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Published in:
2006 International Society of Ecological Economics Conference Proceedings

Published: 01/01/2006

Document Version
Publisher's PDF, also known as Version of record

[Link to publication](#)

Citation for published version (APA):

Kaur, K., & Stanley, O. (2006). Linking ecosystem services to human well-being: A case study of Aboriginal people in north Australia. In *2006 International Society of Ecological Economics Conference Proceedings: Ecological sustainability and human well-being* ISEE Conference proceedings.

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Proceedings

ISEE (International Society of Ecological Economics) Conference “Ecological sustainability and human well-being’ 16-18 Dec, 2006, held at New Delhi, India

Linking ecosystem services to human well-being: A case study of Aboriginal people in north Australia

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Abstract

We use the MEA (Millennium Ecosystem Assessment) framework to explore linkages between ecosystem services and the well-being of Aboriginal people living in the tropical savannas of northern Australia. Both the Aboriginal and non-Aboriginal communities of this region are vitally dependent upon the ecosystem services available from savannas. Among these, only the monetary benefits such as from beef and mineral production are used to measure well-being by the Australia Bureau of Statistics (ABS). In this study, we gather evidence to support the proposition that non-monetary benefits are substantially more important for Aboriginal people, and highlight the drawbacks of the current approach to measure well-being by the ABS.

The ecological services from savannas, such as provisional, cultural, and regulating and supporting are linked to six main constituents of human well-being i.e. basic materials for life, good health, security of natural resources, social relations, freedom to access land and water for the present and future use, and cultural values. The study highlights the importance of various ecosystems services from savannas, which are often wrongly considered to be a non-productive and marginal landscape. This research will be useful in developing land use strategies that can be used to sustain natural resources for the present and future generations and contribute to the development of policies that can improve well-being of Aboriginal people.

Keywords: Aboriginal people, human well-being, ecosystem services, socio-economic-ecological concept of well-being, savannas.

Introduction

The present study investigates the role of ecosystem services in the well-being of Aboriginal people, in the tropical savanna region of north Australia. There is significant literature available to suggest that Aboriginal communities depend upon the natural system (Altman 1987 and 2004; Edwards 1988; Williams 1986 and 1998; Altman and Whitehead 2003; Gray 2005). However, there are not many reports that directly link the goods and services available from natural systems and the well-being of Aboriginal people. Moreover, worldwide, the linkages between natural systems and well-being of Aboriginal people generally are poorly understood (MEA 2003). It is important to note that such linkages are complex, diverse, and may vary according to spatial and temporal scales.

Worldwide, the human-environment interactions have been recognised for Indigenous societies, as reflected by their respect for the plants, animals and other aspects of ecosystems essential to their survival (Dasmann 2002; Posey 1999; Maffi 2001). Learning these interactions from Aboriginal societies all over the world for their closeness to nature can help modern societies to identify the value of natural systems, to understand their dependence upon natural systems for various goods and services, and to develop tools and methods for sustainable use of natural resources.

In Australia, there are about 2.4 percent people of Aboriginal decent and among them, about one third live in remote areas. These Aboriginal communities often practise the traditional system of collecting and hunting food, organising cultural activities, ceremonies and dances (Edwards 1988; Attwood and Arnold 1992; Hill 1995; Williams 1998; Altman and Whitehead 2003; Whitehead 2003 and Altman 2004). The well-being of these societies is closely linked to land and other natural resources. A study on understanding these connections can help to develop land use policies that aim to achieve the sustainable use of resources while accounting the non-monetary values of savanna landscape.

The common approaches to measure well-being applied by socio-economic institutions, such as by the ABS (Australian Bureau of Statistics), consider only the socio-economic indicators (such as income and housing), and overlook the role of ecosystem services. These socio-economic approaches lead to an underestimate of the value of ecosystem services because additional and important elements of well-being are not considered. This paper lists these additional elements and relates them to ecosystem services.

Daily (1997), Salzman et al. (2001), Deutsch et al. (2003), Dasgupta (2004) and Wainger and Price (2004) have drawn attention to the dependence of people's well-being on ecosystem services. However, the first conceptual framework that links ecosystem services with human well-being was developed by the Millennium Ecosystem Assessment study (MEA 2003), which was initiated by the United Nations in 2001. The MEA (2003) proposed that studies be conducted worldwide to assess the current conditions and trends of ecosystems and associated well-being, and the plausible future changes in ecosystems and the consequent changes in well-

being, and to suggest the type of policy response that need to be adopted at the local, national and global level to improve the well-being of people.

