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Assessing the Value of Ecosystem Services From an Indigenous Estate: Warddeken Indigenous Protected Area, Australia

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The value of ecological systems to human well-being and the economy is often not estimated in contemporary economic and policy decision making processes. Estimating non-marketable and marketable values of ecosystem services from Indigenous managed land provides significant information about the role that the natural environment plays in maintaining the well-being of people. This research investigates the value of ecosystem services from an Indigenous Protected Area, the Warddeken Indigenous Protected Area—an estate managed by Indigenous people in northern Australia. It provides valuable insights for policy makers, land managers, and future development programs while informing the importance of managing Indigenous lands for the local and wider public benefits. Additionally, applying the Millennium Ecosystem Assessment framework and the standard ecological economic valuation techniques, this study presents 'realistic' values of marketable and non-marketable ecosystem services identified from the Warddeken Indigenous Protected Area. The total value of ecosystem services was estimated at $32.6 million per year, which are largely non-marketable (such as climate and water regulation) and these values flow to the local and wider public. This research further argues that investing in managing Indigenous estates helps in reducing welfare costs for the Australian Government worth, in the case of the Warddeken Indigenous Protected Area, $8 million per year. Overall, the value of ecosystem services and cost savings demonstrate the real benefits that Indigenous people obtain for working on their land, termed as "Country." In addition, Indigenous land management delivers offsite ecological, social, and cultural ecosystem services (value estimated at $29 million per year for the Warddeken Indigenous Protected Area) which are typically ignored in policy decision making regarding Indigenous matters in Australia. This study highlights the importance of land managed by Indigenous people in Australia and worldwide to comprehend the real value of benefits and suggests developing appropriate stewardship arrangements to support people's efforts.

Keywords: Valuing ecosystem services, Warddeken, Arnhem land, Indigenous land, Australian Indigenous people, Indigenous protected area, Managing natural and cultural resources, Millennium ecosystem assessment

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1 INTRODUCTION

Valuing ecosystem services (ES)–the benefits and goods that people obtain from natural systems–is an emerging area of research which informs and provides support to economic and policy decision making processes. This is particularly important for contexts in which natural resources are used and managed by Indigenous people and local communities. Typically, the value of sustainably managing those resources is disregarded in market-based economic modelling primarily due to a lack of tools that help understand those values in a market context (Costanza et al., 1997; Dawson, et al., 2021; Sangha et al., 2019a). Consequently, the value of Indigenous people's efforts towards sustainably managing natural resources are then often ignored in policy decision making (Sangha et al., 2021). Identifying and describing strategies for measuring the value of ES provides the opportunity for Indigenous people's engagement in ES to become visible to contemporary economies and accounted for in economic and policy decision making processes. Indigenous people in Australia are not unique in terms of their experience of colonisation and their contribution to ES, however the circumstances in the Arnhem Land region of northern Australia are exceptional. Traditional land management practices in the region are demonstrably effective in abating greenhouse gas emissions, which is a priority for Australian Government under the Kyoto Protocols. Combine this with a strong and secure land tenure underwritten by colonial legal authorities, and a very particular and important context emerges. Warddeken Land Management Limited (Ltd.) is one organisation that can provide a valuable lens through which to examine Indigenous led and controlled provision of ES.

The Intergovernmental Platform on Biodiversity and ES (IPBES 2019) and the Millennium Ecosystem Assessment Framework (Millennium Ecosystem Assessment 2005) are the key global initiatives that address the understanding of the value of ES for human well-being. These global initiatives proposed integrated frameworks, in collaboration with experts and practitioners from diverse backgrounds. The frameworks help to provide an overview of how different types of ES contribute to various components of human well-being, and identify the drivers and other factors that impact upon ES-human well-being links. Understanding ES-human well-being links is particularly important for Indigenous people as across the globe, countless Indigenous communities sustainably manage their land and deliver a wide range of benefits to broader local and global populations. However, often people's roles are either ignored or underestimated. This study presents an assessment of the total value of ES (marketable and non-marketable) afforded from sustainably managing an Indigenous estate in the Northern Territory (NT), Australia—the Warddeken Indigenous Protected Area (IPA) (**Figure 1**). The Warddeken IPA encompasses a significant proportion of what is locally identified as the Arnhem Land sandstone plateau and associated ecosystems of high conservation value. The results of this study can inform policy decision making about the diverse values that Indigenous people attribute to their ability to actively manage their land and sea estates and the ways in which this management contributes towards the well-being of both local and global communities.

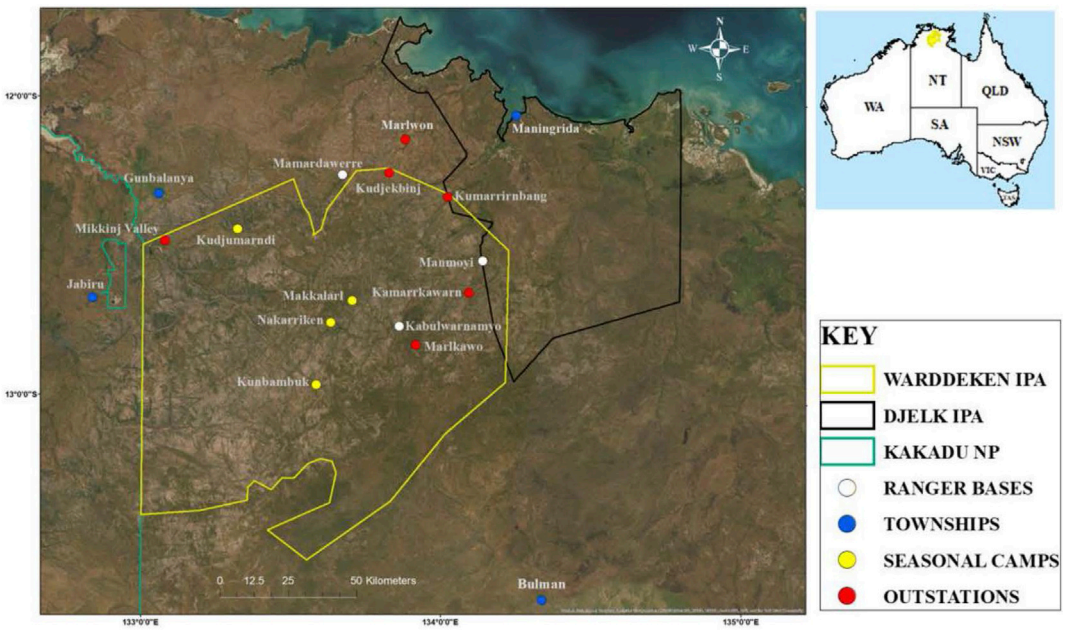

FIGURE 1 | Location of Warddeken IPA in Eastern Arnhem Land, Northern Territory. Spatial data Source: Commonwealth of Australia (2019), (2020a); Department of Infrastructure, Planning and Logistics, NT Government, https://dipl.nt.gov.au/lands-and-planning/building/northern-territory-land-information-systems-ntlis.

The context of Indigenous people in northern Australia is not too dissimilar to the experience of other First Nations populations who are on the periphery of settler-colonial societies. Depopulation of Indigenous people in the Arnhem Land Plateau of Northern Territory (NT) began at the end of the 19th century, due to Western colonization including landscape domination and the establishment of reserves, missions, and government settlements (Garde et al., 2009; Altman et al., 2020). Processes of colonization have generally dispossessed Indigenous people across the Australian continent of their traditional clan estates through war, genocide, and coercion (Smallwood et al., 2021). These colonizing processes were inflicted upon people living in northern Australia, including those in the case study region (Altman et al., 2020).

During the early to mid-20th century, the expansion of larger regional settlements in remote locations of the NT generated movement of people away from their ancestral clan estates that left large tracts of land bereft of human occupation, and significantly diminishing Indigenous cultural management over large tracts of regional and remote land in northern Australia (Altman et al., 2020). Subsequently, the Arnhem Land Plateau (including the Bininj[1] land estates of the Warddeken IPA) has been emptied of sustained human activity for many decades. The consequent reduction of customary burning practices in the Arnhem Land Plateau has meant an increase in large wildfires experienced to date (Yibarbuk et al., 2001; Altman et al., 2020). These large wildfires, in combination with the introduction of feral animals and weeds, had devastating effects on the environment, native species populations and ES (Social Ventures Australia 2016a). In the early 2000's, Indigenous people started to repopulate their clan estates to assert healthier lifestyles, reinvigorate cultural obligations (including visiting sacred sites and allowing the intergenerational transfer of traditional knowledge) and to restart customary forms of land management. This reinvigorating of customary practices is colloquially termed as 'working on Country' in recognition of this work as an obligation to sentient landscapes which own the people rather than the converse (Burgess et al., 2009; Garnett et al., 2009; Warddeken Land Management Ltd. 2017). An increase in wildfires is a relevant and salutary example of the way in which sustained Indigenous Land management practices can provide ES and improve the value of both marketable and non-marketable ES in the region (Sangha et al., 2021). Subsequently, the Warddeken IPA provides a valuable context for focussing upon the analysis of Indigenous people's contribution to contemporary economic and political processes.

