

# Identifying Links between Ecosystem Services and Aboriginal Well-Being and Livelihoods in North Australia: Applying the Millennium Ecosystem Assessment Framework

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**Abstract:** The livelihoods and well-being of Aboriginal and non-Aboriginal communities in remote and rural northern Australia are dependent upon the ecosystem services provided by tropical ecosystems. The well-being of all Australian citizens is measured by the Australia Bureau of Statistics (ABS) using socio-economic indicators. In this study we investigated the importance of non-market benefits derived from ecosystem services for Aboriginal well-being. Through a case study with the Mullunburra-Yidinji people in the Wet Tropics, Queensland, we applied the Millennium Ecosystem Assessment (MA) framework to identify the links between ecosystem services and the MA's six constituents of human well-being. The study demonstrated that cultural and provisioning services were key determinants of community well-being, and these are not currently measured by the ABS. We adapt the MA framework to include the ABS indicators and explore the potential strengths and weaknesses of the approach for measuring the well-being of contemporary remote and rural Aboriginal communities.

**Key words:** Aboriginal people, ecosystem services, gender, human well-being, livelihoods, millennium ecosystem assessment.

## 1. Introduction

This study investigates the role of ecosystem services in the well-being of Aboriginal people living in tropical northern Australia. There is a broad literature which suggests that Aboriginal communities in remote and rural Australia are either dependent upon and/or culturally linked to natural systems [1-7]. However, there are not many studies that have investigated the links between goods and services available from various ecosystems and the well-being of Aboriginal people. Moreover, worldwide, the linkages between natural systems and well-being of

Aboriginal people generally are poorly understood (Millennium Ecosystem Assessment [8]). It is important to note that such linkages are complex, diverse, and may vary according to spatial and temporal scales. For Indigenous societies, the human-environment interactions are well recognized, as reflected by their respect for the plants, animals and other aspects of ecosystems essential to their survival [9-11].

In Australia 2.5 percent of the population are of Aboriginal descent and among them about one third live in remote areas [12]. These Aboriginal communities often practice the traditional system of collecting and hunting food, organizing cultural activities, ceremonies and dances [3-6, 13, 14]. The well-being of these societies is closely linked to land and other natural

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resources [15], however there is no formal recognition of these links in government policies on natural resource management or on the socio-economic status of Indigenous people [16]. The most commonly applied measures for well-being by socio-economic institutions, such as by the ABS (Australian Bureau of Statistics), accounts for income, housing and alike, but overlook the role of ecosystem services (discussed later). These socio-economic approaches tend to misinterpret well-being on the one hand, and to underestimate the value of ecosystem services on the other, because additional and important elements of well-being are not considered. Moreover, these ecosystem services could be vital in well-being, particularly for Indigenous people.

The role of natural resources such as land and water “country” has been recognized in indigenous health [15, 17], but these studies exclude many aspects of well-being that are equally or more important for Indigenous people. Moreover, the list of socio-economic indicators applied by the ABS is the same for Indigenous and non-Indigenous people, which does not reflect well-being of the former [16]. The ABS measures are oriented mainly towards an urbanized population and are assumed to be the core constituents of well-being which are also applied to Indigenous communities to participate in the mainstream economy. Moreover, the role of customary economic activity is overlooked entirely in well-being [18-20], and many elements of the customary economy relate to ecosystem services.

Daily [21], Salzman et al. [22], Deutsch et al. [23], Dasgupta [24] and Wainger and Price [25] have drawn attention to the dependence of people’s well-being on ecosystem services. However, the first conceptual framework that linked ecosystem services with human well-being was developed by the MA study [8], initiated by the United Nations in 2001. The MA suggested the need for research to be conducted worldwide to assess the current conditions and trends of ecosystems and associated well-being at the local, national and global scales to improve the well-being of people. Subsequently,

various sub-global assessments were conducted as a part of or in collaboration with the MA on the current status and trends in ecosystems, mainly at the global scale [26], on scenarios for change in ecosystem services and human well-being [27], associated policy responses [28] and multi-scale assessments [29]. In Australia, there has been no such study.

The present research applies the MA framework at a local case study scale, with the following objectives:

- To explore the linkages between ecosystem services and well-being of Aboriginal people;
- To identify the ecological measures important in the well-being of Aboriginal people that could contribute to the current list of well-being measures used by the ABS.

The paper presents an outline of the concept of well-being, its application and limitations in the Australian context for measuring the well-being of Aboriginal people, and results from a case study. From these, we propose a model for identifying linkages between ecosystem services and the well-being of Aboriginal people to contribute to the design of well-being indicators by the policy makers.

## **2. The Concept of Well-being**

Human well-being is the state of being “healthy, happy or prosperous” (Oxford Dictionary definition). The modern concept of well-being was originally discussed in welfare economics, and includes various attributes that economists consider as important for well-being. Economists view well-being as “developing options for people to have choices by increasing utility/consumerism” [30], emphasizing the provision of various goods and services in terms of their utility values. Therefore, human well-being is reflected generally in relation to income, housing, or other tangible gains in one’s life.

