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Survey

Ecosystem services and Australian agricultural enterprises

Harpinder S. Sandhu [a,*], Neville D. Crossman [a], F. Patrick Smith [b]

[a] CSIRO Ecosystem Sciences and Sustainable Agriculture Flagship, PMB No. 2, Glen Osmond, SA 5064, Australia
[b] CSIRO Ecosystem Sciences and Sustainable Agriculture Flagship, Private Bag 5, PO Wembley, WA 6913, Australia

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ABSTRACT

The role of ecosystem services in agro-ecosystems is often poorly understood by those in agricultural production. Yet food production, itself an ecosystem service, is critical to the survival of humanity and dominates much of the world's terrestrial and marine environments. There is a need to address the under-estimation of ecosystem services in farmland and develop concepts, policies and methods to evaluate them. In this paper, we develop a conceptual framework and consult with agro-industry experts to identify the impacts of different agricultural practices on ecosystem services. We also identify the ecosystem services crucial to the long term functioning of agroecosystems in Australia. Our results demonstrate that the regulating ecosystem services are the most relevant to all of the agriculture sectors we examined. Most concern is the recognised impact that the agricultural sector has had on ecosystem services provision. Results from our survey indicate that the agricultural sector in Australia negatively impacts on all regulating and supporting ecosystem services, despite the importance of these services in the process of agricultural production. We conclude with various policy arguments for better and more explicit recognition of ecosystem services in the management of agroecosystems.

1. Introduction

Natural and modified ecosystems sustain human life through the provision of ecosystem services which includes the production of food, fibre, freshwater supply, soil regeneration, nutrient cycling, flood control and crop pollination (Costanza et al., 1997; Daily, 1997; MEA, 2005). However, there has been a recent trend of decline in ecosystem services globally with 60% of the ecosystem services examined having been degraded in the last 50 years (MEA, 2005). Global efforts to halt this decline in ecosystem services have increased considerably since the completion of the Millennium Ecosystem Assessment (MEA) in 2005 (Daily et al., 2009). The United Nations has established the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services to translate science into action worldwide in consultation with governments and research partners (IPBES, 2010). The Economics of Ecosystems and Biodiversity (TEEB) is one of the initiatives to study the economics of biodiversity loss and is hosted by the United Nations Environment Programme (TEEB, 2010). The TEEB study aims to estimate the economic value for natural ecosystems in order to inform policy to develop schemes or mechanisms for the rewards or payments for ecosystem services (FAO, 2007; Farley and Costanza, 2010; Muradian et al., 2010; Pagiola and Platais, 2007; Wunder, 2005). The concept of ecosystem services has been explored in Australia to guide policies and programmes through the National Strategy for Ecologically Sustainable Development (Cork et al., 2007). There are a number of studies that identify, classify and provide information on the valuation of ecosystem services relevant to Australian ecosystems (Cork et al., 2001, 2002; Crossman et al., 2010; Wallace, 2007; Zander and Garnett, 2011; Zander and Straton, 2010).

Agriculture contributes about 4% annually to the national GDP of Australia and is the single largest source of employment (DFAT, 2009). The success of conventional agriculture in Australia and worldwide is based on provisioning ecosystem services, particularly food and fibre. However, the expansion of these marketable ecosystem services has resulted in the degradation of other valuable and essential ecosystem services such as climate regulation, water regulation, biodiversity and soil erosion protection (Porter et al., 2009). Enhancing the supporting and maintenance ecosystem services is vital to meet the food demands of a population forecast to reach 9 billion by 2050 (UN, 2004).

There are only limited government policies encouraging farmers to provide either market or non-market ecosystem services (Ribaudo et al., 2010; Zander and Garnett, 2011). Furthermore, harmful agricultural impacts on ecosystem services are not well understood by farmers (Sandhu et al., 2007). Determining the impacts of farming on ecosystem services and measuring their impacts on human welfare in both qualitative and quantitative terms are necessary for establishing land management practices that enhance the provision of ecosystem services in agroecosystems (Swinton et al., 2007). Declining natural resources and ecosystem services can have serious consequences for agribusinesses

* Corresponding author.
E-mail address: Harpinder.Sandhu@adelaide.edu.au (H.S. Sandhu).