Essentially, the socio-economic effects of people being removed from their land estates meant that Indigenous people have limited access to resources (living on other people's land and a foreign socio-culture environment and infrastructure) and very limited real access to develop the skills and knowledge to engage with contemporary economies (Altman et al., 2020). The coercive aggregation of people in regional centres created artificial communities of people in areas where there has then been limited attention to the development of contemporary economic infrastructures and has led to the consequent emergence of an economic underclass. This has locked Indigenous communities into a particular kind of poverty and disengagement with the broader Australian settler societies. In recent years, a range of initiatives that aim to engage Indigenous Australians within contemporary economies have facilitated people to begin to understand the possibilities of engaging with broader Australia from positions of strength. Careful engagement has enabled people to reassert their ownership and stewardship over land in ways that meet Indigenous people's social and cultural obligations and address government and industry policy objectives. One such framework for formalising and supporting Indigenous people's aspirations in re-establishing connections and relation to their traditional estates is the Indigenous Protected Areas (IPAs) Program.

An IPA is defined as an area (land or sea) identified as having high conservation priority (Smyth 2006). Successful partnerships have formed between Indigenous landowners and the Australian Federal Government controlling the administration (applications, agreements, and funding) of IPAs, conservation groups and private agencies (Austin et al., 2018). This success is demonstrated through the declaration of 76 declared IPAs, incorporating up to 44% of Australia's National Reserve System (NRS) as in 2021 (see **Figure 2**). Indigenous custodians and/or communities voluntarily declare their land/sea area to promote and manage biodiversity, and meet cultural resource conservation goals (Hill et al., 2011) with a view to delivering environmental, economic, and social benefits to all Australians (Davies et al., 2013). Through a local, consultative process, Indigenous communities apply to the Australian Government to qualify for the IPA status of their land. The government assesses applications and decides on the viability of the proposals and funds according to budgets submitted by the IPA proponents. In essence, whilst the Indigenous custodians, leaders, and Traditional Owners (TOs) within a community are the proponents of any application for IPA status, funding is controlled by the Australian Government and reporting outcomes rely primarily on measures of employment and other market-based indicators (Social Ventures Australia 2016a).

The IPA Program was first implemented through the conservative Liberal-National Coalition Federal Government in 1997 and remains a Federal Government responsibility to fund and administer (Gilligan 2006; Ross et al., 2009). From July 2018 onwards, the IPA Program is funded and administered through the National Indigenous Australians Agency's (NIAA). In 2015, a total of $14.62 M was invested by the Federal Government to support existing IPAs, and consultation projects for the development of proposed IPAs (Social Ventures Australia 2016b). In the 2017 Budget, the Australian Government committed $1.1 billion for the next phase of the National Landcare Program which included an additional $15 million for consultation and planning to establish new IPAs.

The IPA Program's genesis lies in Australian Government's membership obligations to the United Nations Declaration on the Rights of Indigenous People, the United Nations Convention on Biological Diversity (CBD), and adherence to the International Union for Conservation of Nature (IUCN) Guidelines (Lausche

[1]Bininj is the term used to identify local Indigenous people.

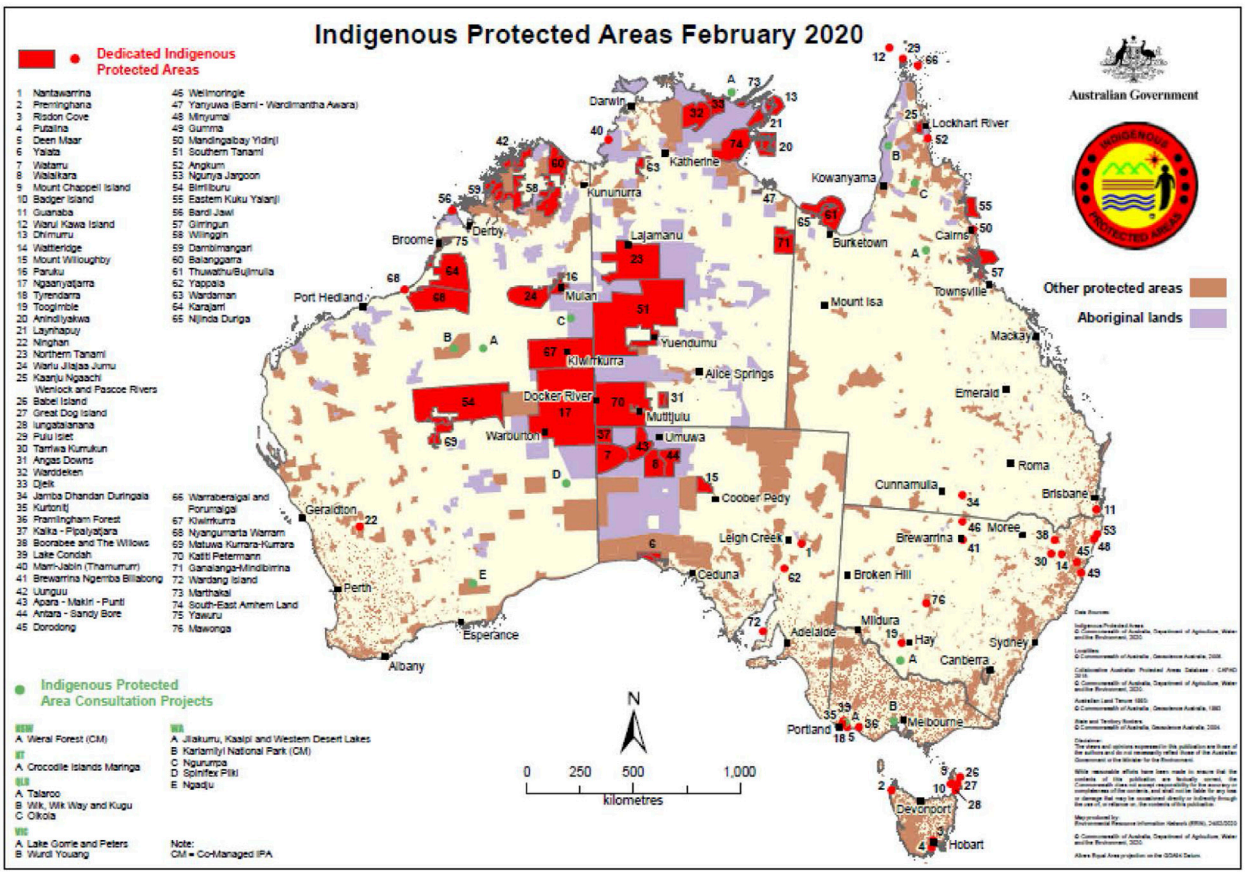

FIGURE 2 | Dedicated IPAs and IPA Consultation Projects. Source: Australian Government National Indigenous Australians Agency, 2021 https://www.niaa.gov.au/sites/default/files/files/ipa-national-map-july-2021.pdf.

TABLE 1 | Main objectives of the National Reserve System and Interim Biogeographic Regionalization for Australia.

	Program Objectives - National Reserve System	Program Objective - interim bioregionalization of Australia
1	Establish an Australian-wide system of protected areas (i.e., national parks and marine reserves) identified with significant biological diversity and ecological sustainability for conservation management	Document a national classification of Australian ecosystems in References to landform, native vegetation and species, and climate
2	Incorporate a comprehensive range of Australian ecosystems for conservation management	
3	Achieve through cooperative arrangement between Australian States and Territories	

Source: (Environment Australia 2000; Gilligan 2006; Smyth and Sutherland 1996; Thackway and Cresswell 1995, Thackway and Cresswell 1997).

2011; International Union for Conservation of Nature and Natural Resources 2012; International Union for Conservation of Nature and Natural Resources 2020). The Program is guided by key legislation at the Federal level, including the Environmental Protection and Biodiversity Conservation Act 1999 (Cth), the Aboriginal Land Rights (NT) Act (1976) (Cth) and the Native Title Act 1993 (Cth). Leading up to the establishment of the IPA Program, the Australian Government established the NRS Program in 1992 and the Interim Biogeographic Regionalization for Australia (IBRA) Program (Department of Agriculture, Water, and the Environment 2020; Bauman and Smyth 2007). The core objectives of the NRS and IBRA Programs are described above in **Table 1**.