### *2.1 Limitations of Current Socio-Economic Indicators of Human Well-Being*

Human well-being is a multi-dimensional concept

that includes socio-economic and other values that people have towards life, and goes beyond income. Dasgupta [24] states that well-being comprises two main components:

(1) Constituents (i.e. happiness, freedom, health and freedom of values or basic liberties);

(2) Determinants (i.e. commodity inputs in well-being such as food, economic resources, shelter, access to knowledge and information).

To date, common measures of well-being include determinants (e.g. quantifiable attributes such as income) and some constituents such as health, but mainly exclude the qualitative measures such as provision of clean air/water, cultural, identity or spiritual values [8]. The quantitative nature of current well-being measures is also criticized by Diener and Suh [31] and Neumayer [32]. For example, income level is considered an important indicator of well-being, even though well-being may not be directly proportional to income [33], and the level of income that satisfies people may vary for different societies [33]. Moreover, these measures ignore many qualitative attributes such as traditional knowledge, cultural or spiritual values. Although in recent times the well-being concept has been expanded from determinants (as mentioned above) to include constituents such as satisfaction of basic material needs and experience of freedom, in practice the concept is still focused on income and related attributes.

In terms of economic growth, some recent studies have focused on highlighting the role of natural systems. For example, Daly and Cobb [34] proposed the Index of Sustainable Economic Welfare (ISEW) which along with gross domestic product includes the cost of environmental degradation. More recent measures such as, Anielski and Rowe's [35] Genuine Progress Indicators focus on net profit, which abstracts the cost of environmental degradation for achieving economic growth. Costanza et al. [36] proposed a quality of life framework that focuses on integrating

human needs, subjective well-being and opportunities to meet human needs. However, these measures mainly focus on economic growth rather than the well-being of people. Moreover, there are no set techniques to account for constituent measures of well-being [24], and many ecological attributes fall under this category.

It is also important to recognize that these non-quantifiable attributes are difficult to measure in the absence of perfect markets. However, there may be some ways to recognize these values. For example, Sen [37] proposed a capability approach to include non-monetary attributes such as human capabilities and functionings (freedom, equality and rights that are important to people). Since the 1990s, health and knowledge have become accepted as important attributes of well-being and are used in the Human Development Index (HDI), published by the United Nations Development Programme (UNDP) [30]. Similarly, there is a need to incorporate the ecological attributes that people value in their lives.

## *2.2 What Is Overlooked in the Australian Context?*

The ABS [6, 38] defines well-being as "a state of health or sufficiency in all aspects of life" and adopts a pragmatic view that reflects well-being from socio-economic characteristics. It uses various social and economic indicators: economic resources, work, education and training, health, housing, family and community, crime and justice, and culture and leisure (including types of businesses/industries providing goods and services for cultural and leisure activities) as presented in Table 1. These mostly relate to either utilities or capabilities of people, and overlook the role of the natural environment in providing services or benefits for people.

The well-being of an individual or a society depends upon many factors including culture, geography and ecological conditions [8, 24]. However, the ABS measures fail to account for diversity in each of these three categories. The Australian community overall could be broadly

divided into a majority group of non-Aboriginal (mainly Europeans) and a minority group of Aboriginal people, with very different cultural, identity and spiritual values [3] (Table 2). These groups also experience different ecological landscapes.

It is believed that non-Aboriginal people place a greater value on materialistic goods and services, such as a good house, car and income, and hence the current ABS approach could be appropriate to them. In contrast, Aboriginal people, in general, place greater emphasis on cultural, spiritual and identity values, which are linked to land (Table 2) [3, 14-16, 18, 20, 38-41]. Traditional and semi-traditional Aboriginal

societies may have materialistic values too, but they exist in addition to their strong cultural, identity and spiritual values. Their life style also suggests the importance of culture and attachment to the land in their lives (Table 3). About 38 percent of the Aboriginal population (> 15 yr age) live in remote areas; among them 77 percent identify themselves with a clan or traditional group, and about 90 percent participate in various cultural and social events (Table 3). For people living in remote areas, their daily living is substantially dependent upon natural resources for a range of services, including bush food and medicine, raw materials for arts and crafts and cultural and spiritual sustenance [2, 7, 42].

