Economic analysis for Queensland's Lake Eyre Basin Full Decision Impact Analysis Statement

Report prepared by:

Syezlin Hasan

James C.R. Smart

Australian Rivers Institute, Griffith University, Brisbane

For:

Department of Environment and Science (DES)

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Approvals

Author signature:  Date: 10 November 2023

Author Name: Syezlin Hasan

Author signature:  Date: 10 November 2023

Author Name: James C. R. Smart

Supervisor signature:  Date: 10 November 2023

Supervisor Name: Professor David Hamilton, Director, Australian Rivers Institute, Griffith University

Author contact details

☎ +61 7 373 55026

✉ s.hasan@griffith.edu.au

https://www.griffith.edu.au/australian-rivers-institute

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1. Executive Summary

This report articulates nature's contribution to people and society in the context of Queensland's Lake Eyre Basin (Qld LEB) region. Currently, the Qld LEB is in a largely intact state with unique environmental and ecological attributes of interconnected rivers, floodplains and other environmental and ecosystem assets. These unique environmental and ecosystems assets underpin delivery of a wide range of goods and services that are highly valued by society. Human interactions with the Qld LEB and its biodiversity, whether directly or indirectly, improve the quality of life and wellbeing of local communities, and of Queensland and Australian society overall. There are effectively no substitutes available for the Qld LEB's unique environmental and ecological attributes.

A more holistic understanding of the values delivered to individuals, Traditional Custodians, local communities and society more broadly by the suite of environmental and ecosystem assets that comprise Qld's LEB region is required to support informed decision making around further resource development. The value of preserving the unique environmental and ecosystem assets of the Qld LEB intact can – in theory - be obtained by estimating the difference between the benefit and cost flows from the existing near intact system and benefit and cost flows from more intensively human-modified versions of this environmental and ecological system. This report provides a narrative, with literature support, regarding the different types of economic values which the Qld LEB currently supplies to individuals, local communities, the resource sector and other businesses, and wider society within Queensland and Australia. Given very limited prior economic evaluation of accompanying benefits and costs however, it does not provide a full monetary valuation of the environmental and ecosystem goods and services which the Qld LEB supplies.

There is a need to account appropriately for the full breadth of benefits Qld's LEB provides to society, including those that are difficult to quantify in biophysical and/or monetary terms, and present them in a coherent framing. The total economic value (TEV) framework can provide this broader articulation – as explained further in the main body of the report. Within the TEV framework, economic value is defined as the importance, worth or usefulness of something to people, whether it can be bought or sold in a market or otherwise. A TEV framing can help inform the trade-off between development and protection of environmental and ecosystem assets in Qld's LEB by representing the wide spectrum of values society ascribes to the outcomes of preservation or further development of those assets.

Use values and non-use values are the two major categorisations of value within TEV. Use values are benefits individuals derive by physically interacting directly or indirectly with environmental or ecosystem assets that supply resources or services from which individuals obtain satisfaction or benefits. *Use value* includes *direct use value*, *indirect use value*, *option value* and *quasi-option value*. *Non-use values* on the other hand, can be generated without any physical connection to or interaction with the environmental or ecosystem assets that provide the services from which an individual obtains satisfaction or benefits. Non-use values stem from the value individuals place on use of the services environmental or ecosystem assets provide *by others* as distinct from use of those services for self *(altruistic and bequest*

value), or the value individuals place on the continued existence of an environmental or ecosystem asset itself – distinct from any use of that asset's services (*existence value*).

The Consultation Regulatory Impact Statement (Consultation RIS) for Qld LEB (DES 2023) and the synthesis report (Côte 2022) indicate that multiple *use values* and *non-use values* are being provided by environmental and ecosystem assets in Qld's LEB in their current, largely intact state, with existing levels of resource extraction (conventional oil and gas) and economic activity (beef grazing and tourism). Use values and non-use values specific to Qld's LEB have been mapped across to the previously described TEV categories and are summarised in Figure ES1.

It is critical that key ecosystem assets comprising the Qld LEB remain in good condition so that they can continue to supply the regulating and supporting ecosystem services (e.g. water quality regulation, flow regulation, nutrient and soil cycling, pollutant assimilation and storage) that underpin the economic activity associated with consumptive and non-consumptive use value, altruistic value and bequest value derived by individuals, resident populations and the wider society in Queensland and Australia. Values delivered by the Qld LEB's environmental and ecosystem assets include oil and gas extraction, water supply for households and businesses, provision of fodder biomass for cattle grazing, habitat for flora and fauna that attract tourists and visitors, and healthy Country that can be cared for by Traditional Custodians (Figure ES1).

Residuals, contaminants, wastes and disturbances from economic activity in the LEB (e.g. contamination and wastewater release, overland flow obstruction, vegetation removal and soil erosion) can be conceptualised as flows of 'pressures' returning from the economy to nature. In combination with resource extractions, these pressures on nature manifest as impacts on the extent and condition of environmental and ecosystem assets in the Qld LEB (e.g. impacts on extent: reduction in groundwater stock and reduction in area and persistence of floodplain wetlands; impacts on condition: reduction in surface and groundwater quality, impairment of ecological functions and processes, changes in ecosystem composition, fragmentation of habitat). The ability of ecosystem assets within Qld LEB region to assimilate, absorb and store residuals and wastes and thereby *regulate* pressures is thus a particularly important ecosystem service, whose impairment or loss could have far-reaching adverse consequences. For example, obstructions to overland flow would reduce the extent of floodplain wetlands, thus impacting the breeding success of resident and migratory bird populations that attract visitors to the region; contamination in excess of natural assimilative capacity would affect the quality of groundwater stocks that support rangeland cattle businesses and supply the raw water input for many of the LEB's towns.

Notwithstanding the accompanying negative externalities, oil and gas production in Qld's LEB contributes ancillary economic benefits to local landholders and ancillary income to local governments in the region, as detailed in the Consultation RIS. Rates revenues from oil and gas leases make very significant contributions to the finances of some local governments in the region, particularly those in parts of the Cooper Creek sub-basin.

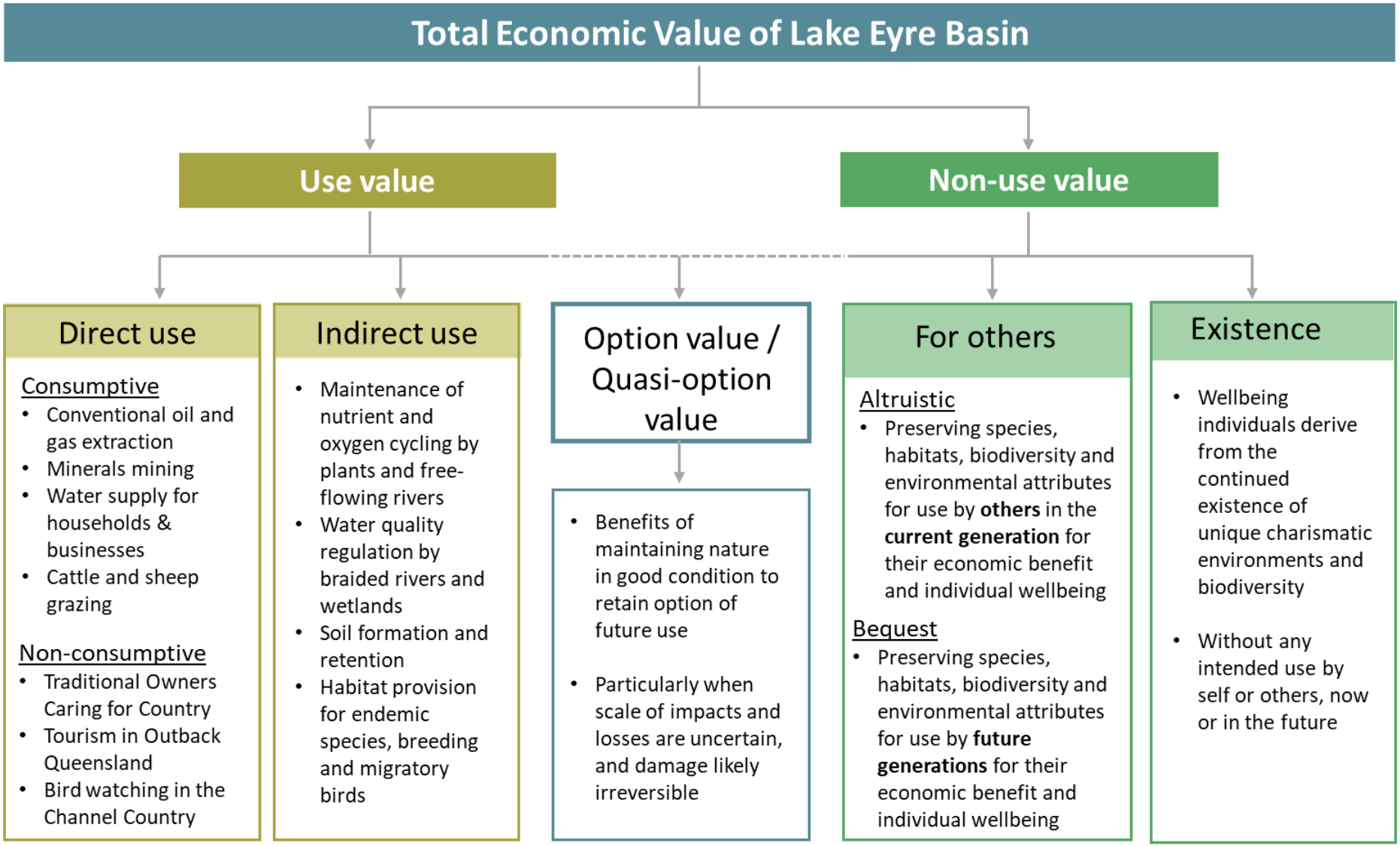

Figure ES1: Total economic value provided by environmental and ecological assets of Lake Eyre Basin.

Managing natural resources is particularly challenging because many of the goods and services supplied by environmental and ecosystem assets are not transacted in markets; hence, observable market prices are 'missing' for these important services. Reliance on market forces alone to inform trade-offs around resource use and service supply will thus likely result in trade-off outcomes that may not be welfare enhancing for society as a whole. This is particularly so if the damage costs from accompanying externalities are not properly accounted for.

The inter-connected, highly variable and unpredictable nature of the LEB make it a challenging system to study (and manage). Consequently, it is difficult to predict the impacts of additional resource developments with high levels of certainty; knowledge gaps and uncertainties will inevitably remain. The inclusion of ecological, economic development and societal objectives in the Queensland Government's regulatory framework indicates a willingness to mobilise public investment to deliver on these objectives. A willingness to commit public investment to protect ecological functions and processes, and recognise and protect Traditional Custodians' cultural heritage, priorities and aspirations implictly recognises the value associated with adopting a precautionary approach towards management of future oil and gas development in Qld's LEB.

The TEV framework also recognises the value of the opportunity for 'learning' that follows from *postponing* development of environmental or ecosystem assets when the consequences of development are both irreversible and uncertain. The 'learning' here could arise from improved understandings of the impacts of development and/or the values delivered by retaining the assets in their undeveloped states. In such situations the value of learning can be sufficient to justify postponing development, even when the expected net present value of development is positive.