IPAs deliver multiple environmental and socio-economic benefits, including healthier fire regimes and improved ecosystems health, and many socio-cultural, educational, economic, and health and well-being benefits. Examples of environmental benefits include a decrease in wildfire frequency and subsequent carbon sequestration, appropriate fire regimes that maximise biodiversity conservation and regular control of weed

infestations. Examples of socio-economic benefits include a growth of employment in local communities, increase access to land, the ability to re-instate cultural practices and sourcing of traditional foods and medicines which promote people's health and well-being (Gilligan 2006; Altman et al., 2007; Burgess et al., 2009; Garnett et al., 2009; Weir et al., 2011; Hill et al., 2013; Barber and Jackson 2017; Austin et al., 2018). IPAs contribute to the preservation of ecological heritage and the conservation of biodiversity, both of which are supported by Indigenous people's engagement with land and sea estates. In addition, IPAs also provide security, opportunity to practice Indigenous socio-cultural governance and employment, along with elevating self-esteem and agency of Indigenous people and communities (Altman et al., 2011). Indigenous management, including customary burning (applying smaller, cool, and early dry season fires in strategic areas) across several IPAs contributes to delivering ES such as regulating climate and water systems, which are typically not valued or measured in current market systems.

The Warddeken IPA in the NT–a case study for this research–is used as an exemplar to demonstrate the diverse range of ES that are delivered from an Indigenous managed estate in northern Australia. The ES provided by Indigenous landowners within the Warddeken IPA are important for local Indigenous communities in terms of provisioning food, water and air, and various cultural benefits–all contributing towards people's health, well-being, and maintenance of cultural obligations. The broader Australian and global populations also benefit from the climate regulating services and biodiversity conservation outcomes that Indigenous ES provide. Notably, the importance of health, education and employment benefits derived from managing IPAs largely remain ignored in public policy decision making to date, a gap that this study addresses.

Assessing the value of ES from IPAs is vital to demonstrate the value of government investment and support the establishment of more IPAs to deliver ES for the benefit of local and wider national and global communities. This study provides such an assessment for the Warddeken IPA, covering an area of 14,000 km^2 in northern Australia. Traditional landowners and managers for the Warddeken IPA have been among the pioneers in reviving and applying customary burning practices (Russell-Smith et al., 2013). Customary burning practices have been demonstrated to reduce nett greenhouse gas (GHG) emissions. These practices are now recognised for their abatement of greenhouse gas (GHG) emissions under the Savanna Burning Methodology (SBM) by the Australia Government (Russell-Smith et al., 2013; Sangha et al., 2021). The Warddeken IPA was central to the first GHG emissions abatement project, West Arnhem Land Fire Abatement (WALFA), that commenced in 2005 (Russell-Smith et al., 2015a). Revival and recognition of Indigenous burning and other land management practices has offered Indigenous people several direct and indirect (environmental, socio-cultural, and economic) benefits for being able to use and develop their skills.

To date, very limited information is available integrating socio-economic and ecological aspects of managing IPAs or other Indigenous lands (Sangha et al., 2019b). The lack of baseline information makes it difficult to illustrate how public investments into IPAs evidence environmental and socio-economic values and benefits (Altman et al., 2011). The only such assessment carried out to date for IPAs (including the Warddeken IPA) was by Social Ventures Australia (2016a) which focused on the social return on investment and omitted ES. This study evaluates the ES for the Warddeken IPA, offering a much broader perspective of government investment in the IPAs then just accounting for social returns. This research estimates the monetary and non-monetary values of ecological and socio-cultural benefits, using various ecological economics valuation techniques. These findings provide an essential first step towards a comprehensive market economic valuation of IPAs which may offer a valuable perspective for governments, policy makers and land managers in the future.

2 METHODOLOGY

To evaluate socio-cultural and ecological values of the Warddeken IPA and to present an integrated picture, a review and analysis of locally available literature was undertaken, including the Annual Reports and the Plan of Management from the Warddeken Land Management Ltd. (WLML) (Warddeken Land Management Ltd. 2010; Warddeken Land Management Ltd. 2014; Warddeken Land Management Ltd. 2015; Warddeken Land Management Ltd. 2016a; Warddeken Land Management Ltd. 2016b; Warddeken Land Management Ltd. 2017; Warddeken Land Management Ltd. 2018; Warddeken Land Management Ltd. 2019; Warddeken Land Management Ltd. 2020). Firstly, a descriptive analysis of social and ecological values of the Warddeken IPA is provided. This is followed by a characterization of the assets that local Indigenous people who are linked culturally to the Warddeken IPA, associate with their land. Their assessment of the health of these assets and consequently, of the well-being benefits that local people derive from living on and managing Country[2] is carried out to effect a measurement of the identified assets' market value. Subsequently, an evaluation of the largely non-marketable ES, applying the Millennium Ecosystem Assessment Framework (Millennium Ecosystem Assessment 2005) and standard ecological economics valuation techniques, was conducted. The details are as follows.

2.1 Social and Ecological Values

To understand the ways value is placed upon landscapes, from a social perspective, a review of publicly available literature (e.g., ecological monitoring and other relevant reports) was undertaken. Assets identified by Indigenous custodians and TOs were primarily chosen for their values in strengthening and maintaining cultural relations to Country and increasing social and emotional well-being. The non-marketable ES quantified in this study include benefits provided by ecosystems (characterized by forests, woodland, heath, and

[2]The term "country" is used to denote "land, waterways, and seas for which [Indigenous Australians] are connected" (Australian Institute of Aboriginal and Torres Strait Islander Studies 2021) and intimately related.

wetlands). These assets were identified primarily for their biodiversity conservation value, but the various perspectives on valuing assets are not necessarily mutually exclusive. Value is assigned differently based on differing epistemic assumptions, but the benefits provided by the assets can overlap. Ecological spatial data (sourced through freely available government data-bases) provided an indication of the extent and complexity of important assets. They were analysed using the Arc GIS (10.4.1) mapping software. Spatial data on ecosystem types was predominantly supplied by the Darwin Centre for Bushfire Research, Charles Darwin University. These datasets were collated and analysed to produce maps of dominant species, and ecosystem types in the Warddeken IPA. Work carried out by Indigenous people in the Warddeken IPA is a complex interaction of local cultural, and broader scientific and political obligations and as such, seeks to manage and increase the value of assets identified by the different stakeholders. The analysis provided here seeks to assign market values for some of these assets based upon the benefits they provide from Indigenous and scientific and conservation perspectives (discussed in **Section 2.3**).

2.2 Well-Being Benefits

The value of well-being benefits that the local Indigenous people derive from the Warddeken IPA, was estimated by applying the cost savings and travel cost approach (following Sangha et al., 2019a; Sangha et al., 2021). The range of well-being benefits vary from employment on Country, self-esteem, building identity, learning language and culture and ability to practice traditional knowledge. To estimate their value, we used a substitute method as explained below (for further details see **Supplementary Appendix SAI**).

Currently, to enhance the well-being of Indigenous people, the Australian Government spends AUD $44,886/person per year across six different welfare sectors, each with several sub-sectors (Steering Committee for the Review of Government Service Provision 2017). In this study, three of six sectors (economic participation, healthy lives, and early childhood development) and one sub-sector (community support and welfare) within the safe and supportive communities' sector are considered to identify the potential Indigenous expenditure cost-savings for the Australian Government. The calculation of the above data assumes that people derive an equivalent benefit from being on Country as they do from government fiscal welfare expenditure (Sangha et al., 2017; 2019b). These cost-savings represent the market value of well-being benefits and identify how Federal Government expenditure on the management of the Warddeken IPA is offset to a significant extent by savings in welfare payments to employ land managers and savings on other expenditure due to improved health and well-being.

To calculate the total cost savings on Government welfare expenditure, the per head expenditure (for each sector, $/yr) was multiplied by the number of people of eligible workforce (i.e., people aged between 15 and 64 years, as defined by the Organisation for Economic Co-operation and Development (OECD 2021). The total cost-savings were estimated for an eligible workforce of 326 people (Australian Bureau of Statistics 2016). In addition, culture-related well-being benefits were estimated based on the Culture Camp Program (Warddeken Land Management Ltd. 2014; Warddeken Land Management Ltd. 2015; Warddeken Land Management Ltd. 2016a; Warddeken Land Management Ltd. 2016b; Warddeken Land Management Ltd. 2017; Warddeken Land Management Ltd. 2018; Warddeken Land Management Ltd. 2019; Warddeken Land Management Ltd. 2020) (see **Supplementary Appendix SAII**). Generally, Culture Camps are structured activities where Indigenous people visit and camp for extended periods on less visited areas within their land estates (often outside of towns and local communities). These activities are an opportunity for the Indigenous Elders to perform cultural obligations on their land estates and educate the younger generation about culture, language, and the environment.