In the second phase of MEA program, various sub-global assessments were conducted as a part of, or in collaboration with MEA, in different parts of the world. Recently, some reports have been published by the MEA, mainly focussing at global scale, on the current states of and trends in ecosystems (MEA 2005a; Vol 1), scenarios (MEA 2005b; Vol 2), policy responses (MEA 2005c; Vol 3) and multiscale assessments (MEA 2005d; Vol 4), to demonstrate how the change in ecosystems have affected human well-being. In Australia, there has been no such study except for the Arafura and Timor Seas Sub Global Assessment in the north of Australia and this has a focus on marine systems only (MEA 2005).

The present research adopts the MEA framework (with some modifications) to help understand the role of ecosystem services from savannas in the well-being of Aboriginal people (applied at a local scale), and attempts to link the constituents of human well-being, as suggested in Fig. 1, to ecosystem services, in the context of natural environment. A model is proposed which will explore the linkages for the savanna region. The main objectives of this study are:

- To explore the linkages between ecosystem services and well-being of Aboriginal people by applying the MEA model at a local scale
- To suggest the ecological measures that could be important in well-being of Aboriginal people and to expand the ABS list of well-being measures
- To highlight the importance of natural resources in people' lives, by identify some non-measurable values such as cultural, spiritual and identity values

The paper presents an outline of savannas and their services, the concept of well-being, and its application and limitations in the Australian context to measure well-being of Aboriginal people, and some socio-economic information about the Aboriginal people living in savanna region. This is followed by an exploration of various relationships between ecosystem services and well-being of Aboriginal people. We prefer to use the phrase ‘Aboriginal people’ rather than ‘Indigenous people’ (which also includes people from Torres Strait and other Islands) because the people living in savannas are largely from the mainland.

1. Savannas

Savannas are natural ecosystems with an upper storey of scattered trees and an understorey of grasses and shrubs. The savannas cover about one third of Australian land mass (1.9 m km²) in the north and cover about two third of Queensland, half of NT and one sixth of WA.

The Australian savannas are the largest and unique in the world for their biodiversity. They provide habitat for hundreds of species of native plants, mammals, birds, reptiles and amphibians and invertebrates. It is a very diverse ecosystem with 22 bioregions, which have about 70 endangered and 200 vulnerable species (Fig. 2; Fox et al. 2001). Overall, the savanna vegetation is dominated by eucalypts, corymbia and acacia, and grasses such as spinifex, mitchell, wiregrass and bluegrass. Both trees and grasses perform ecosystem functions, which complement each other and provide various services. Soils are mainly podozols, red earths, yellow earths, heavy texture grey, brown or red, desert sandplains and siliceous sands, and are generally poor in nutrient content (Fox et al. 2001).

The savanna region is relatively remote compared to other parts in Australia and provides a home for many Aboriginal people. Overall population in rural areas of the tropical savanna is dominated by Aboriginal people (see later), and ecosystem services play an important role in well-being of many of these people.

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 therefore, includes various attributes that economists consider are important. Economists view well-being as ‘developing options for people to have choices by increasing utility/consumerism’ (Human Development report 1990); this concept is mainly interpreted as provision of various goods and services, in terms of their utility values. With a focus of the current concept on socio-economic development of people, various socio-economic attributes such as income, household items etc. have been applied to measure well-being.

2.1 Limitations of current socio-economic indicators of human well-being

Human well-being is a multi-dimensional concept that includes socio-economic aspects and values that people have towards life, and goes beyond income. Dasgupta (2004) states that well-being comprises two main components:

1. Constituents i.e. happiness, freedom, health and freedom of values (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 (quantifiable attributes such as income etc.) and some constituents such as health, but mainly exclude the qualitative measures such as provision of clean air/water, cultural, identity or spiritual values (MEA 2003). Neumayer (2004) and Diener and Suh (1997) criticised current measures of well-being for their quantitative features. For example, the level of income is still considered an important indicator of well-being, even though it may not be directly proportional to well-being (Neumayer 2004); as the level of income that satisfies people may vary between societies (Diener and Biswas-Diener 2002). Moreover, the measure of education used in studies ignores traditional knowledge. Similarly, many cultural, identity and spiritual values that are important for people are not considered in well-being measures. Although, in recent times, the well-being concept has been expanded from determinants (as mentioned above) to include constituents e.g. satisfaction of basic material needs, experience of freedom, in practice, the concept is still mostly focussed on income and related attributes. There, however, are no set techniques to account for constituent measures of well-being (Dasgupta 2004).

