z., Marshall, D., Marshall, H., Millindee, L., Mowaljarlai, D., Myers, A., Nnarda, T., Nuggett, J., Nulgit, L., Nulgit, P., Poelina, A., Poudrill, D., Ross, J., Shandley, J., Skander, R., Skeen, S., Smith, G., Street, M., Thomas, P., Wongawol, B., Yungabun, H., Sunfly, A., Cook, C., Shaw, K., Collard, T., & Collard, Y. (2021). Learning Together for and with the Martuwarra Fitzroy River. *Sustainability Science*, 17(2), 351–375. <https://doi.org/10.1007/s11625-021-00988-x>
- Jackson, S. (2005). Indigenous values and water resource management: a case study from the Northern Territory. *Australasian Journal of Environmental Management*, 12(3), 136–146. <https://doi.org/10.1080/14486563.2005.9725084>
- Jackson, S. (2006, 11-13 October 2005). *Indigenous Economic Opportunities and Water Resource Planning*. Kimberley Appropriate Economies Roundtable Forum, Fitzroy Crossing, WA. <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.454.5317&rep=rep1&type=pdf>
- Jackson, S. (2015). Indigenous social and cultural values relating to water in the Fitzroy Valley, Kimberley (WA): Information availability, knowledge gaps and research needs. WA Government Department of Water and Environmental Regulation. https://water.wa.gov.au/_data/assets/pdf_file/0017/8009/109786.pdf
- Jackson, S., Finn, M., & Featherston, P. (2012). Aquatic resource use by Indigenous Australians in two tropical river catchments: The Fitzroy River and Daly River. *Human Ecology*, 40(6), 893–908. <http://www.jstor.org/stable/23353261>
- Jackson, S., Finn, M., & Scheepers, K. (2014). The use of replacement cost method to assess and manage the impacts of water resource development on Australian indigenous customary economies. *Journal of Environmental Management*, 135, 100–109. <https://doi.org/10.1016/j.jenvman.2014.01.018>
- Jackson, S., Finn, M., Woodward, E., & Featherston, P. (2011). *Indigenous Socio-economic Values and River Flows: A Summary of Research Results: 2008-2010*. CSIRO. https://www.nespnorthern.edu.au/wp-content/uploads/2016/02/TRaCK_2-2_IndigenousSocio-economic_Summary_online-2011_0.pdf
- Jackson, S., Stoeckl, N., Straton, A., & Stanley, O. (2008). The changing value of Australian tropical rivers. *Geographical Research*, 46(3), 275–290. <https://doi.org/10.1111/j.1745-5871.2008.00523.x>
- Kim, M. K., Álvarez-Romero, J., Wallace, K., Pannell, D., Hill, R., & Pressey, R. (2021). Assessment of the potential changes in wellbeing of key interest groups in the Fitzroy River catchment under alternative development scenarios: Traditional Owners’ workshop. University of Western Australia. <https://www.nespnorthern.edu.au/wp-content/uploads/2021/11/Traditional-Owners-workshop-report.pdf>

- Kim, M. K., Álvarez-Romero, J. G., Wallace, K., Pannell, D., Hill, R., Adams, V. M., Douglas, M., & Pressey, R. L. (2021). Participatory multi-stakeholder assessment of alternative development scenarios in contested landscapes. *Sustainability Science*, 17, 221–241. <https://doi.org/10.1007/s11625-021-01056-0>
- Kragt, M. E., Spencer-Cotton, A., & Burton, M. (2016, July 10–14, 2016). Spatial choice experiments to support environmental management of the Kimberley coast. International Environmental Modelling and Software Society (iEMSs), 8th International Congress on Environmental Modelling and Software, Toulouse, France.