**Table 1 Socio-economic indicators applied by the ABS to measure well-being [7, 38].**

Indicators: Areas of concern	Aspects of life contributing to well-being
Work	Satisfying and rewarding work both economic & non-economic
Economic resources	Command over economic resources, enabling consumption
Education and Training	Realisation of personal potential through education
Health	Freedom from disability and illness
Housing	Shelter, security and privacy, through housing
Family and community	Support and nurture through family and community
Crime and justice	Personal safety and protection from crime
Culture and leisure	Time for and access to cultural and leisure activities

**Table 2 Value systems of aboriginal and non-aboriginal communities [3].**

	Aboriginal	Non-Aboriginal
Natural resources:		
Land	Related to, Sacred	Ownership, Secular
Environment	Adapt to	Exploit
Other social values:		
Society	Unified	Diverse
Relationships	Extensive	Limited
Basic unit	Society	Individual
Reality	Spiritual	Material
Possessions	Share, Use	Acquisitive, Accumulate

**Table 3 Characteristics of aboriginal people (>15 years of age) related to their remoteness [41].**

Cultural values	Non-Remote	Remote
Australian Indigenous population (number) >15 years of age: 282,200 (Qld-76000, NT- 36200 and WA 39600)	205100	77100
Currently live in homelands/traditional country (%)	15.8	38
Recognising homelands/traditional country (%)	63.4	85.8
Identifies with clan, tribal or language group (%)	45.7	76.6
Attendance at cultural events in last 12 months (%)	60.9	87.1
Participated in social activities (%)	89.5	91.4

The Aboriginal way of life remains strongly connected to natural resources for use values, various cultural and religious beliefs, and to passing on their traditions to future generations [42, 43]. Although people face trade-offs when economic development is considered, many still prefer to live in remote areas to access the natural resources and live a customary lifestyle (Table 3). This became evident after the welfare period (introduced by the Australian Government from 1920s until 1970s) when people were given the option to move from the missionaries to cities or rural areas. Many opted to return to rural and remote areas under the “outstation” or “homelands movement” to live on their traditional lands, contrary to the expectations of many governmental agencies [43, 44]. This underlines Aboriginal peoples’ values for the natural environment and strongly suggests a need to incorporate the ecological attributes that play a role in the lives of Aboriginal people in well-being measures currently applied by the ABS.

To address the gap in well-being measures of Aboriginal people, Taylor [16] proposed a “recognition space” between Indigenous culture and the government reporting framework that could be adapted to develop social indicators, particularly for Aboriginal people. There is a need to recognize and interpret the elements of well-being that Indigenous people value and practice, beyond the general framework of government reporting that may have little connection to Aboriginal concerns. The Steering Committee for the Review of Government Service Provision [45] suggested three categories of potential indicators: the practice of culture by Indigenous people; the formal recognition of Indigenous culture; and appreciation of Indigenous people by non-Indigenous people. Among these, only the practice of culture has some data available from the National Aboriginal and Torres Strait Islander Social Survey (NATSISS) conducted by the ABS (as listed in Table 3). However, the content of NATSISS is mainly driven by the general ABS social survey in order to

make comparisons with the mainstream population. Dodson [46] argued that the current indicators are designed for governmental agencies to demonstrate success, and suggested that they instead should focus on developing Aboriginal measures of well-being. Identifying and understanding the role of ecosystem services from an Aboriginal perspective in “recognition space” [16] could help to develop an integrated framework that reflects their well-being.

### **3. Ecosystem Services and Well-Being of Aboriginal People**

There are a number of studies investigating the benefits that people derive from ecosystem services [2, 5, 47-55]. However, recognition of these benefits as components of the well-being of people is largely missing. Many studies propose that peoples’ well-being is linked to natural resources in various ways [1, 4, 8, 24, 26-29, 42-44, 55, 56], but comparatively few have established such links [36].

In the Australian context, many well-being related studies lack consideration of ecosystem services that play a role in cultural, spiritual and identity values [5, 7, 15, 16, 18, 57]. Moreover, there is lack of integration between ecosystem services and well-being that can help to interpret and value these links to be useful both for ecosystem services and well-being related research. Based on the information from these studies, the following attributes of natural systems are recognized to play an important role in the well-being of Aboriginal people. Applying the MA categories of the constituents of well-being (Fig. 1), they are:

#### *3.1 Basic Material for Living: Food and Medicine*

Tropical ecosystems are important sources of food and medicine, and Altman [2, 5] has highlighted their role in the customary economy. However, the value of wild food in the well-being of people is not recognized by formal economics, partly because these products do not pass through markets, and also due to the difficulty in estimating their output.