It is relevant to consider how the particular characteristics of Qld's LEB and the uncertainties surrounding the impacts of further oil and gas developments affect the value of the learning that could be gained through postponing development. Qld's LEB in its current state comprises a unique collection of environmental and ecosystem assets of national and global significance which deliver multiple values to human society across the full spectrum of TEV. Considerable uncertainties surround the impacts of further development, and the risk of irreversible loss is substantial. In combination, these features act to substantially increase the benefit of the 'learning' that could be gained by postponing further development.

Existing resource extraction in Qld's LEB, operating under current environmental regulations, will continue to generate positive ancillary income and negative externalities. Previous findings on the risks from future conventional and unconventional oil and gas extraction indicates that a risk-aware, precautionary approach to environmental and natural resource management is warranted. A precautionary approach is paramount to ensure long term sustainability of the QLD LEB's environmental-social-economic systems.

There a strong case for preserving the environmental and ecological functions and processes supplied by environmental and ecosystem assets in Qld's LEB until we have a better understanding of how the cumulative impacts of oil and gas developments and climate

change will affect the suite of use values, non-use values and option values which environmental and ecosystem assets in the region currently deliver to local residents, regional businesses, and Queensland and Australian society more broadly.

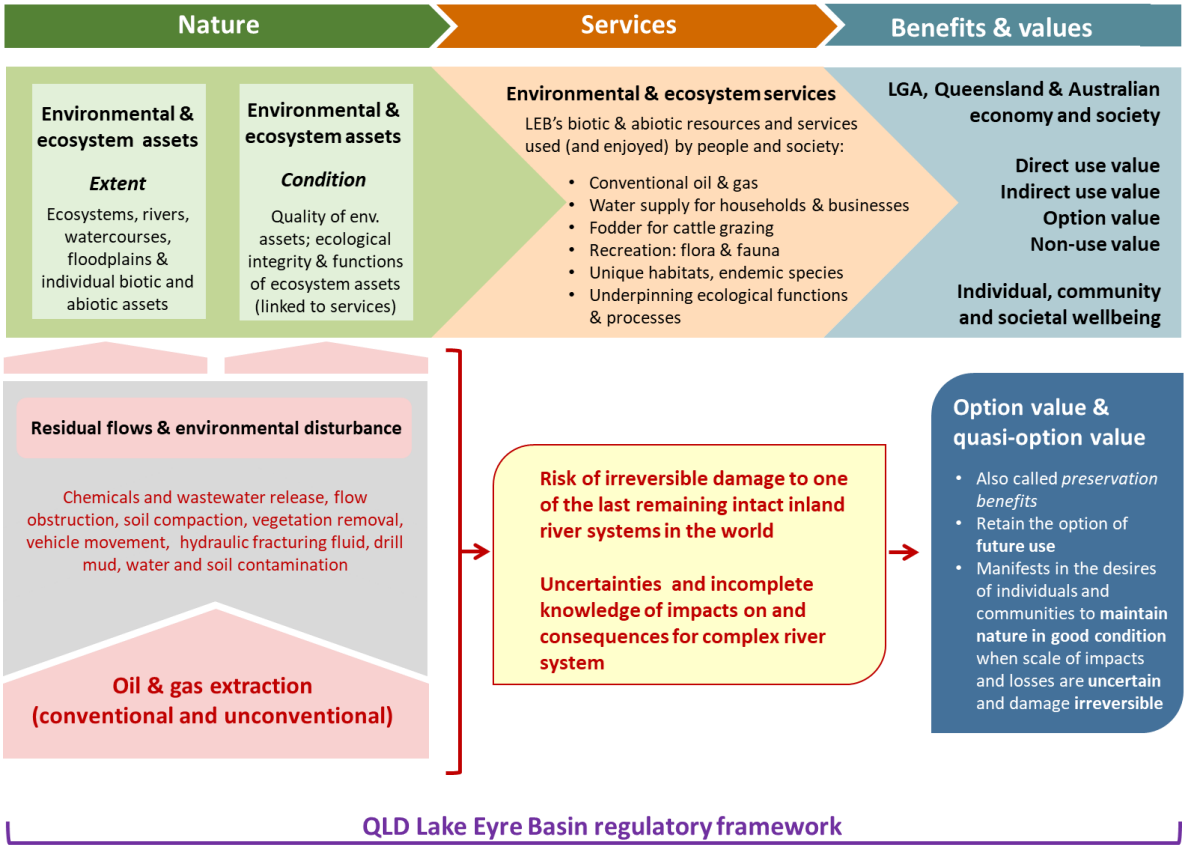

Figure ES2: Nature – in the form of environmental and ecosystem assets – supplies services that provide benefits to people. Conventional and unconventional oil and gas extraction generate residual flows and environmental disturbances, which impact both the extent (quantity) and condition (quality) of environmental and ecosystem assets. When the health and integrity of rivers, floodplains and other ecosystems is compromised, delivery of important environmental and ecosystem services to individuals, communities, and society will be impaired; potentially threatening drinking water supplies and reducing agricultural productivity, the wellbeing of Traditional Custodians, recreational value and recreational revenue across the region. The risk of irreversible damage to environmental and ecosystem assets for which there are effectively no substitutes, coupled with uncertainties about the future, cumulative impacts and incomplete knowledge, give rise to people attaching tangible value to retaining the *option* to derive benefits from this unique system into the future. To ensure continued protection of environmental and ecosystem assets of the Lake Eyre Basin, and the wide range of services they supply, a suite of spatial, regulatory and environmental attributes options have been identified and presented in the Consultation Regulatory Impact Statements.

2. Project Objectives

The authors were commissioned by Queensland Department of Environment and Science (the Department) to prepare a report as an input to the 'Full Decision Impact Analysis Statement' (previously referred to as a Decision RIS) for the Queensland Lake Eyre Basin project. The objective of this report is to provide relevant perspectives on non-monetary (broadly defined) and financial benefits and impacts of the recommended approaches by applying the Total Economic Value (TEV) framework to the multiple values of Queensland's Lake Eyre Basin (LEB). Specifically, the report will:

- Describe the TEV framework and its application in natural resource management.
- Develop a TEV-based perspective on the Qld LEB using the environmental values identified in Côte (2022) Lake Eyre Basin Synthesis Report, (Fielder et al. 2019)'Assessing development risks to the ecological values of the free-flowing rivers of Kati-Thanda-Lake Eyre Basin (Qld)', the Consultation RIS (DES 2023), and other associated information that the Department has obtained through consultation exercises.
- Consider how the various spatial, regulatory and environmental options identified in the Consultation RIS (DES 2023), could potentially safeguard different components of TEV. This will include how articulation of the benefits of avoiding irreversible damage could be framed using the option value and quasi-option value components of TEV.

3. Nature and its benefits to people

From the perspective of Western science, *nature* and *biodiversity* can be compartmentalised into categories such as *abiotic* and *biotic environmental assets*, and *ecosystem assets*. From an anthropocentric economics perspective, environmental and ecosystem assets are considered valuable because they supply *goods* and *services* that deliver *benefits* and *values* to *human* society. See Box 1 for definitions of nature, biodiversity, abiotic and biotic environmental assets, and ecosystem assets.

People interact with and derive value from nature and biodiversity in many ways and obtain multiple benefits from those interactions, directly and indirectly (Díaz et al., 2015; Taskforce on Nature-related Financial Disclosures (TNFD), 2023, p9). For example, a visit to a national park to enjoy beautiful scenery improves a person's wellbeing (Buckley 2020). The fact that a person chooses to spend time and resources to get this experience indicates that value is attached to their visit. Visitors' tourism-related expenditures on food and drink, accommodation and fuel in turn support the wellbeing of populations in local townships and regional centres. Nature also supports economic activity directly; for example, in the LEB setting, by providing grazing fodder to cattle stations or stocks of oil and gas for on-going and potential future extraction. See Figure 1 for a diagrammatic representation of the linkages between environmental and ecosystem assets, the goods and services they supply, and the benefits and values these goods and services deliver to human society.

In other knowledge systems, nature is viewed more holistically by Indigenous peoples (Díaz et al. 2015). For example, Indigenous Traditional Custodians in Australia view nature as a whole and regard interactions with Country (i.e. nature) as *relational* and *reciprocal* where "Traditional Owners have responsibilities to care for Country in order for Country to continue to contribute benefits to current and future generations" (Smart et al., 2022, p.xiii). In the Lake Eyre Basin region, rivers hold special significance in Traditional Custodians' relationship to Country (Box 2). This contrasts with Western science's *linear* and *transactional* perspective on interactions between people and nature (United Nations et al. 2021; Smart et al. 2022).

Box 1 Nature, biodiversity, environmental assets and ecosystem assets

Nature is viewed by the Taskforce on Nature-related Financial Disclosures (TNFD) as a construct of four realms: land, ocean, freshwater and atmosphere(Taskforce on Nature-related Financial Disclosures (TNFD) 2022).

Biodiversity is a related but distinct concept to nature in environmental economics. The TNFD defines biodiversity as "an essential characteristic of nature that is critical to maintaining the quality, resilience and quantity of ecosystem assets and the provision of ecosystem services that business and society rely upon" (Taskforce on Nature-related Financial Disclosures (TNFD) 2022).

Environmental assets are defined by the United Nations System of Environmental-Economic Accounting (SEEA) Central Framework as "the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity" (United Nations et al., 2014, Para 2.17 on p13).

Abiotic environmental assets, as a subset of environmental assets, are non-living resources which can deliver benefits to humanity. Examples of abiotic environmental assets in the LEB region are the region's soils, stocks of surface and groundwater, stocks of minerals, oil and gas in various forms.

Biotic environmental assets, as a subset of environmental assets, are living resources which can deliver benefits to humanity. Examples of biotic environmental assets in the LEB region are grazing fodder for livestock, wild fish stocks, stocks of resident and migratory bird species, some of which may be endemic and/or endangered. Biotic environmental assets can also be regarded as components of biodiversity.

Ecosystem assets are another component of nature which, for clarity within this study, we regard as a separate categorisation. SEEA Ecosystem Accounting (SEEA EA) defines ecosystem assets as "contiguous spaces of a specific ecosystem type characterized by a distinct set of biotic and abiotic components and their interactions" (United Nations et al., 2021, Para 2.11 on p.26). To ensure international standardisation, the International Union for Conservation of Nature (IUCN) produced the Global Ecosystem Typology classification system(Keith et al. 2020) to cover all ecosystem assets globally. This classification system should be used in all SEEA EA-aligned accounts to support integration of policies and decision making on management and protection of ecosystems, biodiversity, and the goods and services they supply, across jurisdictions (regional, state, national and international). Examples of ecosystems assets in the LEB region are rivers, floodplains, lakes, grasslands and water holes. Ecosystem assets provide habitat and resources which support stocks of biotic environmental assets. Ecological functions within ecosystem assets support cycling of stocks, and natural regulation of flows, of water, nutrients, carbon, soils and soil-borne minerals. In the LEB and elsewhere, ecological functions provided by ecosystem assets in the LEB support the condition of the Basin's abiotic and biotic environmental assets (soil and water quality, biotic viability of fish, bird and mammal populations).