- Laborde, S., & Jackson, S. (2021). *Indigenous water requirements in the Martuwarra/Fitzroy River catchment, Western Australia*. Griffith University. <https://www.nespnorthern.edu.au/wp-content/uploads/2021/12/Indigenous-water-requirements-for-the-Martuwarra-final-report.pdf>
- Liedloff, A. C., Woodward, E. L., Harrington, G. A., & Jackson, S. (2013). Integrating indigenous ecological and scientific hydro-geological knowledge using a Bayesian Network in the context of water resource development. *Journal of Hydrology*, 499, 177–187. <https://doi.org/10.1016/j.jhydrol.2013.06.051>
- MacKenzie, J., Butcher, R., Gippel, C., Cottingham, P., Brown, R., Wanganeen, K., Kloeden, T., & Meara, T. (2017). *Cultural Flows Field Studies Final Report*. <https://nban.org.au/wp-content/uploads/2020/06/Cultural-Flow-Field-Studies-Final-Report.pdf>
- Manero, A., Taylor, K., Nikolakis, W., Adamowicz, W., Marshall, V., Spencer-Cotton, A., Nguyen, M., & Grafton, R. Q. (2022, 2022/04/01/). A systematic literature review of non-market valuation of Indigenous peoples' values: Current knowledge, best-practice and framing questions for future research. *Ecosystem Services*, 54. <https://doi.org/10.1016/j.ecoser.2022.101417>
- Martin, K. (2003). Ways of knowing, being and doing: A theoretical framework and methods for indigenous and indigenist re-search. *Journal of Australian Studies*, 27(76), 203–214. <https://doi.org/10.1080/14443050309387838>
- Mathews, D., Semeniuk, V., & Semeniuk, C. (2011). Freshwater seepage along the coast of the western Dampier Peninsula, Kimberley region, Western Australia. *Journal of the Royal Society of Western Australia*, 94(2), 207–212. [https://www.rswa.org.au/publications/Journal/94\(2\)/Mathewsetal.pp.207-212.pdf](https://www.rswa.org.au/publications/Journal/94(2)/Mathewsetal.pp.207-212.pdf)
- McDaniels, T. L., & Trousdale, W. (2005). Resource compensation and negotiation support in an aboriginal context: Using community-based multi-attribute analysis to evaluate non-market losses. *Ecological Economics*, 55(2), 173–186. <https://doi.org/10.1016/j.ecolecon.2005.07.027>
- Merrin, L., Addison, J., Austin, J., Barber, M., Bruce, C., Ebner, B., Higgins, A., Horner, N., Jarvis, D., Kenyon, R., Lau, J., Macintosh, A., Philip, S., Pollino, C., Ponce Reyes, R., Stokes, C., Stratford, D., Waschka, M., Woodward, E., & O'Sullivan, J. (2018). Living and built environment of the Fitzroy catchment. In C. Petheram, C. Bruce, C. Chilcott, & I. Watson (Eds.), *Water resource assessment for the Fitzroy catchment. A report to the Australian Government from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments* (pp. 78–150). CSIRO. <https://doi.org/10.25919/8hws-y339>
- Milgin, A., Nardea, L., Grey, H., Laborde, S., & Jackson, S. (2020). Sustainability crises are crises of relationship: Learning from Nyikina ecology and ethics. *People and Nature*, 2, 1210–1222. <https://doi.org/10.1002/pan3.10149>
- Minister for Water; Forestry; Innovation and ICT; Science; Youth (Western Australia) (MWFIIYSY). (2020). *Western Australian Government submission to National Water Reform Productivity Commission issues paper - May 2020*. Minister for Water; Forestry; Innovation and ICT; Science; Youth. https://www.pc.gov.au/data/assets/pdf_file/0011/255872/sub062-water-reform-2020.pdf
- Moggridge, B. J. (2021). Indigenous water knowledge and values in an Australasian context. *Australasian Journal of Water Resources*, 25(1), 1–3. <https://doi.org/10.1080/13241583.2021.1935919>

- Moggridge, B. J., & Thompson, R. (2021). Cultural value of water and western water management: an Australian indigenous perspective. *Australasian Journal of Water Resources*, 25(1), 4–14. <https://doi.org/10.1080/13241583.2021.1897926>