Other Cultural ES include fire drives, on-Country learning, and the Bush Walking Program. Fire drives can be defined as communal activities carried out with the use of fire to herd game in the direction of waiting hunters–it is both an exercise in food provisioning and performing cultural obligations associated with the land and neighbouring clan groups. Provisioning ES (such as the collection and use of food, medicine and arts, and craft materials) are identified in the WLML publications (Warddeken Land Management Ltd. 2010; Warddeken Land Management Ltd. 2014; Warddeken Land Management Ltd. 2015; Warddeken Land Management Ltd. 2016a; Warddeken Land Management Ltd. 2016b; Warddeken Land Management Ltd. 2017; Warddeken Land Management Ltd. 2018; Warddeken Land Management Ltd. 2019; Warddeken Land Management Ltd. 2020) however measurement of expenditure on these ES are difficult to isolate from general, day-to-day work program expenses. The Culture Camp Program ES is used as the example of the simple travel-cost method applied in this study because of access to readily available public data.

On average, 1-3 cultural camps were organised each year across the Warddeken IPA. Whilst people travelled from a range of other locations, calculations on the travel from the ranger base outstations of Kabulwarnamyo and Manmoyi were applied. The distance travelled to and from the two ranger bases and the culture camp locations was then used to estimate the total cost, applying average fuel prices. These cultural camps are highly significant for the local communities for affording cultural learning, social cohesion, good health, and many other well-being benefits.

2.3 Non-marketable and Marketable (Greenhouse Gas Emission Abatement) Ecosystem Services (Goods and Services)

2.3.1 Non-marketable Ecosystem Services

The standard Basic Value Transfer (BVT) approach was applied to assess the value of ES as a bundle. These ES include a range of regulating and supporting ES such as water and climate regulation, biodiversity protection, and gene pool, for which none of the typical market measures exist (following Costanza et al., 1997; de Groot et al., 2012; Sangha et al., 2017; Sangha et al., 2021). Acknowledging the drawbacks of BVT approach (as highlighted by Brander 2013), the relevant values for ES listed

TABLE 2 | Ward and Clan/Estate in the Warddeken IPA.

WARD	CLAN/ESTATE
Kakbi (Northern Clans)	Wardjdjak (Maburrinj); Ngalngbali (Kudjekbinj); Yurlhmanj (Djalbangurrk); Madjuwarr (Kunukdi); Marrirn (Kumarrirnbang); Wurrik (Mandedjkadjang); Mayirrkulidj (Durlka); Durlmangkarr (Kudjaborrng/Kunburray); Djok (Ngolwarr); Barrbinj (Kumarrinbang/Kudjaldordo)
Karrikad (Western Clans)	Manilakarr Urningangk (Mikkinj); Maddalk (Kumalabukka); Wardjdjak/Worrkorl (Balmana from Kundjikurdubuk); Bolmo (Djedjrungi and Dordokiyu); Badmardi (Balawurru, [succession/caretaking]); Wurnkomoku (Nawoberr); Danek (Kudjumarndi)
Walem (Southern Clans)	Djorrorlom (Bamo); Murruba (Morre); Karnbirr (Djohmi); Mimbilawuy (Karlngarr); Barabba (Mimbrung); Mandjuwarlwarl (Bobbolinjmarr); Bolmo (Marlkawo); Barradj (Yanjkobarnem); Buluwunwun (Walangandjang); Bulumo (Makkebowan)
Koyek (Eastern Clans)	Bordoh (Norlkwarre); Mok/Berdberd (Ankung Djang/Ngalkombarli); Yamarr (Kidbulmaniyimarra); Kulmarru (Kubumi); Rol (Bolkngok); Djordi/Dorrorlom (Kodwalewale); Wurrbarn (Nabrang); Warridjngu (Boburrk)

Source: Warddeken Land Management Ltd (2020:20).

in global study by de Groot et al. (2012), and local values from a regional study by Sangha et al. (2017) were applied. Data from Sangha et al. (2017) was particularly useful for offering local information, which is directly applicable to maintain the continuous flow of ES in the Warddeken IPA. ES value for tropical rainforests was derived as a mean value from Blackwell (2006) and Curtis (2004), and adjusted for 2020 values. Stepwise details are listed in **Supplementary Appendix SAI**.

2.3.2 Marketable Ecosystem Services: Greenhouse Gas Emissions Abatement

Fire management on Warddeken IPA delivers significant economic returns which are of direct market value. With the commencement of SBM in 2013, the Australian Government, under the Clean Energy Program, established protocols to measure the abatement of GHG emissions. Australian Carbon Credit Units (ACCUs) are used to measure GHG abatement from Indigenous fire management in northern Australia (details in Russell-Smith et al., 2013).

The value of ACCUs earned from applying fine-scale fire management practices in the Warddeken IPA was estimated using the average number of ACCUs earned over the last five financial years (see The Clean Energy Regulator 2021) and the average carbon price available from the Emissions Reduction Fund (ERF), i.e. $15.74 (following http://www.cleanenergyregulator.gov.au/ERF/Pages/Auctions%20results/September%202020/Auction-September-2020.aspx). Stepwise details are listed in **Supplementary Appendix SAI**. All values are expressed in AUD unless stated otherwise.

3 RESULTS

This section firstly describes social and ecological values, and well-being benefits that Bininj derive from living in and managing the Warddeken IPA. Secondly, it explains the non-marketable and marketable ES values that ensue from Indigenous management of the Warddeken IPA.

3.1 Social and Ecological Values

Traditional Owners from >30 different clan groups have socio-cultural, political associations and responsibilities for specific areas within the Warddeken IPA (see above **Table 2**), covering a total area of 1.4 million ha (Social Ventures Australia 2016b; Warddeken Land Management Ltd. 2020). Local Bininj reside in six remote outstation[3] communities: Kabulwarnamyo, Manmoyi, Kamarrkawarn, Marlkawo, Kumarrirnbang and Kudjekbinj, within the IPA, and some outstations on neighbouring land estates outside the IPA (**Figure 1**). There are also several outstation camp sites within the Warddeken IPA which are often accessed by TOs to conduct ceremonies and cultural activities on a temporary or semi-permanent basis (**Figure 1**).

TOs within the Warddeken IPA have identified and assessed eleven significant socio-cultural assets embedded within the landscape (**Table 3**). These assets outline the important ecological and physical foundations of people's relationship to Country, and the economic, social, and cultural well-being values that support people to reside within their customary clan estates (Warddeken Land Management Ltd. 2016a). This demonstrates something of the way that Bininj knowledge places people as inextricably intertwined with the landscape and their interpretation of assets lies outside the conventional western mainstream idea of significant assets. TOs have also identified and ranked nine different threats that impact on the health status of the eleven significant assets (**Table 4**).

Bininj knowledge and languages is identified as a significant asset and was accorded a FAIR health status (**Table 3**), which means more work is required to improve the health of this asset. There are, for example, more than 300 Indigenous language terms for ecological zones and landforms in the Arnhem Land Plateau knowledge recording program (Garde et al., 2009). Each clan estate covers countless places (such as campsites, hunting ground and waterfalls) that have specific names and associated stories signifying an integral body of Bininj knowledge and languages (Warddeken Land Management Ltd. 2018). Loss of Bininj knowledge and languages was recognised as a threat of VERY HIGH rank (**Table 4**). TOs prioritised and monitored current work actions for the maintenance and/or improvement of asset health

[3]Outstations are small villages or family-based communities that accommodate families on ancestral lands. An outstation can consist of accommodation for one family group or several related family groups and populations may reach 100 individuals at times when travel is easier.

TABLE 3 | Significant assets and asset health indicators for the Warddeken Indigenous Protected Area.

NO.	Significant Assets	Health Status
1	Bininj Knowledge and Languages (Kunmayali Dja Kunwok)	FAIR (more work required to improve the asset)
2	Sacred Sites (Djang)	FAIR
3	Rock Art (Kunwarddebim)	FAIR
4	Fire (Manwurrk)	GOOD (reasonable)
5	Animals (Mayh)	POOR
6	Food and Medicine Plants (Manme Dja Manrakel)	GOOD
7	Freshwater Places (Kukku)	FAIR
8	Allosyncarpia Forests (Anbinik	FAIR
9	Arnhem Sandstone Shrublands (Kundulk Andjuhdjumbung Kukorlh)	TO BE DETERMINED (not clear yet)
10	Governance	GOOD
11	Communities and Livelihoods	FAIR

Source: Warddeken Land Management Ltd (2016a:11).