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 (1993) proposed a capability approach (CA) which includes non-monetary attributes such as human capabilities and functionings. These include freedom, inequality and rights which are important to people. Since the 1990s, health and knowledge have become considered important attributes of well-being and are used in the Human Development Index (HDI), published by the United Nations Development Programme (UNDP) (Human Development Report 1990). Similarly, there is a need to incorporate the services of natural environment that people value in their lives.

2.2 What is overlooked in the Australian context?

In Australia, the Australian Bureau of Statistics (ABS 2001) defines well-being ‘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, such as economic resources, work, education and training, health (including life expectancy, infant mortality etc.), 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 etc.). All of these indicators relate to either utilities or capabilities of people. However, this approach overlooks the role of natural environment in providing services for people, in particular for Aboriginal people (Kaur 2006).

The well-being of an individual or a society depends upon many factors including culture, geography and ecological conditions (MEA 2003; Dasgupta 2004). In Australia, there is diversity in each of these three categories. The Australian community could be broadly divided in to a majority group of non-Aboriginal (mainly Europeans) and a minority group of Aboriginal people, with differences in cultural, identity and spiritual values (Edwards 1988), and diversity in ecological landscape.

It is believed that non-Aboriginal people place a greater value on materialistic goods and services, such as a good house, car and income. In contrast, Aboriginal people, in general, place greater emphasis on cultural, spiritual and identity values which are linked to land (Edwards 1988 (Table 1); Hill 1995). Contemporary Aboriginal societies may have materialistic values too, but they exist in addition to their strong cultural, identity and spiritual values. Their living style also suggests the importance of culture and attachment to the land in their lives (Table 2;

ABS 2002). About 38 per cent of the Aboriginal population (of > 15 yr age) live in remote areas; among them 77 per cent identify themselves with a clan or traditional group, and about 90 per cent people participate in various cultural and social events (Table 2). For people living in remote areas, their daily living is substantially dependent upon natural resources for a range of benefits available from land and water resources, for example bush food and medicine, paint, art and craft, cultural, spiritual and identity benefits, to name a few (Altman 1987; Keen 2004; Gray et al. 2005).

The standard socio-economic indicators of well-being applied by ABS fail to capture the value of culture, identity or spirituality, or other ecosystems services which are of paramount importance to Aboriginal people (Table 1). Thus, there is a need to incorporate ecosystem attributes that play a role in lives of Aboriginal people, in well-being measures.

To understand the interactions between people and the natural environment, it is important to comprehend the socio-economic characteristics of a community i.e. Aboriginal and non-Aboriginal people of savanna country.

2.3 Socio-economic environment of Aboriginal communities

A brief sketch of population demographics, education, incomes and residency of Aboriginal people compared to non-Aboriginal people is provided to assist an understanding of the Aboriginal way of living and their relationships with ecosystem services (as discussed in the next section).

Population demographics (Australia wide)

In Australia, 458,520 people (2.4 per cent) identified as being of Aboriginal origin in the 2001 Census (ABS 2003). About 29 per cent of people in the Northern Territory (NT), and 3.5 per cent of people in Queensland and 3.5 per cent people in Western Australia (WA) are Aboriginal. These three states contain the Australia's savannas. About 30 per cent of Aboriginal people and 67 per cent of non-Aboriginal people live in major cities. Among the Aboriginal population about 38 per cent (of age >15 years) live in remote areas (Fig 3, Table 2; ABS 2002).

Education, income, and residency

For Australia wide, the ABS census data (2001) suggest that only 17 per cent Aboriginal people (>15 yrs of age) completed schooling up to year 12 compared to 41 per cent among the non-Aboriginal population (Table 3). The percentage of Aboriginal people achieving higher education is less (3 per cent, people of age >15 yrs) compared to 14 per cent among non-Aboriginal people (age >15yrs). Weekly income, either from CDEP (Community Development Employment Program) or from normal employment is much less than for non-Aboriginal employment. Only fewer Aboriginal people are in the workforce (Table 3).

For the savanna region, education, employment and income levels of Aboriginal people are even much lower than the national standards since savannas are vast open landscape where most people live in remote and rural areas, spending more of their time in traditional Aboriginal activities compared to large cities.