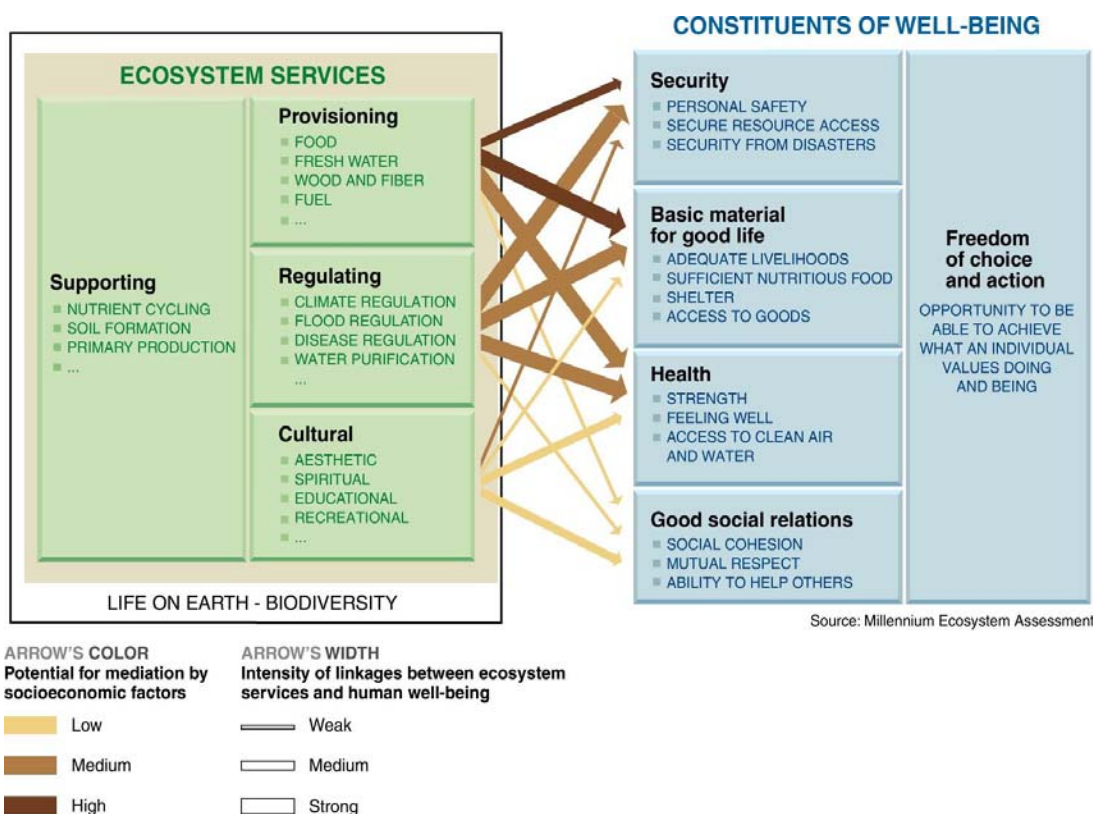


Fig. 1 The Millennium Ecosystem Assessment [8] framework illustrating possible links between ecosystem services and the constituents of human well-being.

### 3.2 Good Health: Provision of Clean Air, Water and Land Resources

Natural landscapes provide good quality air and water, the primary requirements for all human existence. With the rapid depletion of natural resources and changes in climate globally over the past 50 years, concerns have been raised about the continued provision of these services [26]. History provides evidence that civilizations collapsed due to declines in these ecosystem services, for example salinization in Mesopotamia, water logging, soil erosion and water siltation of agro-ecosystems in ancient Greece, Central America and New Zealand [55, 58, 59].

### 3.3 Security in a Healthy Environment for Present and Future Generations

In Australia, since the 1950s, land has been cleared for pasture development, and mining has become an important activity. These developments have led to a

decrease in diversity of native flora and fauna [60, 61] and degradation of soil and river health [62, 63]. The Australian State of the Environment Committee [64] reported that since European settlement most native vegetation has been removed or significantly modified by human activity.

Security of access to clean air, land and water is important for Aboriginal people for their cultural linkages and dependence upon natural resources [65, 66]. It is likely that the dependence of Aboriginal people upon natural resources for their daily needs has contributed to their conservative use of resources. Due to this dependence, Aboriginal people have a holistic approach towards natural resources for spiritual and physical maintenance, and to keep the country healthy for future generations. Many cultural sites have been destroyed by European settlements in the past, and the safety of existing cultural sites is of paramount importance for Aboriginal people so that they can pass on their traditions to future generations [65].

### *3.4 Role of Ecosystem Services in Social Relations*

The Aboriginal way of living is closely linked with nature for their various social activities. Land is considered as “mother”, and cared for with a sense of responsibility [3, 4]. People hunt and gather food in groups. During these trips, the elders teach the younger generations about bush skills, knowledge of plants, animals and the country, and tell stories about the land and their elders. Muir [65] emphasizes that hunting and gathering bush tucker are important activities for cementing social bonds within the group.

In Dreamtime (creation) stories, various plants and animals are important as totems for their links with elders, and with the country. Many ceremonial activities are associated with natural features of land or water. Thus the presence of natural resources imparts opportunity for people to interact and maintain culture [65].

### *3.5 Freedom to Access Land and Water Resources*

Freedom of culture, traditions and religion play an important part in people’s lives. For Aboriginal people, these are related to natural resources. Access to land and water is akin to accessing their own spirits, and freedom to progress their culture and traditions [4]. For example, Corn and Gumbula [67] suggested this in a song by Neprrija Gumbula on “Yolngu Children” (an Aboriginal community in the north Australia), suggesting that to live a Yolngu way of life meant freedom to access natural resources, and this was vital for their well-being. Moreover, freedom to access natural resources is important for Aboriginal people to continue teaching younger generations about bush skills [65], and to assimilate traditional ecological knowledge with modern practices to sustain natural resources and to improve ecosystem services for present and future generations.