TABLE 4 | Warddeken Indigenous Protected Area: Main Threats and Threat Ranking.

NO.	Main Threats	Threat Ranking
1	Empty Country	VERY HIGH
2	Bininj Knowledge and Languages (Kunmayali Dja Kunwok)	VERY HIGH
3	Support for Outstations	VERY HIGH
4	Feral Animals–Cats and Cane Toads	VERY HIGH
5	Feral Animals–Buffalos and Pigs	HIGH
6	Wildfires	HIGH
7	Capacity of Warddeken	MEDIUM
8	Saltwater Crocodiles	MEDIUM
9	Weeds	LOW

Source: Warddeken Land Management Ltd (2016a:81).

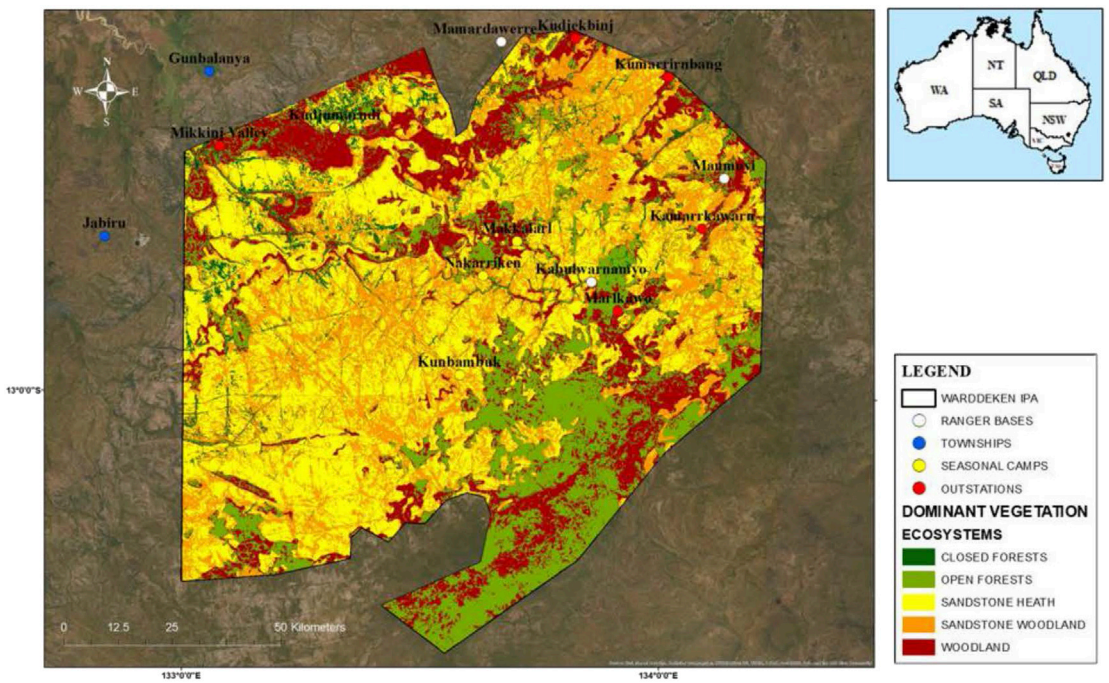

FIGURE 3 | Dominant vegetation ecosystems in the Warddeken IPA. Spatial data Source: Commonwealth of Australia (2020a); Department of Infrastructure, Planning and Logistics, NT Government, https://dipl.nt.gov.au/lands-and-planning/building/northern-territory-land-information-systems-ntlis; Edwards and Russell-Smith (2009).

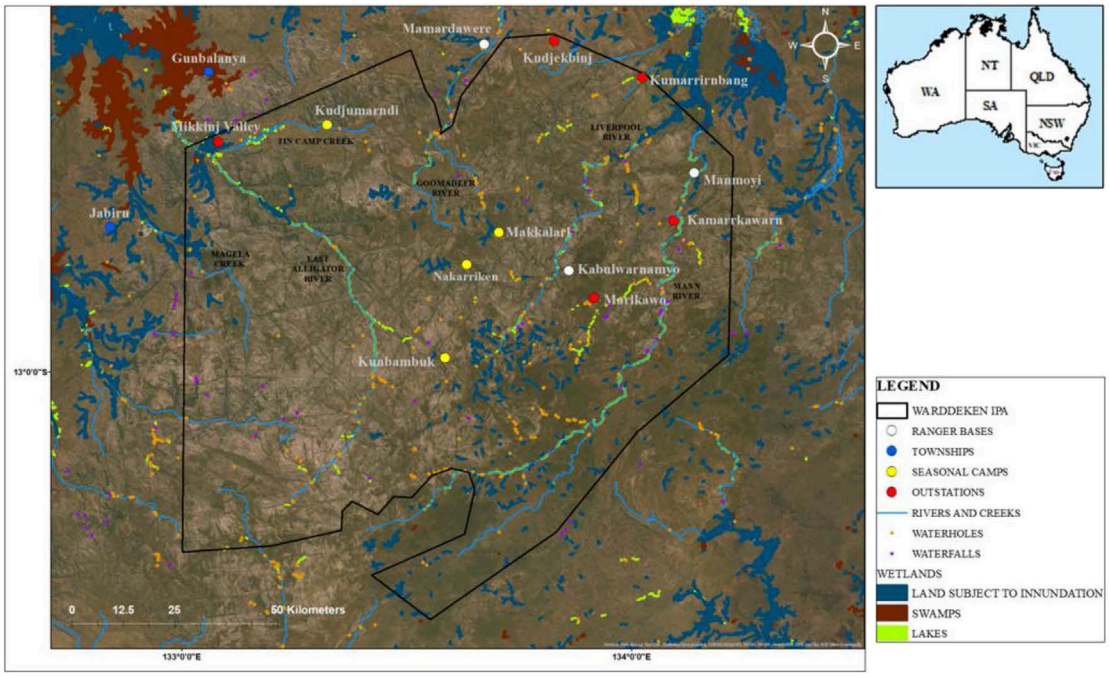

FIGURE 4 | Location of Waterbodies in the Warddeken IPA and Surroundings. Spatial data Source: Commonwealth of Australia (2020a); Department of Infrastructure, Planning and Logistics, NT Government, https://dipl.nt.gov.au/lands-and-planning/building/northern-territory-land-information-systems-ntlis.

over the 2016–2020 Plan of Management period (Warddeken Land Management Ltd. 2016a). This was to ensure that Bininj knowledge and languages are being actively passed on to future generations. Recording knowledge and intergenerational transfer are two methods of sustaining the health of Indigenous knowledges within the Warddeken IPA. Several projects (such as the Place Names; Species Recovery; Kabuwarddebim (Rock Art); Language; and Bush Foods and Medicine Project) have all performed to support the documentation (and preservation) of Bininj knowledge and languages, and its intergenerational transfer.

Ecological assets and the values they are accorded are usually founded in very different epistemic assumptions, but the cultural work done to maintain knowledge and culture almost invariably aligns with scientific understandings of ecosystems and biodiversity conservation. Fulfilling obligation and relation to Country tends, for the most part, to promote conservation practices, and scientific conservation practice supports and facilitates Indigenous-led management of land and the continuance of cultural obligation. Whilst originating from different knowledge practice, the long association and relation between Indigenous land managers and scientists has ensured that the narratives intertwine. Where the foregrounding of one occurs, the other is not far away. Ecological assets and the description of them in scientific terms, reinforces an understanding of the social and cultural values that are inherent within ecosystems and the converse is also usually the case.

The dominant ecosystems in the Warddeken IPA comprise of closed forests, open forests, sandstone health and sandstone woodlands (See above **Figure 3**). Vegetation within these ecosystems is complex and include Eucalypt-dominated woodlands, *Corymbia*, fire-sensitive *Callitris intratropica*, *Allosyncarpia ternata*, and other species in the sparsely populated heathlands, shrublands and hummock grasslands (Russell-Smith et al., 1998). The diverse flora and fauna species in the IPA ensure the supply of food, medicine, arts and crafts and other materials that contribute towards the well-being of local communities (Warddeken Land Management Ltd. 2016a; Warddeken Land Management Ltd. 2020). In addition, the IPA supports a range of freshwater places including springs, wetlands and billabongs, and river systems, offering fish, water chestnuts, turtles, waterlilies, and various medicine plants (Warddeken Land Management Ltd. 2016a; Warddeken Land Management Ltd. 2020) (see above **Figure 4**). The seasonally inundated freshwater wetlands in the IPA are refuges for *Pandanus spiralis* and *Melaleuca* plant species and often include a sedge and herb ground layer surrounded by *Grevillea spp.* or *Banksia spp.* (Edwards and Russell-Smith 2009; Ens et al., 2010). The sandstone outliers located around wetlands in the Warddeken IPA hold significant cultural values with extensive rock art sites, ancient camping places and Indigenous artefacts; some dated up to 50,000 years in age (Chaloupka 1993).