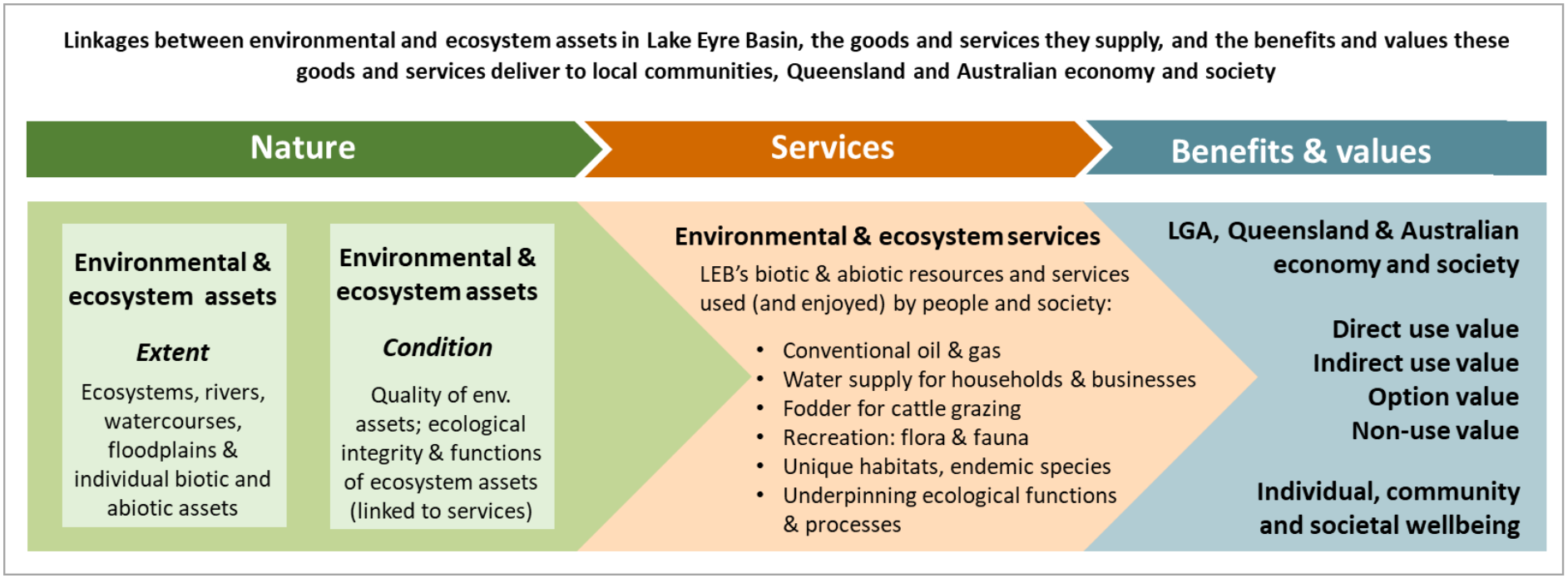

Figure 1 In the terminology of this report, nature within the LEB comprises the LEB's stocks of *environmental and ecosystem assets* that can be measured by their *extent* ('quantity') and *condition* ('quality'). *Environmental assets* comprise non-living natural resources termed *abiotic assets* (LEB: soils, surface and groundwater, minerals, oil and gas) and living natural resources termed *biotic assets* (LEB: stocks of grazing fodder, stocks of resident and migratory birds, fish and other animals). *Ecosystem assets* are contiguous areas of distinct *ecosystem types* (LEB: rivers, floodplains, lakes, grasslands). *Ecological functions* provided by the LEB's ecosystem assets affect the extent and condition of the Basin's abiotic and biotic environmental assets (LEB: quantity and quality of stocks of surface and groundwater, and soils, size and viability of fish, bird and mammal populations). The LEB's environmental and ecosystem assets deliver flows of *environmental services* and *ecosystem services* that *benefit human* society. (Perspective reflects United Nations System of Environmental-Economic Accounting and Taskforce on Nature-related Financial Disclosures). See Section 5 for a description of direct use value, indirect use value, option value and non-use value.

Box 2 Statement from Lake Eyre Basin Traditional Owners Alliance

In the Consultation Regulatory Impact Statement (DES, 2023, p.59), the LEB Traditional Owners Alliance stated:

"For the Traditional Owners, caring for country is more than a matter of economic prosperity, it is a sacred and ancient traditional responsibility carried forward from mother to daughter, father to son and includes social, environmental, cultural considerations. Traditional people live by the seasons and think of country as their mother and of water as the sacred lifeblood, keeping them connected through hunting, fishing, and ceremonial practices. We are kept strong and understand our culture by connecting to the stories and songs that live in our country, and through them continue to observe our own traditional lore, customs, cultural boundaries and obligations."

4. Impacts of economic activities on nature's benefits and values

From a Western scientific perspective, the complex, unique and largely intact system of interconnected environmental and ecosystem assets that make up Queensland's Lake Eyre Basin (Qld LEB) supply four categories of service flows to society (Freeman 1999)[1]:

(i) materials (oil and gas, minerals, water, grazing fodder for livestock),
(ii) life-support services and interlinked processes that maintain a liveable Earth (carbon, water and nutrient cycles, soil formation),
(iii) amenity services (bird watching, outdoor recreation, the pleasures of scenic views), and
(iv) assimilation, disposal and storage of by-products of economic activity (handling emissions and wastewater).

Residuals, contaminants, wastes and disturbances from economic activity in the LEB (e.g. contamination and wastewater release, overland flow obstruction, vegetation removal and soil erosion) can be conceptualised as flows of 'pressures' returning from the economy to nature in the Basin (Figure 2). In combination with resource extractions, these pressures on nature manifest as impacts on the extent and condition of the LEB's environmental and ecosystem assets (e.g. LEB impacts on extent: reduction in groundwater stock and reduction in area and persistence of floodplain wetlands; LEB impacts on condition: reduction in surface and groundwater quality, impairment of ecological functions and processes, changes in ecosystem composition, fragmentation of habitat). The ability of ecosystem assets to assimilate, absorb and store residuals and wastes, and thereby regulate pressures, is thus a particularly important ecosystem service, whose impairment or loss could have far-reaching adverse consequences. For example, in the LEB context, obstructions to overland flow could reduce the extent of floodplain wetlands which could potentially affect breeding success of resident and migratory bird populations that attract visitors to the region; contamination in excess of natural assimilative capacity could potentially affect groundwater stocks that support rangeland cattle businesses and supply the raw water input for many of the LEB's towns.

[1] Freeman's service flow categorisation pre-dates widespread adoption of standard categorisations for ecosystem services (e.g. (MEA 2005; Haines-Young and Potschin 2018). Ecosystem services can be nested within Freeman's categorisation by considering examples of service flows supplied by ecosystem assets. For example, the material flow of grazing biomass from the LEB's rangelands could be categorised as a provisioning ecosystem service; assimilation of nitrate loads by the LEB's wetlands could be categorised as a regulating ecosystem service; the amenity service of watching migratory birds on inundated LEB floodplains could be categorised as a cultural ecosystem service; the contribution of the LEB's woody biomass and soils to carbon sequestration and storage as part of the carbon cycle would be categorised as a supporting ecosystem service. We use Freeman's service categorisations here because they can readily be applied to services supplied by abiotic and biotic environmental assets, and those supplied by ecosystem assets.

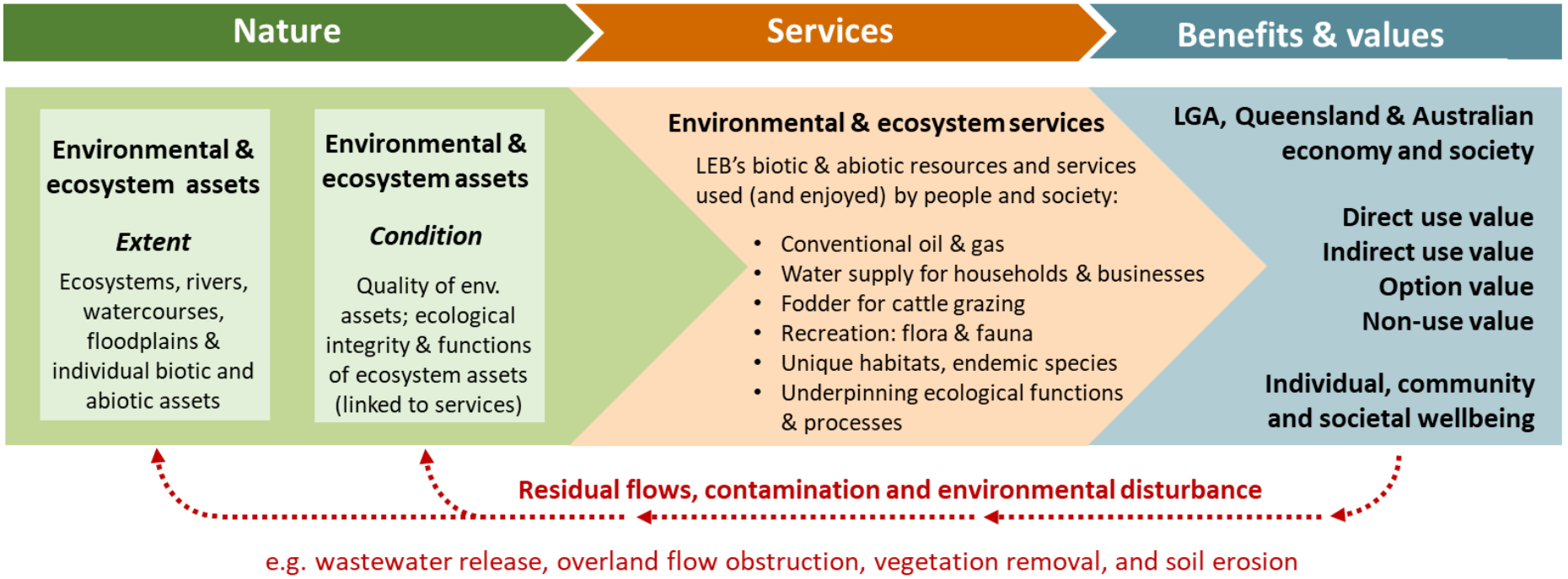

Figure 2: Utilisation of environmental and ecosystem assets and services within the LEB by the human economy produces by-products in the form of residuals, contaminants, wastes, effluents and other pollutants and disturbances. These residuals, contaminants and environmental disturbances flow from economic activity in the LEB back to nature in the Basin, shown here as dotted red arrows. The flows of residuals, contaminants and environmental disturbance from economic activity in the LEB impact (i) the extent and condition of the LEB's environmental assets (with potential adverse consequences for LEB groundwater availability and quality, and soil condition), (ii) the extent and condition of the LEB's ecosystem assets (with potential adverse consequences such as reduced floodplain inundation), and (iii) the ecological functioning of the LEB's ecosystem assets.

Environmental and ecosystem assets in the LEB can only supply limited quantities of resources and services relative to human demands, given their stocks, extents and conditions under the pressures imposed by existing LEB levels of resource extraction (conventional oil and gas) and economic activity (beef grazing and tourism). Resources and services from the LEB's environmental and ecosystem assets are therefore scarce[2]. Because resources and services from the LEB's environmental and ecosystem assets are scarce, choices and trade-offs are inevitable in managing the Basin's assets and resources. In the LEB and elsewhere, it is not usually possible to increase the flow of one type of resource or service, such as gas extraction, without an accompanying decrease in the flow of another type(s) of service such as the quantity or quality of extractable water from surface or groundwater sources.