### *3.6 Cultural Values*

Aboriginal people have identity, spiritual or sacred values related to natural resources. Land is special

because people are connected to it in many ways (traditions, culture, spiritually and in Dreamtime stories). As Christie [52] describes, “their lands and waters underpin who they are and the foundation of their very survival as people”.

Land is an identity of people, of their elders and of their future generations. Many natural features such as hills, rocks, trees, waterholes, human artifacts such as ceremony grounds or traditional burial grounds, are sacred for people and speak about Aboriginal tradition [66-68]. Traditions and history, and their relationship with sites are passed on from one generation to another, and are of paramount importance in well-being of a society [69]. About the Aboriginal people living in the north-eastern Arnhem Land (the Yolngu people), Corn et al. [67] says “our traditional relationship to land is profoundly spiritual...it provided our ceremonial objects, sacred for people,...the sacred names, the kinship, the subsections, the homelands, and whatever language you might speak”.

## **4. Case Study to Demonstrate Links between Ecosystem Services and Well-Being**

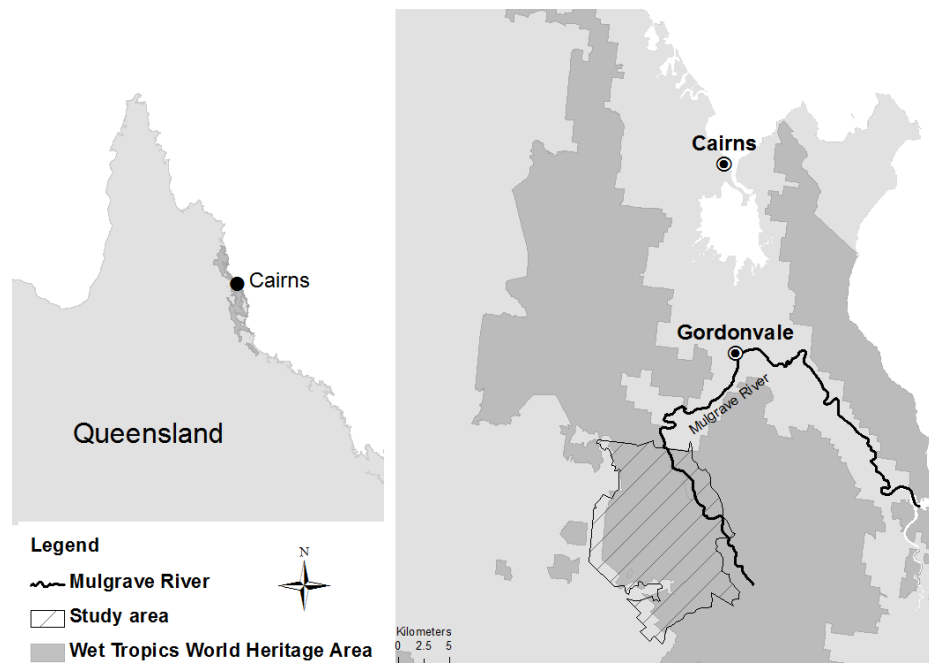
### *4.1 Methods*

To identify the linkages between the well-being of Aboriginal people and ecosystem services, a case study was conducted in collaboration with an Aboriginal community, the Mullunburra-Yidinji clan in the Wet Tropics World Heritage Area, Queensland (Fig. 2).

We applied the MA framework (Fig. 1) using the same constituents of well-being (mentioned in section 2) and classifications of ecosystem services:

- Supporting: services necessary for the production of all other ecosystem services;
- Regulating: benefits obtained from regulation of ecosystem processes;
- Provisioning: products obtained from ecosystems;
- Cultural: non-material benefits obtained from ecosystems.

During the preparatory phase of the study, introductory meetings were held between the research



**Fig. 2** The Mullunbarra-Yidinji clan area in the Wet Tropics World Heritage Area, Queensland, Australia.

team and the community to introduce the research topic. A pilot survey was conducted among the team and 10 elders of the community to test the validity of the questions regarding links between ecosystem services and their well-being. Based upon the consensus of the community, the term “country” is used herein to represent the area of land they depend upon for wild natural resources.

The Aboriginal group that participated in introductory meetings consisted of 40 members, both males and females. However, the members decided among themselves that only elders (total 10, 5 males and 5 females), would participate in the subsequent focus groups, and thus only the elders represented the whole community. During the meetings, the researchers acted as moderators, and a member of the community as a broker to conduct focus groups.

#### 4.2 Focus Group Questions and Results

The following questions were asked in a sequence from general to more specific, and the resulting answers are detailed below:

(1) General discussion on the topic of well-being

This topic was used as a probe to start discussions between participants and to focus talks on the defined topic. Statements from elders included:

- “Well-being, it is to feel well...feel strong and healthy”;
- “To feel good...both in my body and in my mind”;
- “Spend time with my grand-children”;
- “To be happy with myself”;
- “To have time to do what I want”;
- “Spend time with my family...or the other ladies”;
- “It is to be on country”;
- “It is to be free to go on country when I want”.