From a conservation perspective, the Arnhem Sandstone Shrublands Complex covers 39,500 km^2 (see below **Figure 5**) and is recognized as endangered ecological community under the Environment Protection Biodiversity Conservation Act 1999 (Cth). The Warddeken IPA manages a quarter (i.e., 10,760 km^2) of that total area of this ecological community (**Figure 5**). The Arnhem Sandstone Shrubland Complex is recognised globally for its cultural and natural values, diversity of endemic and threatened species, including *Allosyncarpia ternata* (Anbinik)

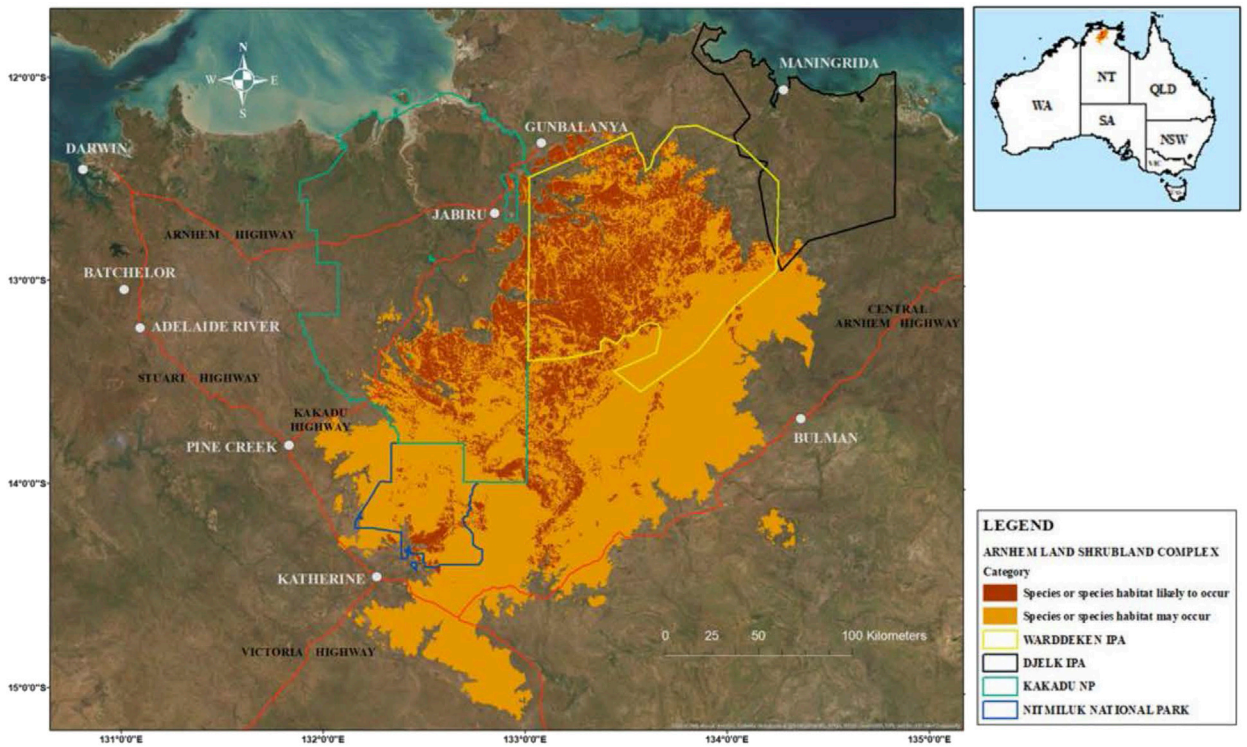

FIGURE 5 | Arnhem Shrubland Complex Ecological Community, NT. Spatial data Source: Commonwealth of Australia (2019), (2020a), (2020b); Department of Infrastructure, Planning and Logistics, NT Government, https://dipl.nt.gov.au/lands-and-planning/building/northern-territory-land-information-systems-ntlis.

TABLE 5 | Well-being benefits estimated from government cost-savings for eligible workforce in the Warddeken Indigenous Protected Area.

Total number of people as eligible workforce (15–64 Years.)	Indigenous welfare sectors Benefiting from people working on-country	Total value (AUD in 2020)
326	1. Safe & Supportive Communities: Community Support & Welfare	2,034,566
326	2. Economic Participation	2,720,144
326	3. Healthy Lives	3,099,934
326	4. Early Childhood Development	133,986
TOTAL AMOUNT OF COST SAVINGS		$7,988,630
SOCIO-CULTURAL BENEFITS	Cultural Camps–Management of Country and intergenerational knowledge transfer	54,896
TOTAL BENEFITS (AUD/YR)		$8,043,526

forests, a key species of conservation significance, and freshwater places. Indigenous management plays a vital role in maintaining this community (Warddeken Land Management Ltd. 2020). *Allosyncarpia* and *Melaleuca* forests are significant ecological communities in the north-west of the Warddeken IPA. *Allosyncarpia* tend to dominate closed forest ecosystems and occurs in a range of sandstone-derived substrates, including gorges, moist gullies, and slopes, and is restricted to Arnhem Land, NT (Bowman, 1991; Freeman et al., 2017). Anbinik plant species are fire-sensitive, evergreen relictual trees, that grow slowly, to a large size and hold a special place among the local Indigenous people (Prior et al., 2007). These trees are respected by TOs as places where people seek shelter from the heat and rain. The remnant forest sites are also sources of food–often described as "bush tucker" (Warddeken Land Management Ltd. 2016b; Warddeken Land Management Ltd. 2017; Warddeken Land Management Ltd. 2018). Most importantly, the Anbinik and other ecological communities require consistent fire management to continue performing various landscape functions and services.

3.2 Well-Being Benefits

The Warddeken IPA offers a range of services including the opportunity for paid on-Country employment as Rangers. Rangers fulfil responsibilities for land and fire management, support the collection of bush foods and traditional medicines,

TABLE 6 | Non-Marketable and Marketable ES Values for Warddeken IPA.

Ecosystem Based Values	Area (KM)	Unit value (AUD) in 2020	Total value
NON-MARKETABLE ECOSYSTEM SERVICES: Applying BVT method using regional-relevant values from Australian Studies–TEEB Database (de Groot et al., 2012)			
FOREST	3176	5697	18,093,672
WOODLANDS	6228	1227	7,641,756
HEALTH	4265	614	2,618,710
WETLANDS	203	2847	577,941
Total Area	13,872		
Non-marketable ES Total Value			$28,932,079
MARKETABLE ECOSYSTEM SERVICES: Greenhouse Gas Emissions (Carbon) Abatement			
Marketable ES Total Value			$3,668,600
NON-MARKETABLE and Marketable ES TOTAL VALUE			$32,600,679

and the maintenance of communities and cultural sites which directly contribute to Indigenous people's well-being (Social Ventures Australia, 2016a).

The work of Indigenous rangers in the Warddeken IPA is at the interface between the socio-cultural and ecological systems. They function to bridge the gap between social systems important for TOs and the value placed on ecological systems assigned by western science. Rangers support the TO's vision to protect and reduce the threats to cultural and environmental assets decrease the threats to biodiversity, improve conservation values and ensure ecological sustainability (**Tables 3** and **4**). Ranger work in the Warddeken IPA also provides positive outcomes for the Australian Government, including the reduction in income support payments, partnership model promotion, increased respect for customary knowledge systems and reduced costs of land management (Social Ventures Australia, 2016a).

The value of well-being benefits for the eligible workforce (326 people) who are residing in communities within the IPA, was estimated at ~$7.9 million per year (see above **Table 5**). A fundamental well-being strategy implemented by the WLML is the conduct of on-Country cultural events, such as cultural camps, bushwalks and fire drives (Warddeken Land Management Ltd. 2016a). A conservative estimation of the value of cultural camps as contributors towards knowledge maintenance and intergenerational knowledge transfer is assessed at ~$55,000 per annum (**Table 5**). The total value of well-being benefits was therefore assessed at $8 million per year (**Table 5**). This could be a much greater amount if other cultural events were similarly assessed, including the work of TOs and other related clan members who regularly visit and work on the Warddeken IPA. In addition, the IPA offers multiple, ongoing, non-monetary well-being benefits for people residing within and around the Warddeken IPA. For example, Rangers and TOs work together on managing cultural heritage within their respective clan estates and teaching the younger Bininj generation about culture and Country (Social Ventures Australia 2016a).