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and societal welfare in general, as well as posing a large risk to the well-being of rural populations highly dependent on land based industries.

Despite growing interests in ecosystem services provided by agroecosystems there is lack of general understanding of impact and dependence of ecosystem services in agricultural enterprises. Some global studies measured impacts of agriculture production on ecosystem services (Bjorklund et al., 1999; Dale and Polasky, 2007; Sandhu et al., 2008; Tilman et al., 2001). However, they are relevant to the production systems rather than the agricultural enterprises. Moreover, it would be useful to have the ability to explain and measure impacts and dependence of ecosystem services relevant to different agricultural enterprises. This would provide information on negative impacts on ecosystem services that can be taken into account for tracking changes in agricultural activities (Dale and Polasky, 2007; UNEP, 2011).

In this paper, we develop a conceptual framework that explains the dependence and impacts of ecosystem services within a set of common agricultural sectors in Australia. The rest of this section deals with an economic arguments for the valuation of ecosystem services in agroecosystems. In Section 2, we develop a conceptual framework after reviewing current literature on the typology of ecosystem services. Section 3 discusses different agricultural enterprises in Australia. In Section 4, we consult with key science, policy and industry stakeholders to identify individual ecosystem services associated with agroecosystems. It also examines the dependence and impacts of ecosystem services within a set of agricultural enterprises. In Section 5, we present the results of this study on how dominant agricultural enterprises in Australia depend on and impact on various ecosystem services and inform the development of the conceptual framework. Section 6 discusses various policy arguments for better and more explicit recognition of ecosystem services in the management of agroecosystems. We conclude with options to manage ecosystem services in agroecosystems to maximise private and public benefits.

1.1. Economic Arguments for the Valuation of Ecosystem Services in Agroecosystems

Ecosystem services in agroecosystems have been demonstrated to be of high value at farm, regional and global scales (Porter et al., 2009; Sandhu et al., 2008). These studies provide marginal values of key ecosystem services on farmland. Marginal value is the price that a consumer is willing to pay for an additional unit of the service. For example, pollination is an important ecosystem services for horticulture, with honey bee hives often imported into the farm to provide this service. The price that farmers are willing to pay to hire a bee hive is equivalent to minimum expected increase in yield which translates to an economic value of pollination.

Ecosystem service values can then be used to quantify economic trade-offs in productive landscapes (House et al., 2007; Pascual and Perrings, 2007; Raudsepp-Hearne et al., 2009) because management changes that improve land practices may come at a cost. A financial incentive that encourages the uptake of ecosystem services is the payment for ecosystem services (PES) to private landowners (FAO, 2007; Muradian et al., 2010; Pascual et al., 2010). In this approach, those that benefit from the provision of ecosystem services make payments to those that supply them, thereby maintaining ecosystem services. The current focus of PES is on water, carbon, and biodiversity in addressing environmental problems through positive incentives to land managers (Kumar and Muradian, 2009; Shelton and Whitten, 2005; Stoneham, et al., 2003). The focus tends to be on preservation of tropical forests in developing countries, with only limited examples in modified agroecosystems. For example, the European Union Common Agricultural Policy implies an ecosystem service enhancing role through support for extensification of farming, organic agriculture, and the conservation of landscapes and biodiversity (Rollett et al., 2008). However, a recent study has addressed the importance of a sub-category of agriculture related PES that focuses on socially valuable and threatened local plant and animal biodiversity to be termed as 'payments for agrobiodiversity conservation services' (PACS; Narloch et al., 2011). PES schemes in Australia could improve ecosystem service provision and ensure food security and long-term farm sustainability (Rosegrant and Cline, 2003). These schemes can help enhance and maintain regulating and supporting services which are vital for agricultural production.

There is a growing consensus that the industrial process, especially within the agriculture sector, depends on healthy and functional ecosystems for their supply chains and there is a need to implement ecosystem services decision making into management to avoid risks and to create new opportunities (Hanson et al., 2008). There is also growing recognition that ecosystem services degradation is not only a biological or ecological issue but has serious economic consequences (Dasgupta et al., 2000). Furthermore, the high variability and uncertainty inherent in agriculture could be amplified as ecosystem services decline and climate change further compound the problem (IPCC, 2007; Stern, 2006). This study will provide better understanding of the impacts and dependence of the agriculture sector on ecosystem services. This will assist to prioritise investment in ecosystem services provision in agroecosystems and design mechanisms to maintain and enhance their contribution to national and global economies (Goldman et al., 2007).