Trade-offs in resource management are particularly challenging because only a subset of the goods and services supplied by environmental and ecosystem assets are traded in markets. For example, Freeman's life support and amenity services – including the assimilation, absorption and storage of residuals and wastes by the LEB's ecosystem assets – are typically not transacted in markets; hence, observable market prices are 'missing' for these important services. Reliance on market forces alone to allocate resource use and service supply within the LEB and elsewhere will likely result in trade-off outcomes that may not be welfare enhancing for society as a whole (Balmford et al. 2002; De Valck et al. 2021).

Sub-optimal outcomes are particularly likely if resource utilisation (such as oil and gas extraction) is accompanied by negative externalities (such as pollution by-products which impose adverse impacts on human health and the condition of environmental and ecosystem assets) for which the associated damage costs are not acknowledged. For example, conventional oil and gas from Qld's LEB trade on commodity markets at observable prices, so the net financial value generated can readily be calculated; however, the full cost of associated negative externalities is difficult to quantify and is therefore often overlooked.

This issue was explored in a Queensland context by De Valck et al. (2021) who compared the estimated net public benefits generated by coal mining, cattle grazing and nature conservation as alternative expansion scenarios for the Bowen Basin in Central Queensland. De Valck et al. found that, over a 31-year time horizon (2016 – 2047), coal mining was the preferred expansion option if the comparison was based solely on economic outcomes such as jobs created, and income tax and resource royalty payments, as it generated 10 to 14 times higher net public benefit than grazing and 800 to 3000 times higher net public benefit than nature conservation. However, when negative externalities such as traffic congestion, air pollution, and adverse impacts on biodiversity or water quality were included in the comparison[3], the coal mining expansion option was shown to impose net public *costs* of between $438 to $690 billion, whereas net public benefits of between $16.35 and $79.29

[2] In economics, goods and services are regarded as scarce when they are not supplied in sufficient quantity to fully satisfy demand.

[3] De Valck et al. (2021) used a social impact risk weighting approach to estimate the monetary cost imposed by relevant externalities. This allowed the externality cost to be scaled by the likelihood, consequences and significance of the externality – see De Valck et al. (2021), Section 4.1.2 and Table A1 for further details.

million were generated by nature conservation, and net public benefits of between $2.84 and $2.85 billion were generated by the cattle grazing scenario (De Valck et al. 2021).

In terms of impacts, mineral and fossil fuel extraction tend to be associated with irreversible damage to the health and ecological integrity of surrounding or connected environmental and ecosystem assets whereas the impacts of cattle grazing and tourism are generally less severe and less likely to be irreversible at least in the context of Qld LEB (Connell 2009; Epstein et al. 2011; Grecu et al. 2018; Mancini and Sala 2018; Sincovich et al. 2018; De Valck et al. 2021; Oerly et al. 2022).

Profitability of the resource sector is strongly influenced by the size, location and accessibility of stocks of fossil fuels and minerals but is relatively unaffected by the condition of other environmental and ecosystem assets. In contrast, economic activities such as organic cattle grazing are highly dependent on maintenance of ecosystem health for business viability and sustainability. This should provide a strong motivation for organic beef producers to maintain the land in good condition. An example of this effort to maintain good environmental condition is described in Sustainability Report 2022/2023 produced by an organic beef producer, OBE Organics (https://www.obeorganic.com/sustainability-and-obe-organic/). Similarly, the tourism sector in the LEB is also highly dependent on the condition of currently largely intact, free-flowing river systems which support unique biodiversity, which in turn attracts domestic and international tourists to experience and enjoy Queensland's Outback. Levels of dependency on and impacts upon nature thus typically differ substantially between resource extractive and non-resource extractive economic activities.

Notwithstanding the negative externalities that accompany fossil fuel extraction, conventional oil and gas production in Qld's LEB contributes ancillary economic benefits to local landholders and ancillary income to local governments in the region, as detailed in the Consultation RIS (DES 2023, p.29). Rates revenues from oil and gas leases make very significant contributions to the finances of some local governments in the region, particularly those in parts of the Cooper Creek sub-basin (Figures 3 and 4).

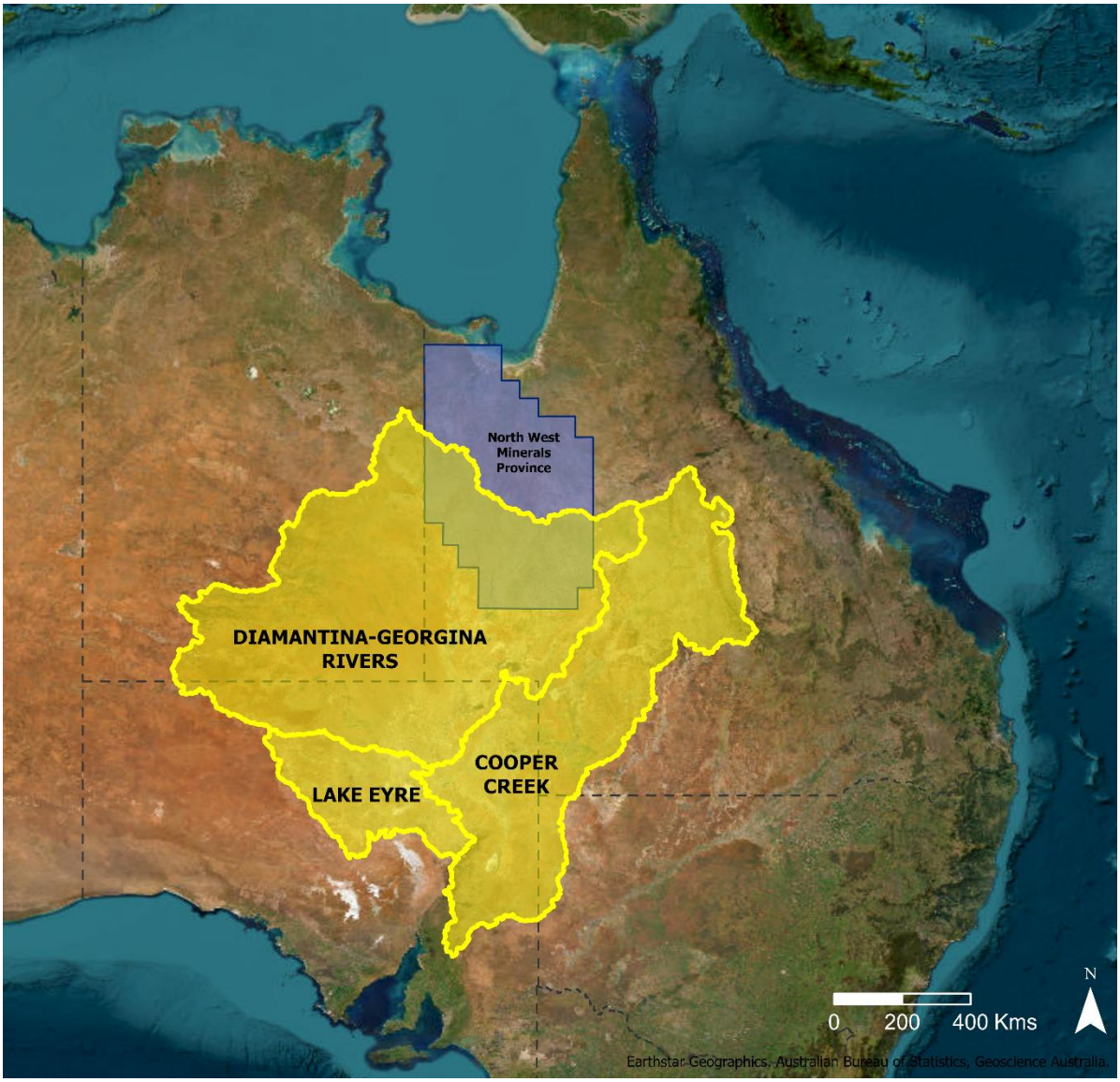

Figure 3: Lake Eyre Basin (yellow) and the North West Minerals Province (purple). Major sub-catchments within Lake Eyre Basin are labelled separately. Map credit: Jeremy Harte, Australian Rivers Institute, Griffith University.

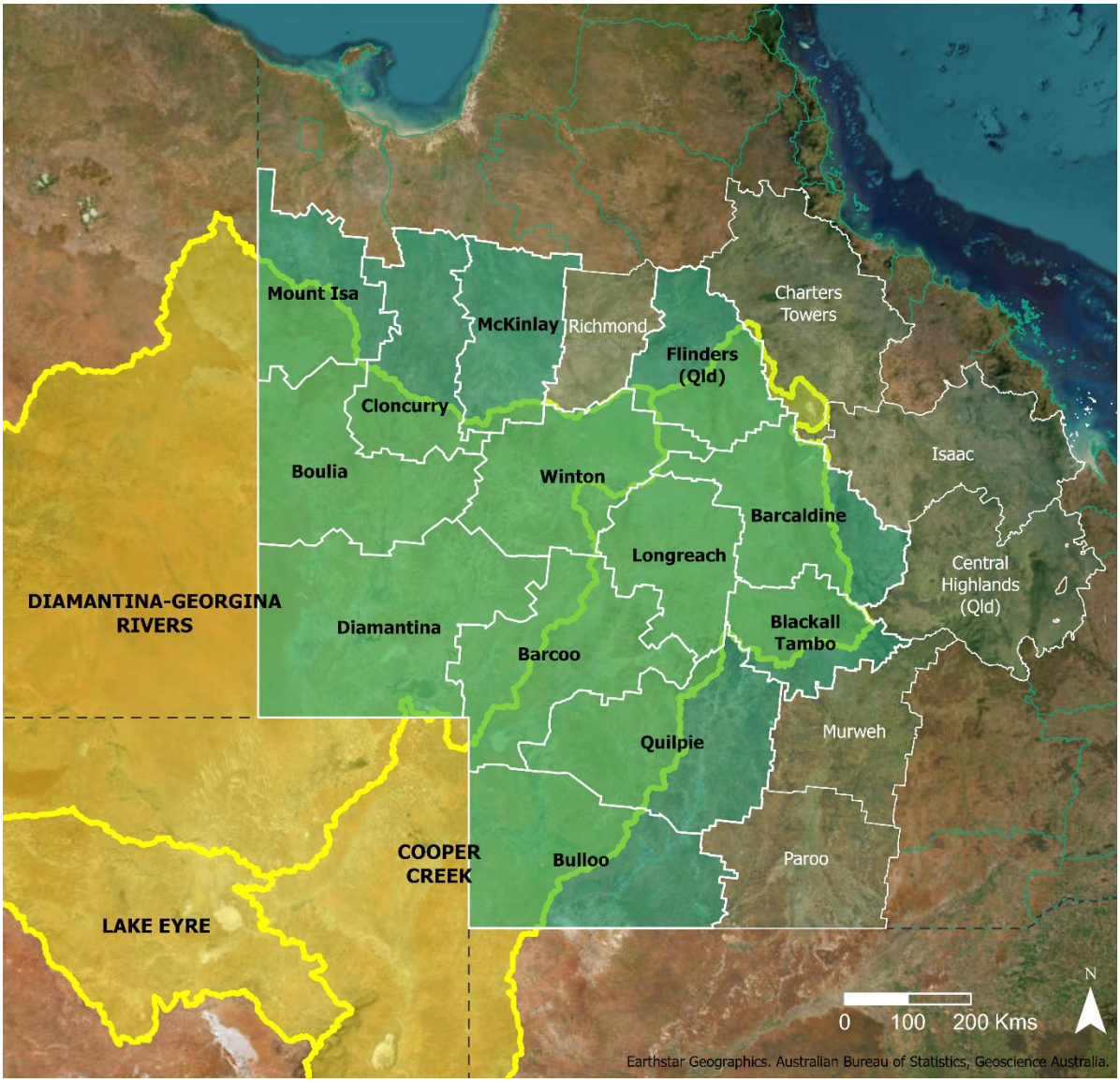

Figure 4: Local Government Areas within Queensland's Lake Eyre Basin. Local Government Areas which overlap the Basin substantially are shaded green. Map credit: Jeremy Harte, Australian Rivers Institute, Griffith University.