3. Relationships between ecosystem services available from savannas and well-being of

Aboriginal people

There are a number of surveys of how people benefit from the services of natural resources (Cribb and Cribb 1975, 1981 and 1982; Altman 1987 and 2004; Clarkson et al. 1992; Isaacs 1987; Jean 1995; Low 1988; Levitt 1981; World resources 2000-2001, and information from websites for the Environmental Protection Agency and the National Land and Water Resources Audit, Australia). Also, many studies of human well-being propose that people's well-being is linked to natural resources in various ways (Sen 1993; Williams 1986 and 1998; ABS 2001; Norwegian Millennium Ecosystem Assessment- Pilot Study 2002; MEA 2003 and 2005a,b,c, and d; Dasgupta 2004; Keen 2004; Integrated Natural Resource Management Plan for the Northern Territory 2005 and for other regions in Queensland and Western Australia). These studies suggest that the following attributes of the savanna landscape play an important role in the well-being of Aboriginal people:

3.1 Basic material for living: food, medicine and shelter

Bush food

There is a substantial literature on the Aboriginal use of plants for food. Some examples are given in Table 4, these include plant food such as illawarra plum, kakadu plum, lemon aspen, lemon myrtle, wattle seeds, cycads, quandong, and other materials such as honey, plant oil (eucalypt and tea tree oil), and native wild flowers. Many animals such as kangaroos, wallabies and emus, which graze on grass and other herbaceous/shrubby vegetation, are also an important source of food. Various water sources (small water holes, lakes and rivers) in savannas provide fish and mussels.

Aboriginal people have developed knowledge and skills to use and manage different plants and animals over many thousands of years. Keen (2004) described the environment and use of resources for seven Aboriginal communities, two of which were in the savanna country (Ngarinyin in the north-east of Australia and Yolngu community in the north-Arnhem Land). Both of these communities used numerous plant species for their seeds, nuts and fruits, as vegetable food, and developed knowledge for the time and method to harvest these materials. Altman (1987) reported the use of various flora and fauna, and honey in daily diet of Momega people of north-east Arnhem Land. Animal meat (kangaroos, wallabies, fish, goannas etc.) provided a good source of protein while plants provided carbohydrates. Isaacs (1987) describes the Aboriginal knowledge about flora and fauna as:

“Aboriginal people have an encyclopaedic knowledge of Australian plants and animals and of seasonal changes in the Australian environment. A batwing coral tree flowers, its orange blossoms fall and women know it is time to go and dig crabs from their hides under the mangrove mud. Their fat, too, will be orange, and the flesh good and filling. Another flower blooms to warn that poisonous stringers are in the northern waters, while the milky white flowers known as ‘oyster flowers’ tell people to move camp to the oyster beds, for the oysters are fat and white. Every child learns the importance of such natural signs. The winds, the blooming of plants and the seeding of grasses, rather than a fixed calendar of dates and months, herald the changes of seasons.” (Isaacs 1987).

In Arnhemland, Whitehead et al. (2002) reported on a number of species currently used by Yolngu people, such as *Ampleocissus acetosa* (Native grape), *Cycas orientis* (Cycad), *Ficus superba* (Native fig), *Morinda citrifolia* (Cheese fruit), *Pouteria serica* (black Plum), *Syzygium*

fibrosum, *Syzygium suborbiculare*, *Terminalia carpentariae* and *Terminalia ferdinandiana* (Billygoat/Kakadu Plum). Similarly, Aboriginal people in the Daly River region use plants such as *Antidesma ghesaembilla* (fruit), *Cochlospermum fraseri* (flowers), *Dioscorea transversa* (yam) and *Sterculia quadrifida* (seeds) which are of commercial potential for future enterprise.

However, the importance of wild food in the well-being of people is not well recognised when economic commentators report on the productivity of savannas, partly because these products do not pass through the markets and partly due to difficulty in estimating their output. Only a few studies have estimated the monetary value of wild food for Aboriginal people. Gray et al. (2005) examined the economic value of wild resources (especially fish) for Aboriginal communities living in the Wallis Lake catchment in NSW of about \$468-1200/adult/year. This reflects only a part of the total value, the actual value would be much more if the non-marketable/non-use services (bush food and medicine, cultural, spiritual or identity values) were considered.

Bush medicine

Many Aboriginal people use herbal medicine. Bark or roots of Acacias are infused or soaked to obtain a liquid drink that is used to treat cough and cold. Many species of eucalypts are used for medicinal purposes, to cure wounds and bruises, cold, snakebites, ophthalmia, headaches and toothache. Tea tree oil from *Melaleuca alternifolia* is very useful for curing many skin diseases and has become a commercial product these days. Some of these species and their medicinal uses are mentioned in Table 5. There is a diverse range of species of medicinal importance for Aboriginal people, some of these are yet to be recorded.

Water

Water plays a central role in bush production as well as in the various religious beliefs of Aboriginal people. There are about 26 small and large rivers (such as the East Alligator, Burdekin, Ord, and Daly rivers) and many creeks having cultural significance in the lives of Aboriginal people. Water is more or less a living entity in Aboriginal culture as Yu (2000) describes the importance of water:

‘Living water’ is an Aboriginal English expression that requires translation as it refers both to physical properties of water sources and their cultural significance.’