2. Typology of Ecosystem Services in Agroecosystems

The ecosystem services framework has been increasingly used to explain the interactions between ecosystems and human well-being. Several studies classified ecosystem services for natural ecosystems into different categories based on their functions (Costanza et al., 1997; Daily, 1997; De Groot et al., 2002). The Millennium Ecosystem Assessment sponsored by the United Nations assessed the consequences of ecosystem change for human well-being and provided a framework to identify and classify ecosystem services (MEA, 2005). It established the scientific basis for actions needed to balance nature and human well-being by sustainable use of ecosystems. It defined ecosystem services as benefits that humans derive from natural and managed ecosystems. Recent studies have contributed to further understanding of ecosystem services for natural resource management (Wallace, 2007), for accounting purposes (Boyd and Banzhaf, 2007), for valuation (Fisher and Turner, 2008) and for policy relevant research (Balmford et al., 2011; Fisher et al., 2008). Recent work by Sagoff (2011) points the differences in ecological and economic criteria in assessing and valuing ecosystem services and advocates for a conceptual framework to integrate market-based and science-based methods to manage ecosystems for human well-being.

Agroecosystems provide many ecosystem services, delivering public benefits (aesthetics, carbon sequestration, provision of cultural services) as well as private benefits (soil erosion control, biological control of pests/diseases, soil health, water regulation) (Abel et al., 2003; Cork et al., 2007; Sandhu et al., 2007). Some benefits, such as provision of food and fibre, are traded in market and are known as marketable ecosystem services whereas the benefits which are less tangible are classified as non-market ecosystem services. Non-market component of ecosystem services can be assessed by non-market valuation techniques (De Groot et al., 2002; Milne, 1991). It is important to understand both market and non-market value of ecosystem services to gain support for public investment in environmental schemes (Zander and Garnett, 2011). The market and non-market ecosystem services components in agriculture have been estimated to be of high economic value (Pimentel et al., 1997; Porter et al., 2009; Sandhu et al., 2008).

We use the MEA typology to define ecosystem services associated with agroecosystems in Australia (Fig. 1). The description of ecosystem services in the MEA is geared toward natural ecosystems. Therefore, based on recent literature (Antle and Valdivia, 2006; Boyd and Banzhaf, 2007; Cork and Shelton, 2000; Cork et al., 2001; Cullen et al., 2004; De Groot et al., 2002; Harrison et al., 2010; MEA, 2005;