Furthermore, conventional cost-benefit analysis will tend to favour industries that generate large economic benefits in the near-term whilst the economic consequences of accompanying environmental damages only become apparent further into the future (Perman et al., 2011, Chapters 11 and 12).

Because nature underpins human life, economic prosperity and well-being, an effective governance system therefore plays a critical role in 'correcting' for these negative externalities and avoiding decision making that might otherwise produce sub-optimal imbalances in the mix of service types supplied from a given suite of environmental and ecosystem assets.

The ultimate goal of natural resource management, enacted through Commonwealth and Queensland legislation, regulation, guidelines and policies, is to enhance societal wellbeing

by ensuring adequate protection of rivers, watercourses, floodplains and other environmental and ecosystem assets whilst also supporting sustainable economic development (DES, 2023). A more holistic understanding of the values delivered to individuals, Traditional Custodians, local communities and society more broadly by the suite of environmental and ecosystem assets that comprise Qld's LEB region is therefore required to achieve this goal. There is a need to account appropriately for all types of values, including those that are difficult to quantify in biophysical and/or monetary terms, and present them in a coherent framing. A wider articulation of value is thus needed to understand the full breadth of benefits Qld's LEB provides to society. The total economic value framework can provide this broader articulation.

Section 5, following, describes the total economic value (TEV) framework in general. Section 6 describes the application of TEV in natural resource management specifically. Section 7 articulates use and non-use value components of TEV that are supplied by Queensland's LEB. Section 8 describes how option value and quasi-option value (which are also components of TEV) can be used to represent the benefits of avoiding irreversible damage to Queensland's LEB. Section 9 provides a perspective on the values generated by First Nations' caring for Country in the LEB, and Section 11 concludes.

5. Total economic value framework

The value of near intact, free-flowing river systems is difficult – but not impossible – to compile. The unique environmental and ecological attributes of Qld LEB in its current, largely intact state mean that there are effectively no substitutes for this unique, interconnected system of environmental and ecosystem assets and the services they supply. This non-substitutability significantly increases the value society places on retaining this unique collection of environmental and ecosystem assets as a near intact whole (Balmford et al., 2002). The value of preserving the unique environmental and ecosystem assets of the Qld LEB intact can – in theory - be obtained by estimating the difference between the benefit flows from the existing near intact and more intensively human-modified versions of this environmental and ecological system (see Balmford et al 2002 for a review of studies that have used this method). However, this would require a detailed economic valuation study designed specifically for the location of interest, and literature searches return no economic valuation studies specific to the Qld LEB. Further research and analysis could employ suitable economic valuation techniques to derive total economic value of Qld LEB (see Bateman et al., 2002, for detailed economic methodology).

A comprehensive, location-specific valuation study of the type described in the preceding paragraph could be constructed within the total economic value framework. The total economic value (TEV) framework can be used to articulate a wide range of values associated with human interactions with nature (Balmford et al., 2002; Bergstrom & Loomis, 2021; Pearce & Turner, 1990). Within TEV, economic value is defined as the importance, worth or usefulness of something to people, whether it can be bought or sold in a market (market values) or otherwise (non-market values) (Natural Capital Coalition, 2016). In the context of Qld's LEB, *values* refer to the *benefits* individuals, communities and society derive from services supplied by the region's environmental and ecosystem assets. The TEV of the Qld LEB thus comprises the sum of all these different value components that deliver benefits to people.

Relative levels of value can be revealed when the outcomes of trade-offs are observed. Trade-offs are made routinely when people choose to commit more of a scarce resource to delivery of one good, service or outcome and thus reduce the amount of resource that remains available to deliver other goods, services or outcomes. The trade-offs people make around the use of scarce resources reveal something about the relative values they place on delivery of the different goods, services or outcomes from resource use. Economics tends to focus on 'available budget' as the 'scarce resource' whose allocation reveals relative value. In daily life, however, it might reasonably be 'free-choice time', or – in the context of this report – the stock of unique, largely intact environmental and ecosystem assets in Qld's LEB. A TEV framing can thus help inform the trade-off between development and preservation of environmental and ecosystem assets in Qld's LEB by representing the wide spectrum of values society ascribes to the outcomes of preservation or development of those assets, rather than focusing solely on those outcomes that generate market revenues.

The TEV framework places the different value components into categories. Two primary types of value individuals derive from nature can be categorised as *use values* and *non-use values* (Figure 5).

Use values are benefits individuals derive by interfacing directly or indirectly with environmental or ecosystem assets that supply resources or services from which individuals obtain satisfaction or benefits. Use value includes *direct use value*, *indirect use value* and *option value*. *Non-use values* on the other hand, can be generated without any physical connection to or interaction with the environmental or ecosystem assets that provide the services from which an individual obtains satisfaction or benefits.

Direct use can be consumptive or non-consumptive. *Consumptive direct use* occurs when resources are extracted or harvested through exploitation of renewable resources (surface water, grazing fodder for livestock, timber harvesting) or non-renewable resources (minerals, conventional and unconventional oil and gas). Harvested or extracted products are tangible readily identifiable goods, most of which are traded in measurable quantities at observable market prices. *Non-consumptive direct use* arises when environmental assets supply benefits to people without the need for extraction or harvesting. Examples include many forms of recreational and artistic use of natural environments (visits to national parks for hiking, camping, painting and photography). The level of benefit and wellbeing obtained will likely be positively correlated with environmental and ecosystem asset condition (Davis et al. 2022). As consumptive direct use of natural resources may degrade environmental quality, there are frequently tensions between consumptive and non-consumptive direct uses of environmental and ecosystem assets.

Indirect use value refers to benefits people derive from an asset without actually using the services supplied by that asset directly. For example, commercial fruit production benefits from pollination by bees, and bee populations are sustained in the locality of fruit farms by adequate areas of appropriate habitat in satisfactory condition. The ecosystem assets that provide habitat to maintain bee populations thus provide an indirect use value to the fruit farmer. In a similar way nutrient cycling facilitated by free-flowing rivers, oxygen cycling by plants, and water quality regulation by wetlands and grasslands all provide indirect use values to agricultural production, household water supply and environment-based recreation and tourism across the LEB. Indirect use value is typically more difficult to quantify than direct use value as very few of the services that generate indirect use value are transacted in markets.

Option value arises from the benefits that would accrue from using a resource or asset at some time in the future. A form of use value, it accounts for the value individuals and, collectively, society place on retaining the *option* to use resources or services from environmental or ecosystem assets in the future. Option values have also been called *preservation benefits* (Weisbrod, 1964). Option value manifests in the desires of people to maintain environmental and ecosystem assets in good condition for the foreseeable future and this is commonly reflected in economic valuation studies as society's willingness to pay to protect natural assets in order to ensure their availability for potential future use.

Quasi-option value arises when there are benefits in delaying an irreversible development decision because of uncertainties and incomplete knowledge about the consequences of that development (Arrow & Fisher, 1974; Fisher & Hanemann, 1987). Quasi-option value thus reflects the benefit gained in delaying a decision to irreversibly develop a resource or asset when the environmental cost of development is uncertain. Quasi-option value will likely increase substantially if there are no substitutes for the assets that would be irreversibly lost or damaged by development (Arrow & Fisher, 1974).

In this report, following De Valck et al. (2023), option value and quasi-option value are regarded as being intermediate between use values and non-use values. They are thus placed between these two main categories of TEV in Figure 5.

The other major category of TEV is *non-use value*, which originates from the satisfaction (or benefit) that individuals derive from the preservation and protection of environmental and ecosystem assets, even though those individuals have no actual, planned or potential use *themselves* for the resources and services those assets supply. Non-use values stem from the value individuals place on either use of the services environmental or ecosystem assets provide *by others* as distinct from use of those services for self *(altruistic and bequest value)*, or the value individuals place on the continued existence of an environmental or ecosystem asset itself – distinct from any use of that asset's services (*existence value*) (Bateman et al 2002).

Existence value arises when individuals derive satisfaction from the continued *existence* of environmental or ecosystem assets, *irrespective* of the services these assets supply to the individuals themselves or to other people. Driven by personal motivations such as stewardship and environmental responsibility, individuals would feel saddened and bereaved if unique species, environments and ecosystems were to be lost. Existence value is likely to be a strong component of value that underpins shared understanding of the need to protect the LEB, given that the area has unique environmental values of global, national and state significance (Côte, 2022, p4 & 12).

Altruistic value relates to a concern for ensuring continuing usage of the services provided by environmental and ecosystem assets for the benefit of fellow humans (distinct from self) *within the same generation*. An individual derives satisfaction from knowing that the services supplied by environmental and ecosystem assets remain available for *others in the current generation* to use and benefit from.

Bequest value arises from the desire that *future generations* should have the option to access and use the goods and services supplied by protected environmental and ecosystem assets. Altruistic and bequest value are sometimes called intragenerational bequest value and intergenerational bequest value, respectively (McConnell, 1983; Randall & Stoll, 1983).

Non-use values for unique, largely intact natural areas like the LEB can be held by populations who have never visited and may have no intention to visit. Where those areas are of national and global significance, non-use values may be held by very large populations. Consequently, even low per-person non-use values may aggregate to become very substantial.

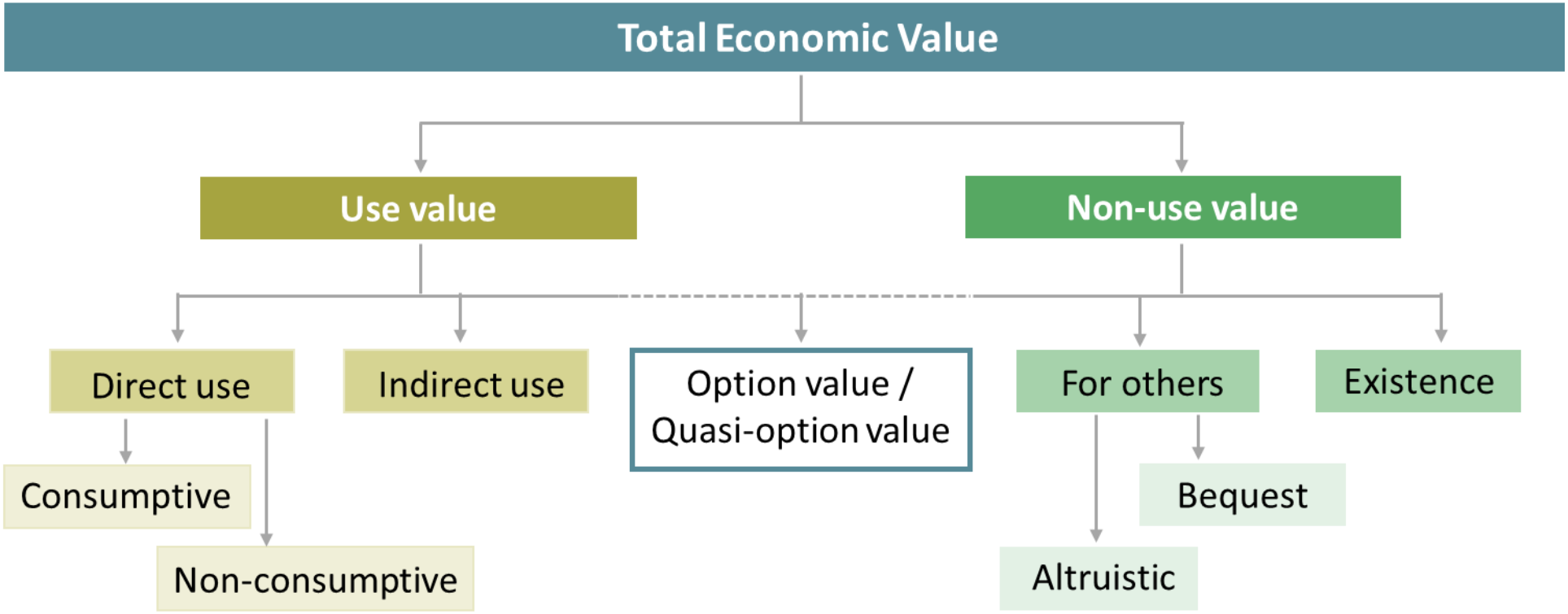

Figure 5 Total economic value framework (Source: adapted from Bateman et al., 2002; De Valck et al., 2023; Perman et al., 2011; TEEB, 2010; Tinch et al., 2019; Wadström et al., 2023).