Moreover, fish and mussels from water bodies are good source of food for Aboriginal people.

Shelter: Wood (timber, fuel wood and bark)

Wood from some trees is still used by the Aboriginal people to make temporary shelters. Many hard wood savanna tree species such as *Eucalyptus camaldulensis* (river red gum), *E. pellita* (red mahogany) or *E. argophloia* (white gum) are used to make furniture and floors by the mainstream community.

Hibiscus tiliaceous is used to make spear shafts for hunting, fishing and for carvings. Some hard wood trees are used to make digging sticks to dig for food such as yams. Bark and wood from many trees is used to cook and store food. Different types of colours are obtained from bark and roots of different trees, and ochre (an extract from bark/roots) is used in cultural ceremonies and ceremonial artwork. Fuel wood is very important not only for fire to cook food but also in many ceremonies, for example wood from *Erythrophleum chlorostachyum* is used in certain religious ceremonies (Roberts and Stanley 1986).

Other important provisional services

Beef

Much of the land in the savanna is used for beef cattle grazing and provides an important source of income for non-Aboriginal people. The grazing industry is the most valuable rural industry in savanna region. The ABS report for 1999-2000 stated that 50 per cent of Australia's meat cattle herd is in the north Australia (ABS 1999-2000). However, some Aboriginal people also own and manage pastoral properties for commercial properties, or for subsistence grazing and other non-monetary benefits.

Recreation

Savannas support diverse and unique species of flora and fauna. People from different parts in Australia (non-Aboriginal and Aboriginal) visit the region for its vast, open landscape, and to experience the Aboriginal culture. There are many national parks and forests which are internationally famous for their unique landscape, rock formations, and flora and fauna. For example, in the Kimberley region, the north west of savanna country, Purnululu National Park is listed as World Heritage site for its sandstones karst, representing major stages of earth's history, including significant on-going geological processes in the development of landforms, and for exceptional natural beauty and aesthetic importance. Another such site of World Heritage listing is Kakadu National park.

Minerals

Mining for bauxite, coal, copper, diamond, gold, iron, lead, nickel, zinc and some other minerals, is a very important source of income after grazing, all over savannas (Fig. 4) (ABS 2006) and provides jobs and investment returns for many non-Aboriginal people. Some

Aboriginal groups receive royalties and other financial benefits from mining. Despite efforts, relatively few Aboriginal people are employed in the industry.

3.2 Good health: provision of clean air, water and land resources

Provision of good quality air and water is important for life as these are the prime needs. With the fast depletion of natural resources and changes in climate all over the world over the past 50 years, concerns are raised for provision of good quality air and water (MEA 2005a). In the past, history provides evidences where civilizations collapsed due to declines in the ecosystem services available from natural resources (e.g. Mesopotamia for salinization or Mayan for water logging and water siltation of Agroecosystems, the ancient Greeks, the Mayans and the Maori) (Flannery 1994; Redman 1999; World Resources Report 2000-2001).

Savannas are valuable, in addition to the outputs (commercial and non-commercial), in providing ecological benefits to regulate CO₂ concentration, water balance and other ecosystem processes. The savanna vegetation contributes, in part, to the control of global temperatures, for the provision of clean air and water, and thus it plays a fundamental role in well-being of people in the region and elsewhere.

3.3 Security in having a healthy environment for the present and future generations

Worldwide, until the beginning of the 20th century, ecosystem services were considered abundant and various ecosystems were manipulated for human needs. However, in the last century, large areas of forests were cleared for agriculture. This led to increase in crop production, but raised many issues about nutrient balance in soils, salinity, acidity, climate change, and loss of flora and fauna.

In savannas, since 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 (Fensham et al. 1999; McIvor 1993; Sangha et al. 2006) and degradation of soil and river health (Boutler et al. 2000). The Australian State of the Environment Committee (2001) found that since European settlement, most native vegetation has been removed or significantly modified by human activity. The rate of land clearance has accelerated over time, with as much cleared during the last 50 years as in the 150 years before 1945.

The modern approach to agricultural development emphasises maximizing financial benefits, while the Aboriginal approach generally aims at a sustainable use of natural resources. It is likely that the dependence of Aboriginal people upon natural resources for their daily needs has contributed to their conservative use of resources. Aborigines have a holistic approach to natural resources for both spiritual and physical maintenance to keep the country healthy for future generations. Security of access to clean air, land and water is important for Aboriginal people for their cultural linkages and dependence upon natural resources (Muir 1998). This is reflected through Aboriginal traditions as Strang (1997) describes “human beings are integrated in natural world, with a responsibility to care for it according to the ancestral law.”