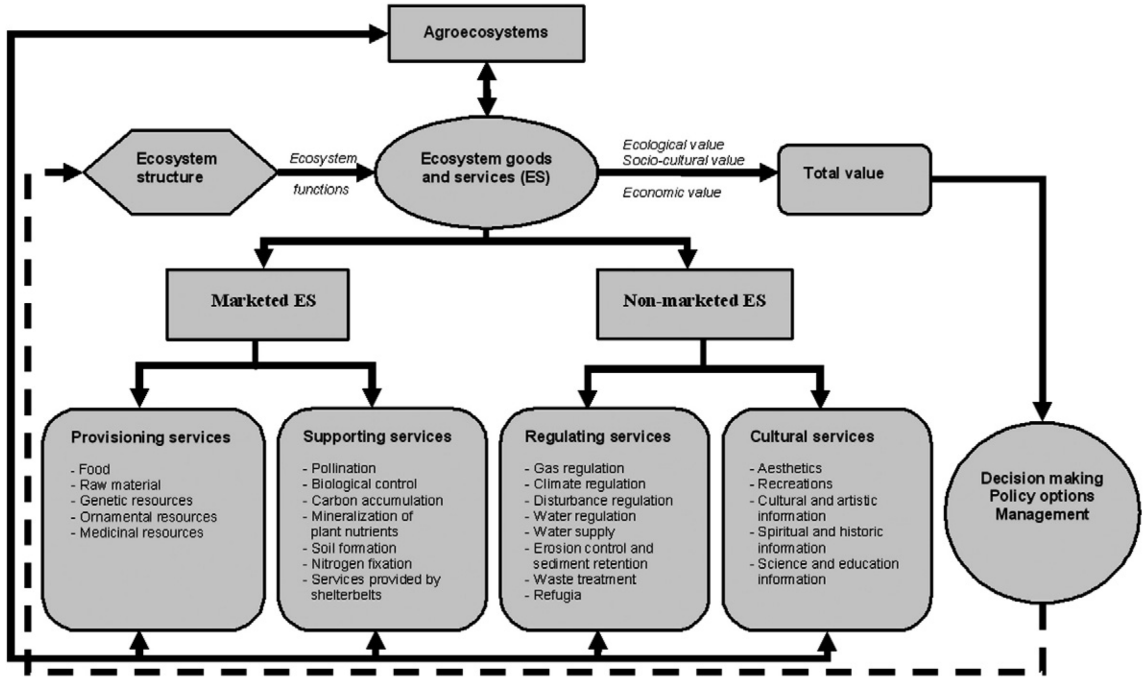

Fig. 1. Conceptual model of ecosystem services in agroecosystems (adapted from De Groot et al., 2002; Sandhu et al., 2007). Intensity of linkages is shown by regular and dashed lines.

Posthumus et al., 2010; Sandhu et al., 2008; Takatsuka et al., 2009; Wallace, 2007; Zhang et al., 2007), we have modified the MEA description to ensure relevance of ecosystem services to agroecosystems. Ecosystem services associated with agroecosystems in Australia were classified into the following four groups.

2.1. Regulating Services

Ecosystems regulate essential ecological processes and life-support systems through bio-geochemical cycles and other biospheric processes (Costanza et al., 1997; Daily, 1997). Key regulating services included in this study are gas regulation, climate regulation, disturbance regulation, water regulation, water supply, erosion control and sediment retention and waste treatment (Costanza et al., 1997; De Groot et al., 2002; MEA, 2005; Sandhu et al., 2007).

2.2. Provisioning Goods and Services

These include food and services for human consumption, ranging from food production, raw materials, genetic resources, ornamental resources and medicinal resources (De Groot et al., 2002; MEA, 2005). These goods and services are produced in agricultural landscapes by consuming some of the supporting and regulating services.

2.3. Cultural Services

Cultural services contribute to the maintenance of human health and well-being by providing recreation, aesthetics and education (Costanza et al., 1997; De Groot et al., 2002; MEA, 2005). These include aesthetic information, cultural and artistic information, spiritual and historic information and science and education information. Agriculture provides these services as some farmers conserve field-boundary vegetation or enhance landscapes by planting hedgerows, shelterbelts or native trees (Ciaian and Paloma, 2011; Drake, 1992; Garrod and Willis, 1995; Pruckner, 1995). Some farms provide accommodation and recreational activities for family members as well as for national and international visitors. Participation of farms in research and education also enhances this cultural service (Warner, 2006). Agricultural landscapes also have cultural heritage value.

2.4. Supporting Services

These are the services that are required to support the production of other ecosystem services. Examples of supporting ecosystem services considered in this study are pollination, biological control, carbon accumulation, mineralisation of plant nutrients, soil formation, nitrogen fixation and services provided by shelterbelts. In agroecosystems, they support food, fibre, feed and wood. Suppression of these supporting ecosystem services can lead to their substitution with external inputs as is the case in substituted agriculture where most of the supporting ecosystem services have been replaced by inputs or technology.

3. Agriculture in Australia

Sixty per cent of Australia's total land area is under agriculture, with the industry contributing 3–4% annually to the national GDP. The total value of agricultural production was $41.8 billion in 2008–09 with an export value of $30.98 billion (DFAT, 2009). The five dominant agricultural enterprises in Australia measured in terms of gross value of production, are:

3.1. Livestock Enterprise

Livestock production in Australia accounts for more than 45% of Australia's total value of agricultural production. Livestock production included 25.3 million heads of meat cattle, 72.7 million sheep and lamb, 2.3 million pigs and 82.8 million chickens (ABS, 2010). The value of livestock industry exports was $11.2 billion in 2008–09. Beef is the leading export commodity with 16% share in the total agriculture exports with a value of $4.9 billion.