6. Total economic value and natural resource management

The total economic value of a suite of environmental and ecosystem assets within a spatially defined area such as the Qld LEB is given by the summation of the use value, option value, quasi-option value, and non-use value delivered by that suite of assets. Anthropogenic management of those assets affects their quantity (stocks and extents) and quality (condition). Changes in stocks, extents and condition affect the quantities and mix of services supplied and thus affect the total economic value delivered. When a TEV framework is being used to inform policy and decision making around natural resource management, it is important to identify and include all components of TEV (Figure 5), and to differentiate clearly between them, to ensure the full suite of values are considered without double counting. As mentioned earlier, this is particularly important for unique natural areas of national and global significance because in these settings option value, quasi-option value and non-use value combined may be larger than the more readily measurable use values.

Full TEV coverage is even more important for environmental and ecosystem assets and systems for which there are few or no remaining substitutes (Bateman et al., 2002). Furthermore, because the monetary values of direct consumptive use values are more readily observable than most indirect use values, option values, quasi-option values and non-use values, decisions to develop a particular environmental or ecosystem asset, or systems of assets, are often made under partial information regarding the economic value of preservation or conservation. Minerals, oil, gas and timber are marketable goods and their extraction yields benefits immediately in the form of consumptive direct use value. Consumptive direct use values from extractive development are often accorded precedence over the benefits – in the form of non-consumptive use values, option values, quasi-option values and non-use values – that would be derived from protection and conservation. If natural resource management is informed solely by surpluses on the revenue returns from marketable commodities, the policies and regulations instituted are likely to favour resource extraction even though this may be sub-optimal for societal wellbeing. Thus, a full perspective on the TEV of preserving Qld's LEB in its current largely intact state with existing levels of resource extraction (conventional oil and gas) and other economic activity (beef grazing and tourism), land management and cultural heritage protection is critical for policy setting and decision making.

The TEV framework has been applied in many studies to inform conservation and management of environmental or ecosystem assets. Contexts include tropical forests in Malaysia (Nitanan et al., 2020), the Weihe River in China (Cheng et al., 2019), mangrove ecosystem in Sri Lanka (Gunawardena & Rowan, 2005), a national park in Sumatra, Indonesia (van Beukering et al., 2003), soil biodiversity (Pascual et al., 2015), river restoration in Finland (Lehtoranta et al. 2017) and a peninsula in the Guadeloupe archipelago in the Caribbean (Mamingi et al., 2019). Economic evaluations incorporating elements from TEV have also been used within cost benefit analysis to provide a broader societal perspective on the benefits and costs of the coal mining industry on local communities in the Bowen Basin, Central Queensland, compared to alternative land use options of grazing and nature conservation (De Valck et al. 2021). However, whilst TEV elements and framings have been used in these

contexts, to the best of the authors' knowledge, none of them are comparable with the Lake Eyre Basin in terms of global environmental and ecological importance, uniqueness and fragility.

Note that while some people derive benefits from and therefore attach value(s) to multiple component(s) of TEV associated with preservation of particular environmental or ecosystem assets, for others the TEV they associate with preserving those assets in near natural condition may be zero. Importantly, the TEV society ascribes to an environmental or ecosystem asset will change if the values the asset delivers via the different sub-categories of TEV change as a result of environmental degradation or irreversible development.

7. Use and non-use values of Queensland's Lake Eyre Basin

(Côte 2022) synthesised studies on (i) development risks to the ecological values of free flowing rivers in Qld's LEB by an Independent Scientific Expert Panel (Fielder et al. 2019), (ii) scientific knowledge of the potential impacts of shale gas and shale oil extraction (Huddlestone-Holmes et al. 2018), and (iii) the impacts of unconventional gas resource development in the Cooper geological basin on water and the natural environment in the basin (Stage 1, Stage 2 and Stage 3 Bioregional Assessments, Hall et al., 2018; Holland et al., 2020, 2021).

Natural flows across the Qld LEB's floodplains, wetlands and braided rivers in their current, near intact state, support *ecological service functions* which underpin the health and ecological integrity of the river-floodplain network. These ecological and environmental service functions thus support delivery of significant wellbeing benefits via direct and indirect use values and non-use values, as well as option and quasi-option values. Côte's synthesis indicates that further resource development in environmentally and ecologically sensitive areas would impact on environmental and ecosystem assets and the services they provide as summarised in the paragraphs below. These impacts would be detrimental to continuing supply of the suite of use and non-use values currently provided by Qld's LEB in its largely intact, state, with existing levels of resource extraction (conventional oil and gas) and economic activity (beef grazing and tourism). (Impacts of resource development on option values and quasi-option values are considered in the subsection following.)

- *Surface water*: unique hydrological features give rise to complex and unique ecosystems with several large ephemeral terminal and sub-terminal lakes. These ecosystems provide habitats for aquatic species (fish, turtles) and waterbird breeding colonies, support large populations of waterbirds during major floods, and provide breeding habitat and food supplies for large numbers of migratory bird species. The extent and condition of these ecosystems and the ecological service functions they provide to populations of aquatic species and birds (Cheng et al. 2019) are reliant on maintenance of the region's natural flow patterns. Healthy populations of aquatic species and birds generate indirect use value to birdwatching and nature-related tourism, and contribute bequest, altruistic and existence value components of non-use value.

- *Hydrogeology and groundwater*: with the exception of the Cooper Basin, the hydrogeological setting of the Qld LEB is still poorly understood. The Eromanga Basin, one of the three geological sub-basins in the Cooper Creek region, includes a series of aquifers and aquitards that are connected to the Great Artesian Basin (GAB). The groundwater systems within the LEB region encompass several aquifer systems that supply many locally important groundwater-dependent artesian springs and the endemic-rich local ecosystems they support. These aquifers and springs provide watering facilities for cattle and thus contribute a major indirect use value to the cattle grazing industry. The current condition of these groundwater assets, relatively unaffected by anthropogenic impacts and pollution, also underpins organic certification that enables certified producers to access premium pricing for their livestock products. Many towns and regional centres in Qld's LEB rely on suitable quality groundwater resources for their household drinking water supply. This is a valuable direct use value.

- *Protected matters*: Being one of the world's last arid river systems without significant human alterations to flow, the Qld LEB's complex and unique ecosystems are rich in endemic biodiversity including at least three native fish species under threat of extinction (Côte, 2022). Ecosystems such as floodplain swamps are breeding grounds for bird species, many of which are migratory and at least one, the Australian Painted snipe, is considered endangered under the EPBC Act (Côte, 2022). A large number of endangered and threatened species rely on national parks, protected areas and the remaining Great Artesian Basin-dependent artesian springs as natural refuges. The GAB springs within the Qld LEB are home to 98 taxa of flora and fauna species, of which 33 are undescribed species and 44% are narrow endemics where a taxon is found in only one spring complex. The Cooper Basin has protected areas listed under Matters of National Environmental Significance (MNES) (a Ramsar-listed wetland, Coongie Lakes, located across the border in South Australia, in which 26 taxa of plants, reptiles, birds and mammals are listed as threatened) and Matters of State Environmental Significance (MSES) (28 species listed as endangered, near threatened, vulnerable or special least concern; seven nationally important wetlands; high ecological value aquatic ecosystems, and regional ecosystems listed as 'of concern'). The Cooper Basin is also home to many culturally significant species and is estimated to support 68 species protected under state or national legislation. Whilst these species may not all be known to the wider population, it is likely that their uniqueness and local endemism will contribute substantial bequest, altruistic and existence value components of non-use value.

  The extent and condition of these sites will be important to Indigenous Traditional Custodians who care for Country in a reciprocal relationship under customary law (thus receiving a non-consumptive direct use value). Knowing that Country is being cared for will also enhance the well-being of Traditional Custodians, including those who cannot readily access these sites (contributing existence and altruistic components of non-use value). Knowing that knowledge of how to care for Country is

being passed on to future generations will also enhance the well-being of Traditional Custodians (through what would be considered in a Western scientific paradigm to be a bequest value component of non-use value).

- *Cultural heritage*: Traditional Custodians hold special connection to the LEB through their obligations to care for rivers and water places on Country. As explained in a preceding section, the welfare and wellbeing of Traditional Custodians is intrinsically connected to natural river flows and river water quality. Some places within the LEB such as the Pituri Sacred areas, the Bilpa Morea Claypan European heritage area, and the Camooweal Caves hold significant historical and cultural values. Nine Indigenous sites, twelve heritage sites and two recreational areas are listed in the Register of the National Estate. The Consultation Regulatory Impact Statement for the Qld LEB reports that many aspects of the tourism industry in Outback Queensland are dependent on an intact and unspoilt environment with natural water flows through complex river networks connecting scattered waterholes across the landscape. These unique assets thus deliver indirect use values which underpin revenues from tourism and recreation across a significant proportion of inland Queensland, in addition to considerable use and non-use values derived from locations' cultural and historical connections.

Côte (2022) and Fielder et al. (2019) detailed an extensive list of the potential threats to the environmental values of the LEB from expansion oil and gas extraction activities and mining. Notwithstanding these compilations, there remains a lack of knowledge and considerable uncertainty with regard to: (i) the full extent of planned activities for unconventional and conventional oil and gas production and mining, and (ii) impacts of groundwater extraction on grazing, tourism, protected wetlands and waterholes, and protected flora and fauna that rely on natural flow regimes (Côte, 2022; Fielder et al., 2019). As noted above, currently intact natural flows across the Qld LEB's floodplains, wetlands and braided rivers support *ecological service functions* which underpin the health and ecological integrity of the river-floodplain network. This network supports delivery of a suite ecosystem services that provide economic benefits via use and non-use values.