There are many sites of cultural importance for Aboriginal people all across savanna landscape. Many of these 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 (Muir 1998).

3.4 Role of ecosystem services in social relations

The Aboriginal way of living is closely linked with nature in cultural, spiritual and other activities. Land is considered as ‘mother’, and cared for with a sense of responsibility (Edwards 1988; Williams 1998). People go out in groups to hunt animals and to gather food. During these trips, the elders teach the young generation about bush skills, pass on knowledge about plants, animals and the country, and tell stories about land and their elders. Muir (1998) says that hunting and gathering bush tucker are the activities that serve to cement the bonds within the group.

In Dreamtime stories (in the Aboriginal culture Dreamtime means 'the time of the creation of all things'), various plants and animals are important for 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 and access to them imparts the opportunity to people to be together, to perform rituals and to have spiritual relationships with the country (Muir 1998).

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, access to land and water is like access to their own spirits and having freedom to live in their own way that can help progress their culture and traditions (Williams 1998). Thus, freedom to access natural resources is vital for their well-being.

The importance of access land is also evident from the song by Neprjna Gumbula (1994) on “Yolngu Children” (an Aboriginal community in the north Australia):

“.....Can’t you hear the Yolngu children

Crying out for freedom and rights
This land and its heritage
Has been handed back again
Yolngu children must live in the Yolngu way of life
We have fought back the land for our new generation
It's beauty and the land of ours will remain the same
For the future of Yolngu children"

(Source: Corn and Gumbula 2001)

Aboriginal people need access to the land to continue teaching their young people about bush skills (Muir 1998). Freedom for Aboriginal people to use resources is also important so as to assimilate traditional ecological knowledge with modern practices to sustain natural resources and to improve the ecosystem services for the present and future generations.

3.6 Cultural values

Aboriginal people have identity, spiritual or sacred values which are related to savannas. Land is special because people are connected to it in many ways (traditions, culture, spiritually and in Dreamtime stories). Jean (1995) says:

For Aboriginal people, their lands and waters underpin who they are and the foundation of their very survival as people. Aboriginal people all over the globe insist that living things can not be separated from the land they grow on, and that people' knowledge and myriad uses of natural resources can not be separated from their culture, their survival as people on the land.

Land is not a separate entity for Aboriginal people rather it is the ‘oneness’ between people and land. Land is an identity of people, of their elders and of their future generations. Thus, connections to land are central in all Aboriginal communities. Dodson (1997) says that everything about Aboriginal society is inextricably interwoven with, and connected to, the land.

Savanna landscape is also sacred for Aboriginal people for its natural features such as hills, rocks, trees, waterholes. Other features can be rock art or other human artefacts such as ceremony grounds or traditional burial grounds, which speak about Aboriginal tradition. Traditions and history, and their relationship with sites are passed on from one generation to another, and are of paramount importance for well-being of a society (Rose 1995). About the Aboriginal people living in the north-eastern Arnhem Land (the Yolngu people), Dodson (1997) says “our traditional relationship to land is profoundly spiritual.this land of ours, it provided our ceremonial objects, sacred for people, and it wasn’t the only sacred things which were given but the land also provided the sacred names, the kinship, the subsections, the homelands, and whatever language you might speak....”

3.7 Other ecosystem services which indirectly play an important role in well-being:

Regulating and supporting services

Savannas provide many ecological services that sustain the ecosystem, the following are considered in this paper:

Biodiversity

Biodiversity maintains ecosystem functions such as nutrient recycling, soil microbial composition, hydrological balance and C storage that directly or indirectly contribute to supply

various goods. The Australian savannas are rich in diversity with 22 bioregions and many species endemic to this landscape (Fox et al. 2001; Australian State of the Environment Committee 2001; Sattler et al. 1999).

Soil stability

Savanna vegetation play a significant role in maintaining soil processes and hydrological balance at the top and bottom depth of soil for having 2-3 storey vegetation with grasses, shrubs/bushes and trees. However, grazing as the main land use has led to soil erosion (Australian State of the Environment Report (land theme) 2001), which further leads to loss of soil nutrients and pollutes water streams and reef subsequently. Prominent loss of nutrients (N and P), mainly from cropping, through sediment flow occurs in the eastern part in Queensland (National Land and Water Resources Audit 2002).