Another fundamental socio-cultural well-being strategy for the Warddeken IPA is bushwalking along customary routes, referred to as Bininj manbolh, in the Arnhem Land Plateau. Bininj manbolh offers great opportunity for TOs to re-engage with Country and strengthen the Elders' capacity to teach Bininj knowledge and languages to the younger generations. Names of places, ancestral creation beings, cultural associations of place to clan estates, rock art images, painting and stories associated with rock art galleries are important components of the knowledge transfer that occurs during Bininj manbolh (Warddeken Land Management Ltd. 2016a). WLML Chairman Dean Yibarbuk noted in the Warddeken Land Management Ltd. (2015:16) that Bininj Manbolh:

For our young people it's all about being on country. walking the paths of the Old People and learning how to talk to the spirits and ancestors who dwell there. This is the way to develop a good feeling for country and it's the feeling for our land that makes us strong in our cultural identity.

The economic value of these bushwalks has not been estimated in this study due to a limited amount of publicly available information relating to location, duration, and attendance.

3.3 Ecosystem Services Values

The ES from the Warddeken IPA include provisioning services (such as bush tucker, bush medicines and arts and craft materials); regulating services such as carbon abatement (climate regulation), protection and diversity of fauna and flora, freshwater regulation (wetlands and billabongs); and cultural services (such as inter-generational knowledge exchange, on-Country learning, cultural camps and bushwalks). The socio-cultural values are presented in terms of well-being benefits in the previous section. This section focuses on regulating services that the Warddeken IPA delivers to the local, regional, and global communities.

3.3.1 Non-marketable Ecosystem Services

The total value of non-marketable ES was estimated by applying the BVT technique, at $28.9 million per year (see above **Table 6**). Forest and woodlands ecosystem types of support most of the ES, hence reflecting $18 million per year and $7.6 million per year worth of ES to the local, regional, and global communities (**Table 6**).

3.3.2 Marketable Ecosystem (Greenhouse Gas Emissions Abatement)

Since GHG emissions abatement under the Australian Government's SBM is currently traded in the market as the Australian Carbon Credit Units, the average market value of emissions abatement was calculated at $3.6 million per year (**Table 6**). Overall, the total value of marketable and non-marketable ES from the Warddeken IPA was estimated at $32.6 million per year.

4 DISCUSSION

This study provides a detailed, first of its kind, assessment of integrated socio-cultural and ecological benefits derived from the establishment and management of IPAs in Australia. Government policy-making processes generally require hard evidence to justify resourcing decisions. In the context of IPAs, the socio-cultural and economic benefits from IPAs, are estimated in this study for the Warddeken IPA at $32.6 million/yr. This result has the potential to inform decision-making related on the distribution and direction of public funding. Australian Government Indigenous well-being strategies, including the National Agreement on Closing the Gap (Commonwealth of Australia 2021), which is in part an attempt to redress violations of Indigenous autonomy and sovereignty in the past, have the potential to be shaped by the measures of economic outcomes demonstrated in this research. Valuing both marketable and non-marketable ES that result from facilitating Indigenous people to manage land in ways consonant with customary values helps in reducing welfare expenditure for the Australian Government. A corresponding increase investment in IPAs would support both an increase in biodiversity conservation and well-being outcomes. This study provides the evidence of economic and well-being benefits which usually flow outside the conventional market (Millennium Ecosystem Assessment 2005; Sangha et al., 2019b), being worth $8 million per annum for the Warddeken IPA. Calculating the contribution of natural resources in terms of their ES benefits offers new insights into the better use and management of natural resources to inform public policy across different sectors such as education, health, and environment management (Sangha et al., 2019b). This kind of assessment may assist decision-makers to integrate the importance of land management into various public health, education, and well-being measures.

The local Bininj socio-cultural and ecological practices are integrated well in the Warddeken IPA Plan of Management. They function to protect environmental and cultural assets and to reduce threats to these assets (Warddeken Land Management Ltd. 2016a). Strategies to reduce asset threats include customary fire management practices—applying cool, patchy, small burns early in the dry season, feral animal and weed control to manage the Country in culturally appropriate ways (Russell-Smith et al., 2013; Altman et al., 2020). This fine-scale management over the past decade has contributed to the provisioning of bush foods, bush medicines and other cultural heritage resources for local people, and cultural learning camps have ensured inter-generational transfer of traditions and practices as shown in the WLML (Warddeken Land Management Ltd. 2014; Warddeken Land Management Ltd. 2015; Warddeken Land Management Ltd. 2016b; Warddeken Land Management Ltd. 2017; Warddeken Land Management Ltd. 2018; Warddeken Land Management Ltd. 2019; Warddeken Land Management Ltd. 2020)–see also **Supplementary Appendix SAII**.

The reinvigoration of customary fire management provides an example of how change can provide well-being spin offs for Bininj and other Australians. TOs and their families in the Warddeken IPA are better off and Indigenous Australians elsewhere look to the work in the Warddeken IPA for inspiration and an example of successful management practice that fulfils both Bininj and broader socio-political and conservation imperatives. More broadly, all Australians benefit from landscapes that are managed in a way that maximises biodiversity conservation and contribute to national aims and international obligations for biodiversity conservation. Indigenous land management is central to, and directly correlated with the well-being of Bininj, but the benefits of the ES they provide extend globally. Efforts towards successful maintenance and conservation of biodiversity have long term impacts on social, cultural, and economic systems and processes.

This research has developed and tested an approach for measuring the economic value of ES services provided through the Warddeken IPA, applying the MA conceptual framework. For ES values estimation, the BVT method was followed using regional-relevant values from the Australian studies listed in TEEB database (following Sangha et al., 2017).

The WLML, through supporting TOs and ranger work, maintains the flow of ecosystems values in the Warddeken IPA. These values translate to supporting health and well-being of people and protecting the environment. An estimated well-being cost saving of $7.9 million per year (**Table 5**) for the Australian Government reflects a wide range of socio-economic well-being benefits that local people derive from working on Country (Burgess et al., 2005; Burgess et al., 2009; Garnett et al., 2009; May 2010; Altman et al., 2011; Weir et al., 2011; Russell-Smith et al., 2015b).

However, the total value of ES estimated from the Warddeken IPA was much greater, i.e., $32.6 million per year. This amount suggests the importance of the management of the Warddeken IPA to continue the flow of ES which contribute towards the well-being of local, as well as regional populations (**Tables 5**, **6**). To date, the only marketable ES is the abatement of GHG emissions and related ACCUs, that directly generates income worth $3.6 million per year (**Table 6**). This carbon market-based abatement further supports multiple community outcomes such as meeting cultural responsibility for the landscape, local employment, cultural camps, on-Country learning activities and inter-generational transfer of knowledge by Elders (Russell-Smith et al., 2015b; Sangha et al., 2017; Sangha and Russell-Smith, 2017).

Importantly, the Australian Government's IPA Program contributes towards fulfilling Australia's commitments under national land rights and environmental legislation (and ensuing policies), and its member ratification of international

human rights and environmental conventions (Ross et al. 2009; Bauman et al., 2013). Without the IPA Program, there would be significant gaps in Australia's NRS which would make it difficult for the government to meet international biodiversity conservation obligations (Austin et al., 2018). The approach to the establishment of the IPA Program illustrates respect for the rights and responsibility of Indigenous people to control their customary estates and associated resources, and their active decision-making about engaging in conservation partnerships (Smyth and Sutherland 1996; Szabo and Smyth 2003; Ross et al., 2009; Bauman et al., 2013; Austin et al., 2018). The IPA Program has the potential to contribute significantly towards several crucial socio-cultural and environmental processes (Social Ventures Australia 2016b). Firstly, IPAs contribute to conserving biodiversity in Australia's National Reserve System. Secondly, IPAs provide an avenue for the engagement of Indigenous people in appropriate forms of employment. Thirdly, IPAs strengthen and maintain Indigenous cultural connections to customary clan estates with co-benefits of positively contributing toward well-being, socio-cultural and economic outcomes. Fourthly, IPAs empower and sustain the vision and economic independence of Indigenous people. Understanding the real and diverse values attributed to IPAs may facilitate the establishment of more IPAs in the future, enabling Indigenous people's increased agency in the management of their Country.