3.2. Grains Enterprise

Annual grain production in Australia ranges from 15 to 40 million tonnes with wheat and barley being the highest with 21.4 and 8 million tonnes of production, respectively (ABS, 2010). The value of grain exports was $5.0 billion in 2008–2009. The dominant grains produced are wheat, barley, pulses, oilseeds and coarse grains. Wheat is Australia's second largest agricultural export commodity, with a value of $3.7 billion and 12.2% share in total agricultural exports (DFAT, 2009).

3.3. Wine Enterprise

Australia produced 1.71 million tonnes of wine from 157,000 ha area planted under vineyards in 2008–09 (ABS, 2010). The Australian wine industries contributed $2.5 billion to agricultural exports (ABS, 2010). Wine is the third largest with an 8.1% share of agricultural exports (DFAT, 2009).

3.4. Dairy Enterprise

The dairy industry in Australia includes 2.6 million milk cattle (ABS, 2010). It is also a major export industry yielding $2445 million in export income (DFAT, 2009).

3.5. Horticulture Enterprise

The horticulture industry produces about 1 million tonnes of fruits (citrus, apples, pears, bananas, etc.) and 2 million tonnes of vegetables annually (ABS, 2010). The horticulture industry includes fruits and vegetables yielding export income of $1.1 billion in 2008–2009.

4. Methodology

4.1. Data Collection

A group of 30 experts was selected after strategic sampling (Handwerker, 2005; Yin, 2003) from the list of experts who are leaders in the fields of agricultural sciences and ecosystem services associated with Australian research organisations, universities, government or industry. Experts from all five enterprises were shortlisted based upon their expert knowledge of these enterprises. The group comprised ecologists, economists, agricultural scientists, policy makers and private industry experts. A questionnaire was supplied to each expert and those who responded were further interviewed by phone or in-person. In the present work, although a larger sample size would be required for a full understanding of the ecosystem services in Australian agriculture, that used here is not uncommon of studies using this type of in-depth analysis (Abeyasekera et al., 2001; Atwell et al., 2011; Sandhu et al., 2007, 2010; Tyndall et al., 2011; Yin, 2003).

4.2. Semi-Structured Interviews

Interviews were conducted with 19 of the 30 experts in late 2008/early 2009 as other experts were not available during this time period. The topics for discussion in the interview were:

1. What do you understand by ecosystem services in general and in the context of Australian agriculture?
2. What are the current issues in Australian agriculture?
3. How can the ecosystem services approach address these challenges?

The interviews were recorded using digital audio recorder and later transcribed. Significant statements extracted from these transcripts were used as the raw data for analysis. NVivo 8 qualitative analysis software (Davidson and Jacobs, 2008; QSR, 2009) was used for identifying the significant statements. In accordance with the methodology suggested by Riemen (1986), meanings were then formulated from the significant statements. We used NVivo 8 to code individual's responses to the questions discussed in the interviews. We coded responses to understand how ecosystem services are defined by experts. These formulated meanings were arrived at by reading, re-reading, and reflecting upon the significant statements in the original transcription to get the meaning of the statements in the original context.

4.3. Relevance and Impact of Enterprises on Ecosystem Services

A written questionnaire supplied to each member of the expert group was used to assess relevance and impacts of enterprises on ecosystem services. Fifteen respondents returned the completed questionnaire. The questionnaire asked to assign relevance of each ecosystem service to each of the five enterprises (grain, wine, horticulture, dairy and livestock) on the Likert scale of 1–10 (1 — low; 10 — high) (Bernard, 2005). The impact (negative/positive/no impacts) of each enterprise on the provision of each ecosystem service was also recorded. The mean values were obtained from the responses for each of the 25 ecosystem services categories for five agricultural enterprises. Responses were pooled into three categories — low (1–3), medium (4–7) and high (8–10) for relevance and impacts and presented in graphic format.

5. Results

5.1. Understanding Ecosystem Services in Australian Context

Transcribed interviews of the19 members (based on profession) were grouped into the following 5 categories: i) ecologists; ii) economists; iii) agricultural scientists; iv) policy makers, and; v) agricultural practitioners or industry experts.