- Nakata, M. (2002). Indigenous knowledge and the cultural interface: Underlying issues at the intersection of knowledge and information systems. *IFLA journal*, 28(5-6), 281–291. <https://doi.org/10.1177/034003520202800513>
- National Water Commission (NWC). (2011). *Water markets in Australia: A short history*. <https://apo.org.au/sites/default/files/resource-files/2011-12/apo-nid27438.pdf>
- Newman, B., Wilson, K. A., Melbourne, J., Mathews, D., Wysong, M., & Iacona, G. D. (2019). The contributions of nature to people within the Yawuru Indigenous Protected Area. *Conservation Science Practice*, 1(6). <https://doi.org/10.1111/csp2.16>
- Nikolakis, W., & Grafton, R. Q. (2011). *Assessment of the potential costs and benefits of water trading across northern Australia*. Charles Darwin University. https://www.nespnorthern.edu.au/wp-content/uploads/2016/02/6.1_Final_Report_WaterMarkets_WN_RQ.pdf
- Nikolakis, W., Grafton, R. Q., & To, H. (2010). *Stakeholder values and attitudes towards water markets across northern Australia*. Charles Darwin University. <https://core.ac.uk/display/47205773>
- Pascual, U., Muradian, R., Brander, L., Gómez-Baggethun, E., Martín-López, B., Verma, M., Armsworth, P., Christie, M., Cornelissen, H., & Eppink, F. (2012). The economics of valuing ecosystem services and biodiversity. In P. Kumar (Ed.), *The economics of ecosystems and biodiversity: Ecological and economic foundations* (pp. 183–256). Routledge. <https://doi.org/10.4324/9781849775489>
- Pelizzon, A., Poelina, A., Akhtar-Khavari, A., Clark, C., Laborde, S., Macpherson, E., O'Bryan, K., O'Donnell, E., & Page, J. (2021). Yoongoorrookoo: The emergence of ancestral personhood. *Griffith Law Review*, 30(3), 505–529. <https://doi.org/10.1080/10383441.2021.1996882>
- Perman, R., Ma, Y., Common, M., Maddison, D., & McGilvray, J. (2011). *Natural resource and environmental economics* (Fourth ed.). Pearson Education.
- Petheram, C., Bruce, C., Chilcott, C., & Watson, I. (2018). Water resource assessment for the Fitzroy catchment. A report to the Australian Government from the CSIRO Northern Australia Water Research Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments. <https://publications.csiro.au/rpr/pub?pid=csiro:EP186908>
- Pettit, N. E., Warfe, D. M., Close, P. G., Pusey, B. J., Dobbs, R., Davies, C., Valdez, D., & Davies, P. M. (2016). Carbon sources for aquatic food webs of riverine and lacustrine tropical waterholes with variable groundwater influence. *Marine Freshwater Research*, 68(3), 442–451. <https://doi.org/10.1071/MF15365>
- Poelina, A. (2019). A Coalition of Hope! A Regional Governance Approach to Indigenous Australian Cultural Wellbeing. In *Located Research: Regional Places, Transitions and Challenges* (pp. 153-180). https://doi.org/10.1007/978-981-32-9694-7_10
- Poelina, A., Brueckner, M., & McDuffie, M. (2021). For the greater good? Questioning the social licence of extractive-led development in Western Australia's Martuwarra Fitzroy River region. *Extractive Industries and Society*, 8(3), Article 100827. <https://doi.org/10.1016/j.exis.2020.10.010>
- Poelina, A., Taylor, K. S., & Perdrisat, I. (2019). Martuwarra Fitzroy River Council: An Indigenous cultural approach to collaborative water governance. *Australasian Journal of Environmental Management*, 26(3), 236–254. <https://doi.org/10.1080/14486563.2019.1651226>
- Productivity Commission (PC). (2017). *National Water Reform 2017*. Productivity Commission. <https://www.pc.gov.au/inquiries/completed/water-reform-2020/report>
- Productivity Commission (PC). (2021). *National Water Reform 2020* (1740377214). Productivity Commission. <https://www.pc.gov.au/inquiries/completed/water-reform-2020/report>