From a TEV perspective, the Consultation RIS (DES 2023) and the synthesis report (Côte 2022) evidence that a wide variety of *use values* and *non-use values* are provided by environmental and ecosystem assets in Qld LEB's in their current, largely intact state, with existing resource extraction (conventional oil and gas) and economic activities (beef grazing and tourism) in operation (Figure 6). The value generated by market-based economic activities can be quantified relatively easily. However, much of the value contributed by non-market services from the Qld LEB's environmental and ecosystem assets has not yet been quantified. Nevertheless, the full suite of values within TEV should be considered in decision making. This report provides a narrative, with literature support, for this purpose.

When viewing Figure 6, note that consumptive and non-consumptive direct use values, and the altruistic and bequest components of non-use value, will typically all have economic activity associated with them. For consumptive and non-consumptive direct use values, this will be economic activity generated by the recipient of the value *themselves* (as these are

'values for self'), whereas a major reason for an individual holding altruistic and bequest components of non-use value will typically be because they gain satisfaction from knowing that the resource or asset concerned is available for *others* to use - either in the current generation (altruistic value) or in future generations (bequest value). Provided that key LEB ecosystem assets (wetlands, floodplains, braided river systems) remain in good condition, they can continue to supply the regulating and supporting ecosytem services (e.g. water quality regulation, flow regulation, nutrient and soil cycling, pollutant assimilation and storage) that underpin the LEB-based economic activity associated with these consumptive and non-consumptive use values, altruistic and bequest values. These include water supply for LEB households and businesses, fodder biomass for organic-certified cattle grazing across the Basin, habitat for flora and fauna that attract tourists and visitors to the LEB, and healthy Country that can be cared for by Traditional Custodians. Healthy ecosystem assets thus contribute indirect use values to a broad range of economic activity in rural towns and regional centres across Qld's LEB.

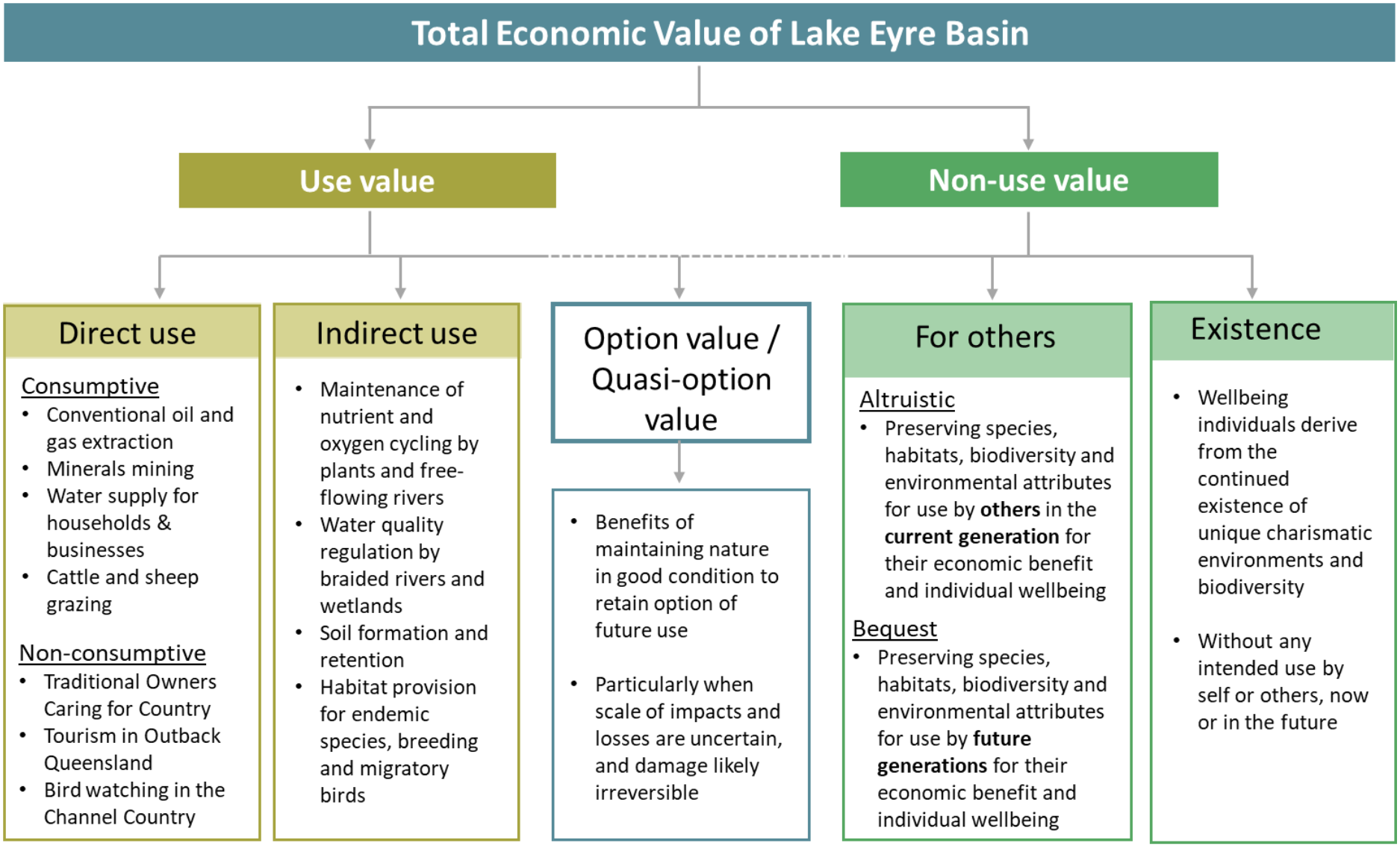
Total Economic Value of Lake Eyre Basin
Use value
Non-use value
Direct use
Consumptive
• Conventional oil and gas extraction
• Minerals mining
• Water supply for households & businesses
• Cattle and sheep grazing
Non-consumptive
• Traditional Owners Caring for Country
• Tourism in Outback Queensland
• Bird watching in the Channel Country
Indirect use
• Maintenance of nutrient and oxygen cycling by plants and free-flowing rivers
• Water quality regulation by braided rivers and wetlands
• Soil formation and retention
• Habitat provision for endemic species, breeding and migratory birds
Option value / Quasi-option value
• Benefits of maintaining nature in good condition to retain option of future use
• Particularly when scale of impacts and losses are uncertain, and damage likely irreversible
For others
Altruistic
• Preserving species, habitats, biodiversity and environmental attributes for use by others in the current generation for their economic benefit and individual wellbeing
Bequest
• Preserving species, habitats, biodiversity and environmental attributes for use by future generations for their economic benefit and individual wellbeing
Existence
• Wellbeing individuals derive from the continued existence of unique charismatic environments and biodiversity
• Without any intended use by self or others, now or in the future

Figure 6 The Total Economic Value framework applied to Queensland's Lake Eyre Basin with existing economic activities in operation. Note that consumptive and non-consumptive direct use values, and the altruistic and bequest components of non-use value, will typically all have economic activity associated with them. For consumptive and non-consumptive direct use values, this will be economic activity generated by the recipient of the value *themselves*, whereas a major reason for an individual holding altruistic and bequest components of non-use value will typically be because they themselves gain satisfaction from knowing that the resource or asset concerned is available for *others* to use - either in the current generation (altruistic value) or in future generations (bequest value). Provided key ecosystem assets remain in good condition, they can continue to supply the regulating and supporting ecosystem services that underpin the economic activity associated with these components of consumptive and non-consumptive use value, altruistic and bequest value. Healthy ecosystem assets thus contribute indirect use values to a broad range of economic activities in Qld's LEB.

8. Quasi-option value and the benefits of avoiding irreversible development in Queensland's Lake Eyre Basin

While several studies have examined the potential impacts of unconventional oil and gas extraction and mining for additional mineral resources on the extent and condition of environmental and ecosystem assets in the Qld LEB, significant knowledge gaps and uncertainties remain. The inter-connected, highly variable and unpredictable nature of the LEB make it a challenging system to study. Consequently, it is difficult to predict the impacts of potential resource developments with high levels of certainty; inevitably, knowledge gaps and uncertainties remain (Côte 2022), particularly regarding:

- the impacts of oil and gas production on protected matters in the LEB;
- the impacts of hydraulic fracturing, chemical contamination, alterations to landscape and surface hydrology on the extent and condition of environmental and ecosystem assets mediated through changes in the quantity and quality of surface and groundwaters in the LEB;
- the impacts of alteration or loss of ecological functions from ecosystem assets which provide habitat and food to support large populations of breeding birds during flow events, and visiting populations of migratory birds – both of which attract visitors and tourists to the LEB region;
- impacts on the condition of cultural heritage sites in the LEB, including sites that are sacred to Traditional Custodians such as waterholes that are important for customary rituals;
- the impacts of disturbances to groundwater levels, water quality and soil regulation on household water supply, agricultural productivity and continuing organic certification of beef production across the LEB.

The Consultation RIS further outlined uncertainties with regard to potential economic profitability of oil and gas extraction from the Qld LEB. These include uncertainties regarding the recoverability of new oil and gas reserves, pipeline capacity and distances to markets, the significant time and resources required to obtain environmental approvals for new developments, demand-side risks from decarbonisation and increasingly intense scrutiny of climate responsibilities in the resource extraction and finance sectors (Task Force on Climate-related Financial Disclosure (TCFD) 2017).

Additionally, Côte (2022, p39-40) highlighted that the links between resource development activities and their *cumulative impacts* on threatened species and ecosystem assets have not been studied in arid environments, and local impacts within the LEB are not known. It was further highlighted that climate change impacts were *not* considered in all reviewed studies, and risks to cultural heritage have not been quantified in the Stage 3 Bioregional Assessments that focused on the Cooper geological basin (Côte 2022).

Furthermore, studies on the impacts of resource extraction activities detailed in Hall et al. (2018), Holland et al. (2020, 2021) and Huddlestone-Holmes et al. (2018) all assumed that adverse impacts should be covered (i.e. adequately managed) by current regulatory frameworks. This contrasts with findings from the Independent Scientific Expert Panel (Fielder

et al. 2019) which suggested that the current regulatory framework would not deliver adequate protection of environmental values (Côte, 2022).

Traeger (2014) builds on earlier work by Mensink and Requate (2005) and Fisher (2000) to show that quasi-option value, as originally proposed by Arrow and Fisher (1974), Henry (1974) and (Hanemann 1989), reports the value of the opportunity for 'learning' that follows from *postponing* development of environmental (or ecosystem) assets when the consequences of development are both irreversible and uncertain. The 'learning' here could arise from improved understandings of the impacts of development and/or the values delivered by retaining the assets in their undeveloped states. Traeger shows that in such situations the value of learning can be sufficient to justify postponing development, even when the expected net present value of development is positive (Traeger 2014; Section 4).

Given Traeger's findings, it is helpful to consider how the particular characteristics of Qld's LEB and the uncertainties surrounding further oil and gas developments in the LEB could affect the value of the learning that could be gained through postponing development.

Drawing on studies by Côte (2022), Fielder et al (2019), Hall et al. (2018), Holland et al. (2020, 2021), and Huddlestone-Holmes et al. (2018), the foregoing sections and paragraphs have established that Qld's LEB in its current state comprises a unique collection of environmental and ecosystem assets of national and global significance which deliver multiple values to human society across the full spectrum of TEV. Prior studies have also established that there are considerable uncertainties surrounding the impacts of further development, and that the risk of irreversible loss is substantial. The likely very substantial full-spectrum TEV delivered by Qld's LEB in its current state, together with very considerably uncertainties surrounding the impacts of further development which could cause irreversible loss, all act to substantially increase the value of the 'learning' that could be gained by postponing further development. The higher this quasi-option value, the more likely that it will be sufficient to outweigh a positive expected net present value from development.