Ecologists consider ecosystem services as a tool to better understand the relationship between biodiversity and other functions of ecosystems (agroecosystems in this case) which helps to manage agroecosystems for multiple outcomes. They described ecosystem services as a concept applied principally to agroecosystems where there are production benefits from the environment, but also mentioned ecosystem services that natural environments provide without any additional production benefit. Economists on the other hand consider ecosystem services as benefits that farmers derive from managing agricultural landscapes. They define ecosystem services as the flow of benefits from the farmland, though not necessarily in financial terms. For agricultural scientists, ecosystem services are used as inputs for the sustainable production of food and fibre. Policy makers, in a similar vein to economists, consider ecosystem services as an integration of natural services which can provide benefits to farmers. However the policy makers we surveyed extend the benefits to the wider society. They regard agroecosystems to be more simplified but still useful in providing public benefits on top of the private benefits. Practitioners or industry experts consider ecosystem services as a valuable component for the sustainability of their industry and think the services should be managed in a holistic way.

5.2. Relevance and Impact of Enterprises on Ecosystem Services

In this study, most of the regulating and supporting services were found to be of medium level relevance to various agricultural enterprises (Fig. 2). Provisioning services (food production) was assigned medium relevance in all but the wine industry. Cultural services were also given low relevance. The impact of current agricultural services was found to be negative on most of the regulating and supporting services in all the industries. However, there was positive impact on provisioning and cultural services in general (Fig. 3).

Group members identified all regulating and supporting services to be of medium importance (mean 4–8) to livestock production. However, regulating and supporting services are thought to be impacted negatively by current livestock management practices. In this study, respondents identified six regulating and five supporting services to be of medium relevance (mean 4–8) to grain production. Respondents also thought that grain production was impacting

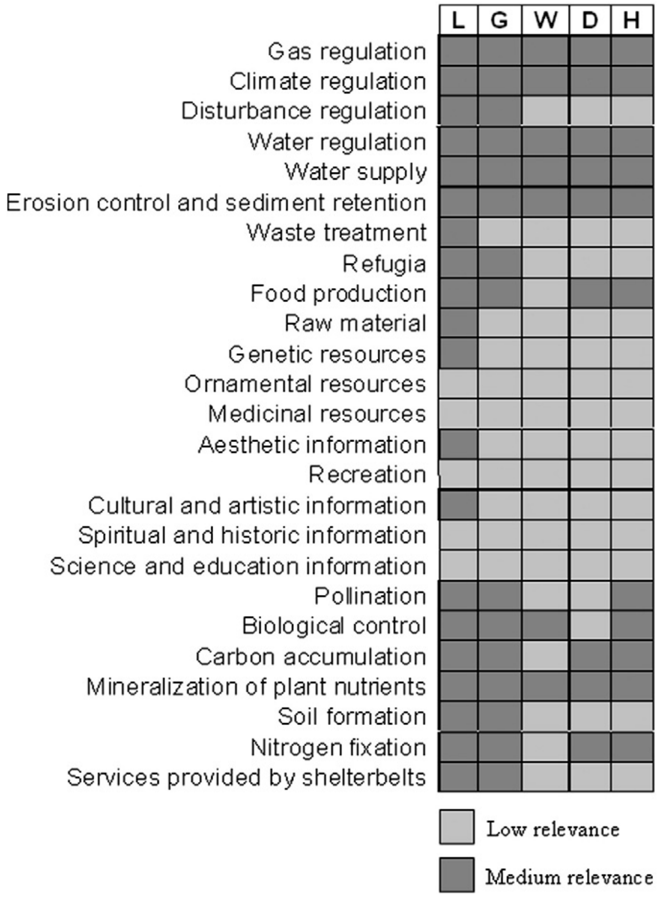

Fig. 2. Relevance of ecosystem services to different Australian agricultural enterprises. It is noteworthy that none of the ecosystem services got high relevance rating in this study. (L: Livestock industry; G: Grains industry; W: Wine industry; D: Dairy industry; H: Horticulture industry).