In the last few years, management practices, such as low grazing pressure, fencing off creeks and keeping some parts of grazing land as nature refuge, have been promoted by the governmental agencies (National Land and Water Resources Audit 2002). These will enhance soil stability over time and help maintaining equilibrium in ecosystem processes in the future.

Reef protection

Savannas contribute to protect the Great Barrier Reef from degradation. The reef is located all along the eastern coast of savannas region. The land use practices, in particular of savanna area in Queensland significantly affect the reef. The Australian Government funded 'Catchment to Reef' project in 2002 through Cooperative Research Centre for Reef aims to assess the impact of different land use practices and river flows on reef. The natural vegetation in savannas serve the

purpose by holding the soil particles together and minimising the sediment loss and the flow of chemicals in water streams which open in the Pacific Ocean, and thus helps to protect the reef.

Hydrological balance

Maintaining hydrological balance of an ecosystem is important to obtain production (pasture and crops) and other ecological benefits (bush food and medicine, and aesthetic value). Trees in the savannas help maintain salt levels by up taking water from deep soil, and prevent many other associated problems of acidity, water logging or pollution in waterways. Consequently, a healthy landscape with native vegetation offers various ecological services for people in the region.

Climate stability (C sequestration)

Savannas contribute to climate regulation at local, national and international scale by sequestering C, mainly in trees and shrubs and soils. Savanna vegetation sequesters from 0-30 t C/ha (Raupach et al. 2001) depending upon the land and vegetation types. The total amount of C sequestered in savannas for the total area of 190 m ha, at the minimum rate of about 10 t/ha is 190×10^7 t, which is a significant figure to contribute in reduction of CO₂ concentration in the atmosphere.

4. Human use and current status of various ecosystem services

Aboriginal communities benefit from ecosystem services from the savannas in many ways, as discussed above. The role that various ecosystem services play in well-being of Aboriginal people may change over time with change in people's attitude and circumstances (Kaur 2006). Even so, the socio-economic approaches of the ABS and others to measure well-being ignore many ecological values that are important to Aboriginal people.

There has been a significant change in the ecological benefits obtained from savannas from bush food, medicine, shelter etc. to commercial production of beef or minerals, with European arrival since 1780s. As a consequence, the landscape has undergone a change from supporting a nomadic lifestyle to a contemporary life style. For the last 100-200 years, although Aboriginal people have modified their lifestyle, they still retain their connections to land, and their dependence upon various ecological services for their living. Table 6 presents trends (based upon information obtained from the Environmental Protection Agency (EPA) and the National Land and Water Resources Audit (NLWRA), Australia) in human use of ecological services from savannas, and their status over the past 100 years. The changes in land use, and in people's attitude (towards commercial benefits) has affected the availability of various services, and consequently their usage. Use of bush food and medicine has declined, as many Aboriginal people do not have that traditional knowledge (and many non-Aboriginal people are not aware of wild food/medicinal plants). There are hardly any bush food and medicines available in the supermarkets or alternative medicinal stores. Moreover, with land development for pastoral activities over the last 100 years, the change in native vegetation has adversely affected the availability of many resources. There are upward trends in some ecological uses such as beef production, which has increased over the past years (ABS 1999-2000), though the condition of grazing systems has deteriorated (National Land and Water Resources Audit 2002). Recreational use of the natural environment has increased over the past years, especially for non-Aboriginal people, with establishment of National parks, while the cultural use of landscape for Aboriginal people has decreased since many people have lost rights to visit many areas of their traditional country to which they belong (Hill 1995).

5. A model to link ecosystem services with well-being of Aboriginal people in north Australia

We propose a model that highlights the relationships between various ecosystem services and Aboriginal well-being (Fig 5) (details of these relationships are discussed by Kaur 2006). There are multiple relationships, as each of the ecosystem services contributes to more than one component of well-being. For example, bush food and medicine contribute to provision of basic materials for life, good health, security of food and in social relations.

This model extends the MEA (2003) work in term of its application at local scale and is based upon information obtained from various sources (the EPA, NLWRA, and other references as described in section 3). It differs from the proposed MEA (2003) framework which considers various constituents of well-being with a strong focus on social perspective (as freedom, rights etc). Whereas, in the current model, all the well-being constituents are taken from the perspective of natural resources, showing how ecosystem services are related to well-being.

The model (Fig 5) includes the ABS socio-economic indicators, as these are considered a part of contemporary Aboriginal well-being. It is important to note that many standard socio-economic measures also relate to ecosystems services in one way or another with most such links are indirect. For example, economic resources such as income from the timber industry depend upon natural resources for the type of species, soil fertility, water availability and climate. However, these connections are merely forgotten when the commodity outputs are obtained from the industry since the sources of raw materials or the factors contributing to a commodity output remain largely unseen (Dasgupta 2004; Kaur 2006).