When on country, some participants agreed that they “could dream”, “...when I go on country, I remember things and people, I feel connected and happy”. Then, the group started talking about this element of well-being using examples such as “collect the food I like”; “go swimming” and finally a theme emerged around the idea of “being involved in managing my country and my ancestors’ country”; “be free to manage the land”. Most importantly, a participant mentioned that “country..... the rivers and the land,...it is sick now, so we are sick”.



(2) What are the benefits associated with the use of country to your well-being?

The list of benefits provided by the country, as expressed by the group, were as follows:

- “Food, because it is fresh, natural and healthy”;
- “Medicines, because they are natural, and still used by the people”;
- “Spiritual connection through initiation and dreaming stories”;
- “Healing place, good for health”;
- “Provides a sense of identity. For example, country provides material for shield making that is always different from one clan to another, and this is our identity”;
- “Provides places to practice our traditional and cultural ways”;
- “Offers places that people respect and remember”;
- “Totems linked to the country”;
- “Provision of cultural sites like walking tracks, water holes, story places and language, when people go on country”;
- “Provides places for recreation like swimming holes and camping grounds”;
- “Provides enjoyment because it is de-stressing, calming and it is time spent with family when one is on country”.

(3) Can you identify significant places on the map (aerial photos provided) associated with the wild resources you use?

The participants were given aerial photos of the clan area, and were invited to mark the places that were of high use value for them. Men and women undertook the exercise independently, since some places are important for men’ business and others for women’ business. In total they identified 70 places which were divided into four categories, according to the benefits provided:

- Regional areas: provide swimming, fishing, camping, resources for teaching, family outings and hunting;
- Food areas: sources of food, healthy life, medicine and bartering with other tribes;

- Story areas: places that people respect because they provide spiritual and healing benefits;

- Burial areas: these are sacred areas where only certain people are allowed to visit. They have great spiritual and cultural significance.

(4) Could you rank these significant areas of your country from lowest to highest in importance?

Participants were asked if they could rank, as a group, the places identified from lowest to highest in importance in relation to their well-being. Men and women decided to respond separately to answer this question, and their responses are presented in Table 4.

(5) Can you rank the benefits from your country from lowest to highest in importance?

The same method as for question iv was used to rank the benefits on a low to high scale, and again men and women responded separately as shown in Table 5.

## 5. A Model to Integrate Ecosystem Services with Well-Being for Aboriginal People

The respondents’ reflections of well-being were largely related to the benefits derived from being on country, and the resulting freedom, family bonds and intergenerational connections. Consequently the services derived from their country were largely cultural (identity, spiritual and ceremonial) and to a lesser extent provisioning (food and medicine). Clearly these are closely related, since provisioning services form an integral part of cultural activities, and therefore could also be considered part of cultural services.

Importantly, there was discussion about country being “sick”, and the importance for well-being as managing and restoring country, suggesting that many of the services provided are in decline as a consequence of disconnection between the Mullunbarra community and their country. In response, elders are applying indigenous ecological knowledge to restore the Mulgrave River [70].

Our results also demonstrate that the links between ecosystem services and well-being can be expressed in

**Table 4 Ranking of significant places by the aboriginal men and women.**

Low	Medium/High	High
<b>MEN:</b>		
Public recreational areas	Walking tracks	Fire places
Public tracks and roads	Camping grounds	Story places
	Teaching areas	Burial sites
	Fish traps	Ceremonial places
		Food areas
		Initiation areas
		Hunting areas
		Areas for tools materials
		Extinction areas
<b>WOMEN:</b>		
Recreation areas	Walking tracks	Story places
	Fish traps	Burial sites
	Hunting areas	Healing places
		Camping grounds
		Initiation areas
		Medicine and food areas

**Table 5 Ranking of well-being benefits by the aboriginal men and women.**

Low	Medium/High	High
<b>MEN:</b>		
Recreation	Food	Spiritual values
	Medicine	Language
		Identity values
		Tools
		Cultural values
<b>WOMEN:</b>		
Recreation	Food	Spiritual values
	Fishing/hunting	Language
	Gathering with family (social service)	Identity values for keeping the culture alive
		Transfer of knowledge

a spatially-explicit manner. Notably the identification of significant areas, the services they provide and their relative importance was a gender-specific issue, suggesting that future development of well-being indicators may have to be undertaken at a highly localized and context-specific scale. We interpreted these results into the MA framework (Fig. 3) to illustrate the linkages between ecosystem services and the community's well-being. The case study highlights that the links between any ecosystem service and the derived benefits are complex and involve culture, gender, scale and generational issues. Hence we only included the most important services

that were directly related to well-being. Each service was connected to one or more of the components of well-being. For example, bush food and medicine contributed to the provision of basic materials for life, good health, and to social relations (Fig. 3). We also included the more conventional [71] eight socio-economic well-being indicators which are likely to be important for the community, and have indirect linkages to ecosystem services. Although we did not measure these linkages in the case study, we propose that this addition to the MA framework would be appropriate for remote and rural Aboriginal communities.