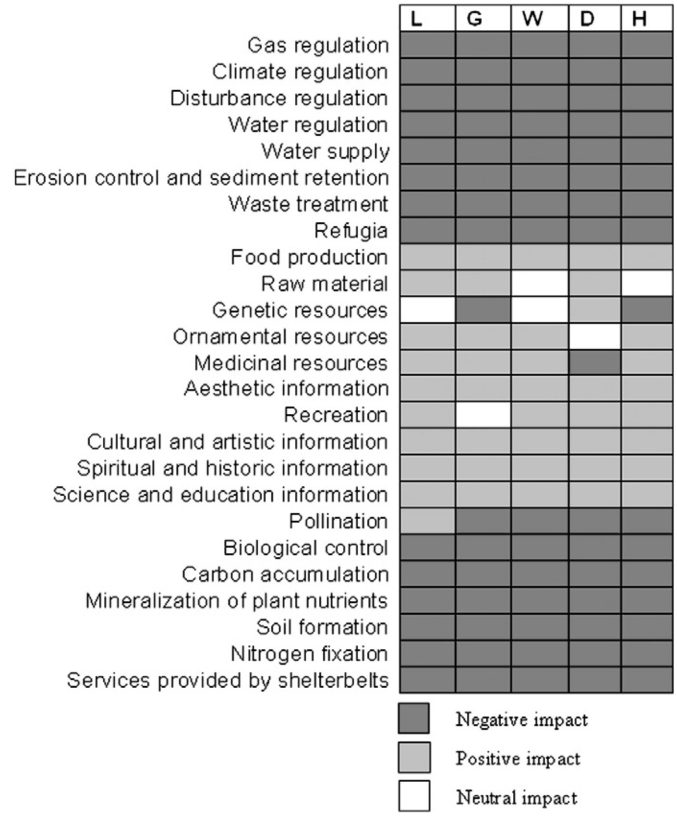

Fig. 3. Impact of current agricultural practices on ecosystem services in different Australian agricultural enterprises. (L: Livestock industry; G: Grains industry; W: Wine industry; D: Dairy industry; H: Horticulture industry).

negatively on these services. Five regulating and two supporting services were found to be of medium relevance (mean 4–8) to wine production. The existing practices within wine production, particularly grape growing are thought to have negative impacts on these ecosystem services but positive impacts on cultural services. Five regulating and three supporting services were found to be of medium relevance (mean 4–8) to the dairy industry. However, current practices are thought to have negative impacts on these ecosystem services except that of one provisioning services and cultural services.

6. Discussion

Agriculture is both a producer and consumer of ecosystem services and it can negatively or positively impact the level of ecosystem services provision under various land uses (Sandhu et al., 2007; Takatsuka et al., 2009). Planning that minimises the harm to and enhances the provision of ecosystem services in agriculture requires an understanding of the interplay between agricultural production and ecosystem services (Dale and Polasky, 2007). We have assessed the services that the major Australian agricultural enterprises depend on for production (Fig. 2). We also assess the services which are impacted on by the various forms of agricultural production (Fig. 3). As we now demonstrate, various ecosystem services are integral to high value agriculture. Furthermore, the ecosystem services framework provides a holistic decision-making tool within agroecosystems (Fig. 1). We argue that clear identification of the ecosystem services relevant to agriculture will help the sector overcome major natural resource management challenges such as degradation of soils, loss of biodiversity etc. (Cork et al., 2007).

6.1. Multiple Ecosystem Services Benefits

Agricultural production contributes substantially to Australia's GDP and is a large employer employing 370,000 people directly (ABS, 2010). However, climate change poses a significant challenge to production within all of the nations' agricultural enterprises (AGO, 2002; Kingwell, 2006). For example, predictions estimate that the most productive agricultural regions in the southeast and southwest of Australia face reductions in natural winter and spring rainfall of up to 40% under climate change (CSIRO and Bureau of Meteorology, 2007). Maintaining or improving the status of regulating services (gas regulation, climate regulation, water regulation and water supply), identified as relevant to all enterprises in our study, is a critical element of climate change mitigation and adaptation strategies (Howden et al., 2003).

Several supporting services, such as integrated pest management, pollination and soil carbon are relevant to and impacted on by agricultural production as observed in this study (Abel et al., 2003). The negative impacts on these supporting services exacerbate the risks posed by climate change and subsequent reductions in natural rainfall (CSIRO and Bureau of Meteorology, 2007). There are various on-farm practices that enhance supporting services and increase resilience to climate change. For example, zero-tillage and stubble retention promote soil carbon sequestration, which enhances the soil's capacity during dry periods but also mitigates climate change by reducing atmospheric carbon concentrations. Implementing integrated pest management practices reduces the use of pesticides by taking advantage of natural predator–prey relationships, which then reduces impact on natural pollinators, reduces water contamination, and lowers dependence on expensive fossil-fuel based inputs which will be more expensive under a market instrument to reduce carbon emissions. Adjusting land management practices can thus have multiple ecosystem service benefits and can buffer production against the forecast impacts of climate change. Improving regulating and supporting services can help to support multifunctional agriculture for the long-term sustainability of agricultural enterprises (Gliessman, 2010) as supported by various experts in this study.