- Pusey, B. J., & Kath, J. (2015). *Environmental Water Management in the Fitzroy River Valley: Information availability, knowledge gaps and research needs*. Unpublished report to the Department of Water, Western Australia. https://www.researchgate.net/profile/Bradley-Pusey/publication/292476008_Environmental_Water_Management_in_the_Fitzroy_River_Valley_-_Information_availability_knowledge_gaps_and_research_needs/links/56aed7af08ae19a3851638b9/Environmental-Water-Management-in-the-Fitzroy-River-Valley-Information-availability-knowledge-gaps-and-research-needs.pdf
- RiverOfLife, M., Poelina, A., Alexandra, J., & Samnakay, N. (2020). *A conservation and management plan for the National Heritage listed Fitzroy River Catchment Estate (No. 1)*. https://researchonline.nd.edu.au/cgi/viewcontent.cgi?article=1001&context=nulungu_reports
- RiverOfLife, M., Poelina, A., Bagnall, D., & Lim, M. (2020, Nov). Recognizing the Martuwarra's First Law Right to Life as a Living Ancestral Being. *Transnational Environmental Law*, 9(3), 541–568. <https://doi.org/10.1017/s2047102520000163>
- RiverOfLife, M., Poelina, A., Butterly, L., Carmody, E., Perdrisat, M., Taylor, K., Manero, A., Grafton, Q., & Williams, J. (2021). *Submission in response to: Derby Groundwater Allocation Plan*.
- RiverOfLife, M., Taylor, K. S., & Poelina, A. (2021, Jan). Living Waters, Law First: Nyikina and Mangala water governance in the Kimberley, Western Australia. *Australasian Journal of Water Resources*, 25(1), 40–56. <https://doi.org/10.1080/13241583.2021.1880538>
- RiverOfLife, M., Unamen Shipu Romaine River, Poelina, A., Woollorton, S., Guimond, L., & Durand, G. S. (2021). Hearing, voicing and healing: Rivers as culturally located and connected. *River Research and Applications*, 38(3), 422–434. <https://doi.org/10.1002/rra.3843>
- Samnakay, N. (2020). *The multiple values of the Martuwarra – Fitzroy River (Australia) – new governance required to protect free-flowing rivers*. <https://globalwaterforum.org/2020/09/27/the-multiple-values-of-the-martuwarra-fitzroy-river-australia-new-governance-required-to-protect-free-flowing-rivers/>
- Schulz, C., & Martin-Ortega, J. (2018, 2018/12/01/). Quantifying relational values — why not? *Current Opinion in Environmental Sustainability*, 35, 15–21. <https://doi.org/10.1016/j.cosust.2018.10.015>
- Simmonds, J. S., Dyer, A. B., Fitzsimons, J., Hinchley, D., & Maron, M. (2021). *Assessing biodiversity and cultural values for single-site and multi-property development proposals in northern Australia*. https://www.nespthreatenedspecies.edu.au/media/5c11l45q/nesp_73_final-report_el-formatted-v4.pdf
- Spencer-Cotton, A., Kragt, M. E., & Burton, M. (2016). Human values and aspirations for coastal waters of the Kimberley: Social values and management preferences using Choice Experiments Technical Report 3 of the Kimberley Marine Research Program Node. (Working Paper, Issue 1606). School of Agricultural and Resource Economics.
- Stoeckl, N., Grainger, D., Esparon, M., Farr, M., Larson, S., Kennard, M., Álvarez-Romero, J. G., Cattarino, L., Adams, V., & Douglas, M. (2016). *Integrated models, frameworks and decision support tools to guide management and planning in Northern Australia. Final report*. https://researchonline.jcu.edu.au/48810/1/Integrated_models_frameworks.pdf
- Stoeckl, N., Jarvis, D., Larson, S., Larson, A., Grainger, D., & Ewamian Aboriginal Corporation. (2021, 2021/08/01/). Australian Indigenous insights into ecosystem services: Beyond services towards connectedness – People, place and time. *Ecosystem Services*, 50. <https://doi.org/10.1016/j.ecoser.2021.101341>
- Stokes, C., Addison, J., Macintosh, A., Jarvis, D., Higgins, A., Doshi, A., Waschka, M., Jones, J., Asmi, W., & Horner, N. (2017). *Costs, benefits, institutional and social considerations for irrigation development. A technical report to the Australian Government from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments*.