Existing resource extraction in Qld's LEB, operating under current environmental regulations, will continue to generate positive ancillary income and negative externalities. Previous findings on the risks from future conventional and unconventional oil and gas extraction indicates that a risk-aware, precautionary approach to environmental and natural resource management is warranted. A precautionary approach is paramount to ensure long term sustainability of QLD LEB's environmental-social-economic systems.

There a strong case for preserving the environmental and ecological functions and processes supplied by environmental and ecosystem assets in Qld's LEB until we have a better understanding of how the cumulative impacts of oil and gas developments and climate change will affect the suite of use values, non-use values and option values which environmental and ecosystem assets in the region currently deliver to local residents, regional businesses, and Queensland and Australian society more broadly.

Against this backdrop, the Consultation RIS proposed a suite of potential options for amended regulation of high impact activities in the Qld LEB via regulation of the locations at which development activities can be undertaken ('spatial options'), the types of activities than can be conducted under relevant levels of monitoring and oversight ('regulatory options'), and the environmental attributes that must be considered when undertaking environmental assessments at the proposal stage ('options for capturing environmental attributes of river systems').

The Qld LEB regulatory framework (within which existing provisions and proposed amendments sit) seeks to (DES 2023):

- protect the LEB's ecological functions and processes;
- support sustainable economic activities within the LEB whilst also avoiding ecological impacts and harm to people;
- recognise and protect Traditional Custodians' cultural heritage, priorities and aspirations across the LEB;
- deliver equitable distribution of the benefits from economic activities within the LEB;
- support fulfilment of personal, community and societal needs and wellbeing.

The inclusion of ecological, economic development and societal objectives in the regulatory framework indicates a willingness to mobilise public investment to deliver on these objectives. A willingness to commit public investment to protect ecological functions and processes, and recognise and protect Traditional Custodians' cultural heritage, priorities and aspirations implictly recognises the option value and quasi-option value (i.e. value in postponing development to gain the benefits of further 'learning') associated with a precautionary approach towards management of additional oil and gas development in Qld's LEB. Such a precautionary approach would recognise the benefits inherent in delaying an *irreversible* development decision, particularly one impacting environmental and ecosystem assets for which there are effectively no substitutes, when there are uncertainties and incomplete knowledge regarding the consequences.

9. First Nations' Caring for Country in the LEB

Humans interact with their environment differently, much of this may derive from differences in internal and cultural value systems and beliefs. The TEV and the ecosystem services framework is a western science-derived framing, grounded in an anthropocentric instrumental value paradigm within which human - nature interactions are conceptualised as being *transactional* and *linear* (services *from* environment and ecosystems *to* people), and environmental and ecosystem assets are regarded as valuable *because* they supply goods and services to human society (United Nations et al., 2021, Section 6.3.4 and particularly paragraph 6.72 on p137). First Nations have a fundamentally different concept of these interactions and values; frequently, these two paradigms do not neatly align (de Valck et al. 2023). Indigenous Traditional Custodians typically regard interactions with Country as *relational* and *reciprocal,* with the values arising from those reciprocal interactions being

grounded in the fundamental *relationship* between custodians and Country (Comberti et al. 2015; Chan et al. 2016). Traditional Custodians have responsibilities to care for Country in order for Country to continue to contribute benefits to current and future generations (Strang 2000; Scheepers and Jackson 2012; Jackson et al. 2014).

Given our understanding of the ways in which Indigenous peoples conceptualise socio-ecological relations elsewhere in Australia (Jackson and Palmer 2015), we acknowledge that Indigenous perspectives cannot be incorporated into TEV in any straightforward way. Research conducted with Traditional Custodians of Australia's northern savannahs, suggests that the ontological category of 'nature' cannot be taken for granted as a source of ecological stocks and flows; instead, Indigenous Traditional Custodians *co-produce* with Country, and the ecosystem services and associated values flow from that relation (Jackson and Palmer 2015). The concept of co-production recognises that responsibilities under customary law require that custodians care for Country appropriately in order for Country to continue to provide ecosystem services (West et al. 2018; Fletcher et al. 2021). Further research is required to determine whether (or not) this conceptualisation is consistent and appropriate for the First Nations of the LEB.

The SEEA Ecosystem Accounts (United Nations et al. 2021) Table 6.3 description of 'services [that] may underpin people's cultural identity', within the broader category of 'cultural ecosystem services', can potentially accommodate the value (in the sense of an increase in wellbeing) that Traditional Custodians derive from fulfilling their custodial responsibilities by caring for Country. Survey-based research by Larson et al. (2019) with the Ewamian people (Traditional Owners of land in the Gilbert and upper Mitchell catchments in north Queensland) found that "knowing that Country is being looked after" (Larson et al., 2019, p.89) can also be an important source of wellbeing for Indigenous people – *beyond* just those custodians involved on-ground in caring for Country. Thus, subject to discussion with First Nations of the LEB specifically, 'knowing that Country is being cared for' could potentially be viewed as a cultural ecosystem service in its own right – and a source of non-use value to the First Nations of the LEB. The wellbeing that Indigenous people derive from knowing that Country is being cared for can be further enhanced by knowing that Country will *continue* to be cared for into the future. This is evidenced by the importance Traditional Custodians place on passing on knowledge of how to care for Country to younger generations.

Here we recognise the importance of the wellbeing enhancements that follow from Traditional Custodians caring for Country, knowing that Country is being cared for, and knowing that Country will continue to be cared for, and suggest approaches through which these enhancements to wellbeing could be recognised within TEV. However, we caution that our suggestions for which categories of TEV could potentially be used to enumerate these wellbeing enhancements only provide a starting point for further research. The objectification of phenomena (into 'catch' or 'harvest', for example) and the choice of spatial and temporal scales within which wellbeing enhancements are produced through Custodianship of Country will generate forms of knowledge that are contestable (McElwee 2017) and therefore warrant more focused attention, consultation and discussion with First Nations within the Qld LEB.

10. Conclusion

To conclude, Figure 7 summarises the potential – but still uncertain – impacts of future resource development on the environmental and ecological functions supplied by the Qld LEB's environmental and ecosystem assets, and on the sustainability of the region's agricultural and tourism sectors. Figure 7 also indicates how the risks of irreversible damage to environmental and ecosystem assets, uncertainties and incomplete knowledge give rise to quasi-option value. The same figure also indicate the proposed amendments to existing regulation in response to emerging risks and uncertainties from future conventional and unconventional oil and gas extraction.

The foregoing sections have established that considerable uncertainties surround the likely cumulative impacts of future oil and gas extraction in Qld's LEB. When coupled with the impacts of climate change, this increases the risk of irreversible damage to the region's unique suite of environmental and ecosystem assets and the wide range of services and values they deliver to local communities and regional centres. These uncertainties emphasise the importance of option and quasi-option values and warrant a precautionary approach to natural resource management within which decision making needs to be both far sighted and risk aware.

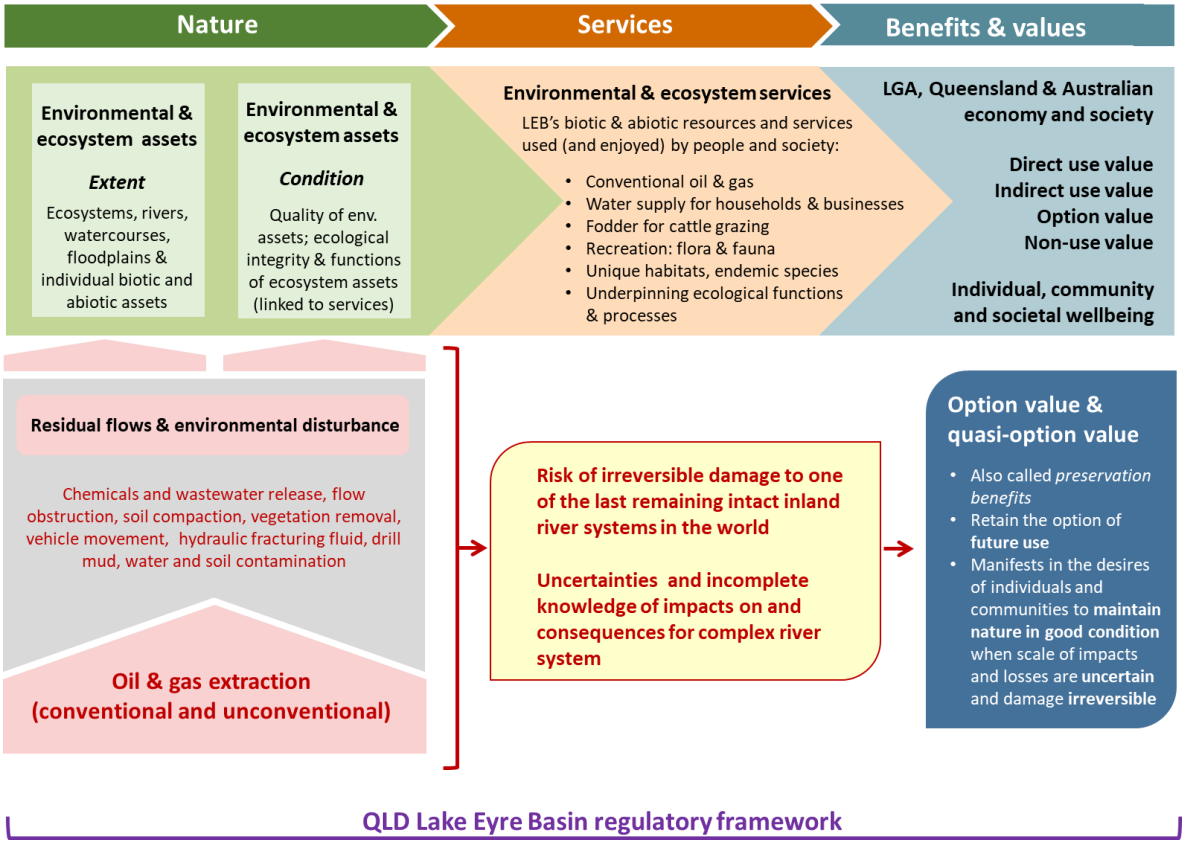

Figure 7 Nature – in the form of environmental and ecosystem assets – supplies services that provide benefits to people. Conventional and unconventional oil and gas extraction generate residual flows and environmental disturbances, which impact both the extent (quantity) and condition (quality) of environmental and ecosystem assets. When the health and integrity of rivers, floodplains and other ecosystems is compromised, delivery of important environmental and ecosystem services to individuals, communities, and society will be impaired; potentially threatening drinking water supplies and reducing agricultural productivity, the wellbeing of Traditional Custodians, recreational value and recreational revenue across the region. The risk of irreversible damage to environmental and ecosystem assets for which there are effectively no substitutes, coupled with uncertainties about the future, cumulative impacts and incomplete knowledge, give rise to people attaching tangible value to retaining the *option* to derive benefits from this unique system into the future. To ensure continued protection of environmental and ecosystem assets of the Lake Eyre Basin, and the wide range of services they supply, a suite of spatial, regulatory and environmental attributes options have been identified and presented in the Consultation Regulatory Impact Statements.

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