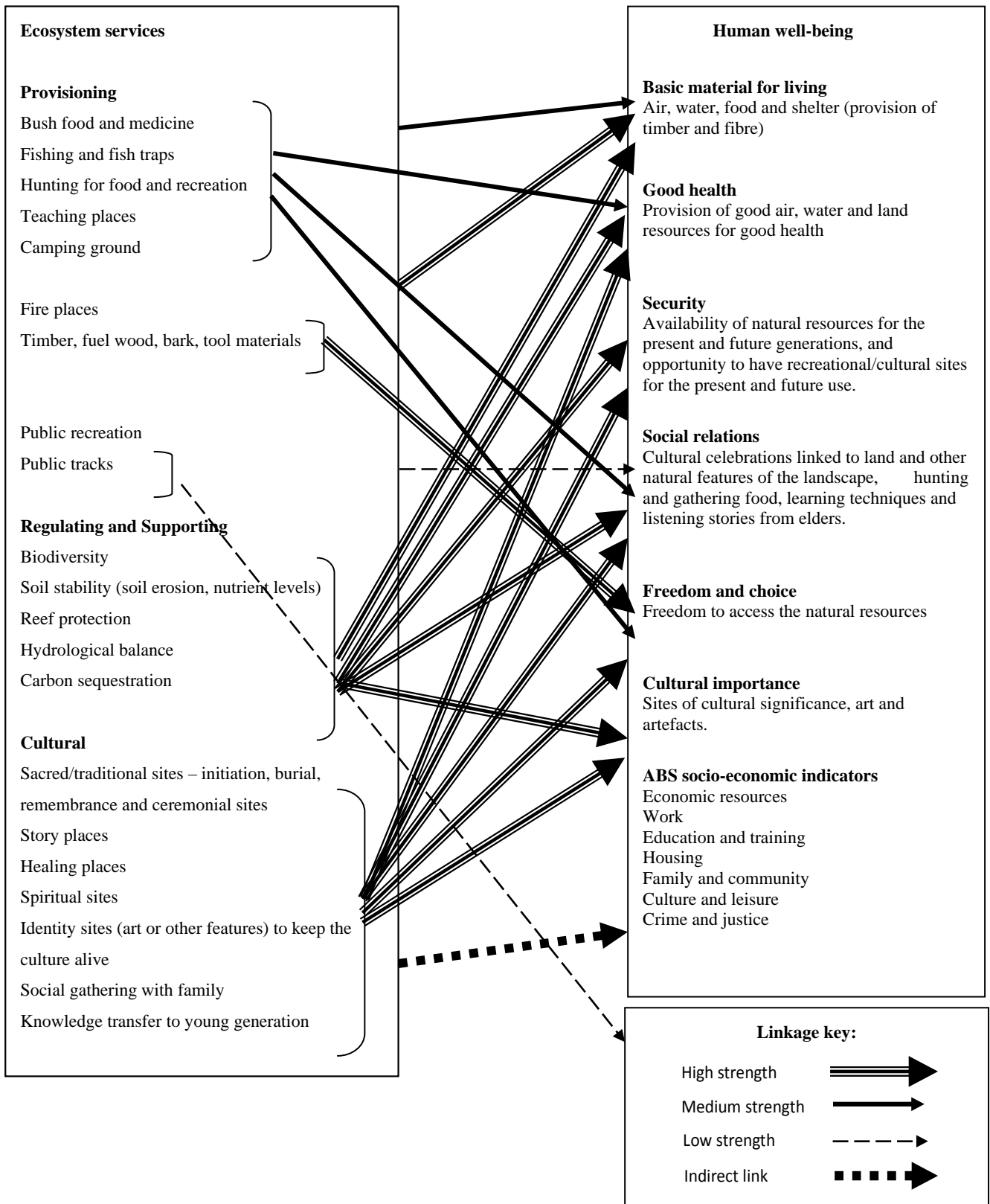


Fig. 3 Relationships between ecosystem services and the constituents of well-being identified by the Mullunburra-Yidinji community.

## **6. Discussion and Conclusion**

Ecosystem services play a vital role in human well-being. Humans and ecosystems are part of one system and are intricately linked, but in policy these components are often considered in isolation. Recent studies have pointed to the importance of ecosystem services in livelihoods [23, 36], human health [72], cultural activities [73, 74], their overall monetary value for policy decision making [75] and in human well-being [8, 26-29, 76, 77].

Recently, Altman [18], Grieves [39], Garnett et al. [40], Taylor [16], Dockery [20] and Ganesharajah [15] have highlighted from a social-economic perspective how Aboriginal well-being depends upon land and related resources. Greiner et al. [78] suggested that the contribution of culture and country was secondary to family and community's contribution to the well-being of Nywaigi Traditional Owners in north Queensland. However, there is little information on the possible links between the ecological services derived from an ecosystem and the well-being of people, which could develop a more holistic view of well-being and a framework to apply for future measures. The present study attempted to demonstrate these links by identifying ecosystem services and their contribution to the constituents of well-being, and integrating these into a framework for indicator development.