- Stokes, C., & Jarvis, D. (2018). Overview of economic opportunities and constraints. In C. Petheram, C. Bruce, C. Chilcott, & I. Watson (Eds.), *Water resource assessment for the Fitzroy catchment. A report to the Australian Government from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments* (pp. 311–342). CSIRO. <https://doi.org/10.25919/8hws-y339>
- Storey, A. (2006, 11-13 October 2005). *Ecological values of the Fitzroy River with links to indigenous cultural values*. Kimberley Appropriate Economies Roundtable Forum, Fitzroy Crossing, WA. <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.454.5317&rep=rep1&type=pdf>
- Storey, A., Freund, R., & Davies, P. M. (2001). *Fitzroy River system: Environmental values*. Unpublished report prepared for Water and Rivers Commission.
- Straton, A., & Zander, K. (2009). *The value of Australia's tropical river ecosystem services*. Charles Darwin University. http://www.nespnorthern.edu.au/wp-content/uploads/2016/02/TRaCK-2.1_Value-of-tropical-river-ecosystem-services_final-report_Aug09.pdf
- TEEB. (2010). *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB*.
- Toussaint, S. (2008). Kimberley friction: Complex attachments to water-places in Northern Australia. *Oceania*, 78(1), 46–61. <https://doi.org/10.1002/j.1834-4461.2008.tb00027.x>
- Toussaint, S. (2014). Fishing for Fish and for Jaminyjarti in Northern Aboriginal Australia. *Oceania*, 84(1), 38–51. <http://www.jstor.org/stable/42705331>
- Toussaint, S., Sullivan, P., Yu, S., & Mularty Jr, M. (2001). *Fitzroy Valley Indigenous cultural values study (a preliminary assessment)*. https://www.water.wa.gov.au/_data/assets/pdf_file/0018/4842/46326.pdf
- Treloyn, S., Martin, M. D., & Charles, R. G. (2016). Cultural precedents for the repatriation of legacy song records to communities of origin. *Australian Aboriginal Studies*(2), 94–103. <https://doi.org/10.3316/informit.521032219518643>
- Vogwill, R. (2015). *Water resources of the Mardoowarra (Fitzroy River) catchment*. University of Western Australia. <https://www.wilderness.org.au/images/resources/FitzroyRiverReport.pdf>
- Watson, J., Watson, A., Poelina, A., Poelina, N., Watson, W., Camilleri, J., & Vernes, T. (2011). *Nyikina and Mangala Mardoowarra Wila Booroo Natural and Cultural Heritage Plan*. WWF-Australia. <https://www.wwf.org.au/ArticleDocuments/360/pub-nyikina-and-mangala-mardoowarra-wila-booroo-heritage-plan-1dec11.pdf.aspx>
- Woods, K. (2020). *Culture Counts: A choice modelling approach to quantifying cultural values for First Nations People*. [Doctoral Thesis, Charles Darwin University & Australian National University]. Australian National University Open Access Theses. <https://openresearch-repository.anu.edu.au/handle/1885/236331>
- Yu, S. (2006, 11-13 October 2005). *Cultural studies of the Fitzroy River, WA*. Kimberley Appropriate Economies Roundtable Forum, Fitzroy Crossing, WA. <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.454.5317&rep=rep1&type=pdf>
- Zander, K. K., Garnett, S. T., & Straton, A. (2010). Trade-offs between development, culture and conservation - Willingness to pay for tropical river management among urban Australians. *Journal of Environmental Management*, 91(12), 2519–2528. <https://doi.org/10.1016/j.jenvman.2010.07.012>
- Zander, K. K., & Straton, A. (2010). An economic assessment of the value of tropical river ecosystem services: Heterogeneous preferences among Aboriginal and non-Aboriginal Australians. *Ecological Economics*, 69(12), 2417–2426. <https://doi.org/10.1016/j.ecolecon.2010.07.010>