6. Discussion and conclusion

Ecosystem services inevitably play a vital role in human well-being. In fact both, humans and ecosystems are part of one system and are intricately linked with each other. The importance of ecosystem services in human well-being was ignored in the past mainly due to their abundance.

Recent studies emphasise the importance of ecosystem services for human health (Butler et al. 2005), cultural activities (Ramakrishnan 1996; Ramakrishnan et al. 2005), and for their overall monetary value for policy decision making (Costanza et al. 1998). However, in the absence of a holistic view, the importance of ecosystem services in the well-being of people is generally underestimated. It is important to translate these ecosystem values for well-being of people that can help them interpret the impacts of their activities on the environment for changes in well-being.

The MEA (2003) framework proposed the linkages between human well-being and ecosystem services. Although the framework proposed by MEA (2003) is thought-provoking, it does not suggest the methods that could be used to measure these linkages. The MEA reports on biodiversity (MEA 2005e) and general synthesis (MEA 2005f) highlight the complexities in linking ecosystem services with human well-being. The type of attributes and strength of these linkages, in fact, may vary according to the culture, geography and ecological conditions. The MEA framework could suit well for case studies, at a local scale, but could be difficult to apply at larger or national scales if there are variations in culture and regional landscape. However, this study highly recommends the need for the development of a holistic view: for a socio-economist to understand security beyond the political system in the context of natural resources, and for an ecologist to value ecosystem services according to people's needs.

There are studies published recently that apply the MEA (2003) framework and highlight the complexity and diversity of relationships between ecosystem services and human well-being, and suggest the need to evolve appropriate tools and methods to evaluate such relationships. Pereira et al. (2005) studied such linkages for a rural community of Sistelo in northern Portugal using participatory rural appraisal and rapid rural appraisal and some other field methods (observation, semi-constructed interviews, ranking exercises etc.). In Sistelo, with land abandonment and youth migration to cities, there were declines in cultivated fields, the numbers of cattle, goat and sheep and a decline in forests, reduction of local food production whereas some components of well-being such as money to buy household items or for health services have improved. However, while people highly acknowledged the value of ecosystem services for health, natural beauty and tranquillity of life, there is no measure of strength of such linkages. The application of the MEA (2003) framework, with some modifications, to Aboriginal people in the northern region has proved useful in suggesting the linkages between two integral components of this ecosystem i.e. people and the savanna ecosystem.

The present study combined the ecological attributes with the standard socio-economic attributes of well-being to assist socio-economic institutions develop a socio-economic-ecological perspective of well-being. However, the relative importance of various attributes of well-being vary according to the community. Such a list of indicators could be useful for ABS to improve the current list of well-being measures, however there are issues for methods to measure such ecological attributes. In 2005, the ABS applied MAP (Measures of Australia's Progress; ABS 2005) to measure the quality of life, which included some environmental attributes such as number of threatened species, areas of land cleared, salinity area etc., in addition to socio-

economic attributes. However, these measures did not include the value of a landscape from people' perspective and missed cultural, identity and spiritual values of the natural environment which are directly connected to people' lives. By understanding the importance of ecosystem services in well-being of people, as demonstrated in the proposed model, this study will help develop policies on land use and management to ensure the availability of ecosystem services for people. A similar framework could be applicable to other regions where people directly value ecosystem services and goods in their lives.

A recent study by Rapport and Singh (2006) suggests the inclusion of ecohealth-based indicators to highlight the interdependencies of human and environment. Similarly, for the ABS, this study can help to identify some measures for ecosystem services (based upon ranking) to incorporate in the standard list of well-being measures.

Integrating well-being and ecosystem services helps people to realise the value of natural systems and the consequences of their adverse actions. The work reported by MEA (2005a and b) explained that the ecosystems have been changed significantly over the past 50 years, and these changes can adversely affect human well-being. The results are alarming and suggest for the need to conserve the natural ecosystems.

Clarkson et al. (1992) 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 natural environment.

Acknowledgements

Our thanks to the Cooperative Research Centre for Tropical Savannas (CRC-TS) and James Cook University Townsville, Queensland, for providing funds and infrastructure respectively. Feedback from Prof. Walter V. Reid (Director, MEA) and Prof. Kanchan Chopra (Panel member, MEA) while developing the proposal is acknowledged. Our sincere thanks to the reviewers for their constructive feedback that helped improve the manuscript.

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