6.2. Policy Responses

The framework we provide (Fig. 1) borrows from previous studies that focus on the interdependence of ecosystem services and humans within natural, unmodified landscapes. Our framework is unique because it identifies the processes that transform bio-physical function into benefit within agroecosystems. This benefit could be monetary (marketable ecosystem services) or non-monetary benefit (non-marketable ecosystem services) (Zander and Garnett, 2011). But as we show the benefits are complex because there are substantial interplays between services, natural resources and agricultural production (Figs. 2 and 3). Experts consulted in this study considered ecosystem services as benefits other than agricultural production. They argued that well-designed policy is needed to capture the full range of benefits

Various policy instruments have been designed to create demand for ecosystem services, such as cap and trade on carbon emissions (Tietenberg, 2006), wetland and biodiversity banking (Carroll et al., 2008), payments for ecosystem services (Kumar and Muradian, 2009; Narloch et al., 2011) and environmental certification (Wille, 2004). The primary aim of these instruments in agroecosystems is to generate public good ecosystem services on farmland for private benefit. Discussions with experts supported this view as they considered ecosystem services to extend the benefits to the wider society. For example, carbon markets provide an economic incentive for farmers to generate carbon credits and trade them in markets for private and public benefit. Environmental certification is aimed to provide agricultural producers with a market advantage that then commands higher prices for their outputs.

However, a minimum level of ecosystem services provision is required, such as some safe minimum standard, to support the direct marketable ecosystem services of food and fibre production. In our study, we have shown that the agriculture sector perceives ecosystem services as an opportunity to manage value chains, minimise ecological footprints and lower the input cost of alternative technologies. Agriculturalists have also considered adopting the concept of ecosystem services for compliance and regulation issues (Sandhu et al., 2012).

There is a much greater need to understand and implement measures to address erosion of ecosystem services in agriculture and food processing. Agroecosystems cover 1.54 billion hectares worldwide and an additional 0.4 billion hectares will be required to meet the food demand of growing population (Tilman et al., 2001). This has potential to increase agriculture's ecological footprint. The need to address the threats to ecosystem services is more acute in agriculture than in other ecosystems (Robertson and Swinton, 2005) so that agricultural land can increase the rate at which it provides vital multiple ecosystem services in addition to the production of food and fibre. The ecosystem services framework in Australia is fast becoming the policy basis for engaging farming communities and stakeholders in natural resource management issues such as conservation of remnant native vegetation, preventing species loss, and reduction of dryland salinity (Cork et al., 2007; Zander and Garnett, 2011). The framework presented in this study can provide useful information to guide policy for the multifunctional landscapes in Australia (Fig. 1).

An increasing number of business organisations are responding positively to the regulatory and voluntary market pressures to address the challenges of sustainability, natural resource management and ecosystem service provision (Hanson et al., 2008). Businesses which are more dependent on natural resources need to incorporate ecosystem services into their business decisions (Hanson et al., 2008). A number of Australian business organisations are using an ecosystem services framework to better understand environmental impacts and opportunities due to changing ecosystems (Sandhu et al., in press).

7. Conclusion

Agriculture depends on multiple ecosystem services. Furthermore, agricultural practices impact negatively on various ecosystem services, which may be the services it depends on for production. Appropriate management of heavily modified ecosystems is required to sustain ecosystem services while yielding high levels of food production. Our study identified the ecosystem services provided by five main agricultural enterprises in Australia. Our results can be used to prioritise efforts toward targeting the management of ecosystem services in agroecosystems typical of those in temperate climate regions of the developed world.

However, we suggest there are further avenues for research associated with ecosystem services in agroecosystems. Future research should target comparison of the output rate and value of each ecosystem services under alternative farming systems, the economic geography of ecosystem services and the spatial and temporal patterns of the value of ecosystem services.

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