Although the global TEEB valuation database provides a general unit value for specific ecosystems principally based upon studies outside of Australia (Sangha et al., 2017), the paucity of research to value ES more locally in Australia has necessitated the use of this database. Given the significant differences in land use internationally and locally, and the differing relation between people and the values they derive from land in tropical north Australia, the TEEB ES values potentially underestimated ES values in the Warddeken context. Valuations using TEEB database in remote Indigenous communities have some methodological limitations. Principally, TEEB database classifies case study locations (such as Australia) as High Income (de Groot et al., 2012). The unit value for various ecosystems specified in TEEB may be different for remote Indigenous communities, such as those within the Warddeken IPA, with low-income levels. A likely bias inherent in the valuations calculated in TEEB database do not consider the different socio-economic priorities in Indigenous managed lands, such as the Warddeken IPA. Additionally, the endemic and specialised ecosystems in the Warddeken IPA are not specifically identified in the TEEB database. Therefore, the values drawn from ecosystem categories available in TEEB database, may represent an underestimate for those ecosystems present in the Warddeken IPA.

Over the last 2 decades environmental science and policy have increasingly paid attention to understanding the monetary values of ES and this may help to engage the market economy to develop an economic motivation for conservation management (Gómez-Baggethun and Ruiz-Pérez 2011). Assigning monetary value to ES and biodiversity has generated considerable debate among environmental scientists (Costanza 2006; Gómez-Baggethun and Ruiz-Pérez 2011; Sagoff 2011; Díaz et al., 2015). A core dispute concerns whether the quantification and valuation of ES is possible and/or appropriate, since the roles of biological diversity and socio-cultural processes are so complex (Gómez-Baggethun and Ruiz-Pérez 2011; Sagoff 2011; Díaz et al., 2015). Some researchers have stated that economic valuation of ES is more appropriate in the short term, for provisioning, but not for more complex ES (such as regulatory and cultural services) (Pascual et al., 2010; Kallis et al., 2013; Díaz et al., 2015). Economic valuation of such ES may not be suitable, required, adequate or applicable in the long-term, due to the unpredictable, complex and dynamic nature of Country and people (Pascual et al., 2010; Kallis et al., 2013; Díaz et al., 2015). A rationale for engaging with the ES valuations, despite the disputed benefits identified above and the current inadequacy of applying the TEEB database to Australian ecosystems, is the potential that this work communicates important principles to economists and policymakers. ES valuations using these methods listed in this study provide a signal to the importance of the work carried out by Indigenous land managers and TOs in the IPA contexts specifically, and in Australia more generally. In Arnhem Land, the only assessment of this kind done to date for IPAs (including the Warddeken IPA) is by Social Ventures Australia (2016b) which focused on the social return on investment and excluded ES. This study has addressed ES for the Warddeken IPA and may help inform social and economic policies to appropriately understand the role of Indigenous land management across the north of Australia.

Significant assets, such as Bininj knowledge and languages, sacred sites, endemic fauna, freshwater places, communities, and livelihoods (also see **Table 3**), are identified as high priority for TOs when caring for their Country in the Arnhem Land Plateau—contributing towards the health and well-being of both people and Country (Warddeken Land Management Ltd. 2016a). The main threats to these assets (see **Table 4**) signify a risk to the health of the Country and the well-being of people in the Arnhem Land Plateau (Warddeken Land Management Ltd. 2016a). Quantifying ES makes important services provided by the IPA visible to the government and policy makers. Whilst the data informing calculations in this research may be incomplete, it provides a mechanism to understand the crucial value of assets, and processes that are traditionally important for people. It delivers the necessary motivation for their recognition within this socio-economic context. The ES evaluation in this study can assist to maintain the health of these significant assets that TOs value and mitigate potential threats. A quantitative valuation provides the necessary motivation within a broader market-based economic context for conservation management, a reduction of the threats to wellbeing of people and a means to establish a visible return on investment—generating future payment for ES economies.

Socio-cultural activities managed through the WLML, such as the Cultural Camps and Bushwalking Programs, are vital strategies for local Indigenous people and communities. They enable the preservation of the cultural and natural legacy of Country and increase the health of significant assets and well-

being of Country and people (Warddeken Land Management Ltd. 2016a). However, it is acknowledged that the value of such activities has not been fully estimated in this study due to the lack of publicly available data. There are several other cultural ES that are not allocated an economic value, such as bushwalking and on-Country learning (Warddeken Land Management Ltd. 2016a; Fogarty 2012). Cultural ES beyond monetary valuation remain significant. Cultural ES values are of direct and vital benefit to Bininj, and this reinforces their importance in the broader socio-cultural context.

Regulating ES unequivocally benefits broader communities and attempts are frequently made to quantify this in some way (albeit provisional). The Provisioning ES provide for the sustenance, economic independence, and improved health and well-being for Bininj in the Warddeken IPA. There are economic and socio-cultural benefits that spin off to governments, taxpayers, and the community in general. Cultural ES can be quantified and therefore made visible to and measurable for economists, but no quantification can ever capture the depth of value and benefits these ES provide. Each attempt to quantify is limited by the frames of reference and epistemic assumptions of the quantifier. However, the process offers cultural ES an opportunity to be acknowledged and accounted and, in some way, shift the focus of the narrative in economic discussions about Indigenous Australia.

This project has assessed the benefits that accrue from Bininj being actively involved in the management of socio-cultural landscapes, particularly for their own well-being benefits including the marketable ES (GHG emissions abatement), valued at $8 million per year. This is a conservative estimate as this study considered only people between the age of 15–64 years and only some of the socio-cultural benefits associated with the WLML Cultural Camp Program. The WLML Bushwalking Program also provides Bininj with the opportunity to renew their connections to Country and visit areas only accessible by walking (Warddeken Land Management Ltd. 2016a).

The purpose of this assessment is to gain an understanding of all ES services that flow from the Warddeken IPA and to provide a valuation of those for which evidentiary data exists within the public literature. It justifies the need for Bininj to maintain the landscape within the Warddeken IPA to continue providing these important services to local people and the wider Australian communities. Limitations of this study include: a reliance on using publicly available data, rather data collected in the field; the use of regionally available ES valuation data; a minimal valuation of one of the identified cultural ES (Cultural Camp Program). The future valuation of other Warddeken IPA cultural ES (including on-Country learning and the Bushwalking Program) and provisioning ES (bush tucker, bush medicine, art, and craft materials) would provide a more accurate assessment of non-marketable ES. Applying only published data might not represent all (and may overlook some) significant ecological and cultural services that are occurring in the Warddeken IPA. Therefore, this research project is an initial attempt to assess the environmental benefits of the Warddeken IPA. This work could be expanded in the future by conducting workshops with TOs to understand their values for the IPA. Integrating this with an in-depth costing of social and cultural activities may provide invaluable evidence of the need for a shift in focus away from a support of existing welfare strategies towards those that re-invigorate cultural practices and support Indigenous autonomy and agency.

In conclusion, this study demonstrates a diverse range of benefits that flow from managing the Warddeken IPA, and many of these benefits flow outside conventional market systems and processes. Understanding the importance of these benefits is critical for informing policy decision making to develop and support programs for more Indigenous people to work on Country. The total value of well-being benefits, in terms of cost savings for the Australian Government, was estimated at $8 million per year for the local communities. The ES benefits, marketable for a range of regulating and supporting services (worth $28.9 million per year) suggest that a very small proportion of total benefits are currently valued in the market setting. This study acknowledges that these non-marketable ES estimates provide an overall (though not exact) figure to highlight the importance of ES, typically either ignored or under-valued. This is particularly vital to emphasize when many Indigenous communities work hard to keep their Country healthy. Overall, the total ES values and related well-being cost savings for the Warddeken IPA indicate that investing in managing the Indigenous estate delivers a multitude of benefits that need to be considered when supporting future investment in IPAs. Public policy programs such as the Australian Government's Closing the Gap and the Australian Government's conservation strategies, could improve on their reportable outcomes through sustained investment in Indigenous land management, and therefore contribute directly and indirectly to improving the well-being of Indigenous people.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

CC, is recognized as the first author in the manuscript. CC, contributed to collect all data for figures, tables etc, produce the ecological maps (using ArC GIS) and undertaken the initial research and writing (as part of a Master of Environmental Management (MEM) Research Project Thesis) for the manuscript. GW, is recognized as the last author in the manuscript and contributed via overseeing Indigenous methodology and policy theories. CC, GW wrote the first draft of the manuscript based on the research, text and data in Research Project Thesis. KS is recognized as the senior author in the

manuscript and contributed via overseeing data collection, manuscript text and ecological economics theories. CC, GW, KS contributed to the conception and design of the study. All authors contributed to manuscript revision, read and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2022.845178/full#supplementary-material

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