It is imperative to translate ecosystem services for well-being in order to understand the value of ecosystem services and to interpret the impacts of human activities on the environment, and resulting changes in well-being. Taylor's [16] proposal about a "recognition space" between Indigenous culture and a well-being framework can be achieved by incorporating human values for ecosystem services. The MA framework could be a valuable tool in this regard for interpreting both the ecosystem services and elements of well-being that people value in relation to natural resources.

The MA framework is the first of its kind which

proposes linkages between ecosystem services and human well-being. However, it does not provide suggestions for methods with which to measure these linkages, and this has been identified as a key research priority [77, 79-81]. The MA reports on biodiversity [76] and a general synthesis [77] highlights the complexities in linking ecosystem services with human well-being. The type of attributes and strength of these linkages may be specific to local cultural, geographical and local ecological conditions, as demonstrated in our case study. The focus group meetings with the Aboriginal community revealed that there are many complex and overlapping links (Fig. 3, Tables 4 and 5). Our experience suggests that the MA framework can be usefully adapted for such local scale case studies to capture this complexity, but may be difficult to apply at regional or national scales where such complexity would have to be aggregated.

Our model adapts the MA framework by including the eight socio-economic indicators used by the ABS [38], since these are also relevant to contemporary Aboriginal well-being. It is important to note that many standard socio-economic measures also relate to ecosystem services in one way or another, but most links are indirect. These connections are largely hidden because commodity outputs are obtained from industry, and the sources of raw materials remain largely unseen [24, 61].

In Australia, NATSISS (applied by the ABS) is the only attempt to integrate some cultural values of Aboriginal people. Only five out of 88 variables (see Table 3) are solely of relevance to Indigenous culture, because the policy focus remains on making comparisons with the mainstream population, and not measuring the well-being of Aboriginal people per se. This raises the fundamental question of whether Australia's societal goal should be to achieve socio-economic equality between Aboriginal and non-Aboriginal people, or to facilitate choice and self-determination amongst all citizens [82]. The latter are a key constituent of Aboriginal well-being [20], and

resonate with Sen's [83] argument for development to enable "people to lead the lives they value". Hence a clearer conceptualization of development for remote and rural Aboriginal communities, which goes beyond material and monetary goals, is required before an overarching well-being framework can be applied.

If such a policy window is created, we believe that linking ecosystem services to human well-being would be a culturally-appropriate approach for measuring the well-being of such communities. However, our case study suggests that the relative importance of various attributes of well-being linked to ecosystem services varies amongst a community, both spatially and between genders. Regardless, a list of ecological indicators identified through the MA framework could augment the ABS's current list of socio-economic measures, and we suggest that these should also be included to develop a hybrid framework.

Developing a hybrid framework also requires understanding of well-being in relation to types of ecosystems, thus demands for local scale studies. This type of approach will also help to develop a holistic view: for a socio-economist to understand security and other well-being components beyond the socio-political system in the context of natural resources, and for an ecologist to value ecosystem services according to people's needs. There is only one such study conducted in the northern part of Northern Territory "A healthy country, healthy people" project led by Garnett et al. [17, 40]. They demonstrated the links between culture and natural resource management by assessing the status of ecosystem health and relating that to ethnographic features (health, ecological knowledge, identity, culture and spirituality). However, this was mainly an exploratory study to assert Indigenous Cultural and Natural Resource Management programme, and did not lead to develop a framework/tool for how to embed ecological aspects with well-being of people, which is applied in the present study.

In 2005, the ABS developed Measures of Australia's

Progress (MAP) [71] to measure the quality of life, which included some environmental attributes such as the number of threatened species and areas of land cleared as a separate list from socio-economic attributes. However, these measures are not integrated, nor do they include the value of landscapes from people's perspectives and they ignore cultural, identity and spiritual values. By revealing the importance of ecosystem services in human well-being our framework could be applied to guide natural resource management which maintains and restores key ecosystem services for people. This framework could also be applicable to other regions where people directly depend upon ecosystem goods and services and goods for their livelihoods, including non-Aboriginal communities.

Integrating well-being and ecosystem services also helps people realize the consequences of their adverse actions. The MA [26, 27] concluded that ecosystems have been changed significantly over the past 50 years, and these changes can adversely affect human well-being. The proposed model in this study is important not only for Aboriginal communities but also for non-Aboriginal communities to interpret their impacts on, and indirect values that people may have for, an ecosystem. Clarkson et al. [50] pointed out "we must conceptualize our ideas on the quality of life that incorporate the health of the planet as the primary goal rather than the satisfaction of the material wants that go hand in hand with accumulation of wealth and uninterrupted expansion and exploitation of the gifts of the earth". Learning from Aboriginal perspectives will not only help to enhance well-being of Aboriginal people but will also help the mainstream community to realize their dependence upon the natural environment.

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