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Economic evaluation of sustainable land management interventions

Framework to assess the Caring for our Country sustainable farm practices component

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Summary

Caring for our Country is Australia's flagship natural resource management program, of which a key objective is the promotion of sustainable farm practices. This report develops an economic assessment framework for the sustainable land management component of the program.

Government interventions, such as those under Caring for our Country, can be appropriate when the aggregate results of the choices made by landholders are not optimal from a social welfare perspective. This can occur when there are externalities, or when risk and uncertainty complicates decision-making.

Public policies on sustainable land management aim to address the spillover costs to society caused by these sources of market failure when the costs of intervention are less than the spillover costs themselves. Under Caring for our Country, this is achieved by bridging knowledge gaps, providing incentives for adoption of innovations and cost sharing that underwrites private risk in order to maximise social benefit.

Conventional use of economic evaluation approaches, such as benefit-cost analysis and cost-effectiveness analysis, is suitable for selecting programs before implementation, but has often proven impractical when rigorously evaluating programs after implementation. This is because distinguishing between the effects of an intervention and the effects of other factors is problematic.

Successful interventions should ensure that sustainable land practices become the rational choice of landholders. If this occurs farmers will seek to increase productivity in terms of environmental inputs and outputs, as well as conventional inputs and outputs. Productivity measured will thus reflect social benefit, regardless of how that benefit is distributed.

Consultation undertaken as part of this project provided useful insight into how interventions relate to farm business management decisions. Farmers adopt sustainable practices as a part of a package of measures to achieve business growth and resilience. For most landholders the objective is business competitiveness, achieved through activities that enhance productivity and risk management.

In this report we propose a framework that can estimate agri-environmental productivity from data sourced from ABARES and Caring for our Country programs, and decompose the estimate into various components to identify the effect of interventions on farm productivity. Such an assessment could offer a robust basis to assess the benefits of overlapping government programs designed to influence landholder behaviour.

A pilot study could be implemented to test the feasibility of the framework and identify any problems before wider implementation across Caring for our Country programs.

While this paper focuses on sustainable land management practices, the methods proposed will work equally well for fisheries and forestry enterprises, where appropriate data is available.

1 Introduction

Purpose

The purpose of this document is to develop a methodological framework for an economic assessment of the sustainable farm practices component of the sustainable agriculture stream of Caring for our Country (Australian Government 2012).

Caring for our Country, the Australian Government's flagship natural resource management program focuses on better management of Australia's environment and natural resources. It aims to provide leadership and guidance to secure multiple outcomes across environmental priority areas, particularly those requiring national coordination.

In the first phase of the program, from July 2008 to June 2013, the Australian Government directed \$2.25 billion toward strategic objectives. In phase two of Caring for our Country, which will run from 2013 to 2018, the program will be divided into two broad streams focused on sustainable agriculture and sustainable environment. The agriculture stream is the focus of this report.

The strategic objectives for the sustainable agriculture stream for the next five years are:

- sustainable production of food
- innovation in Australian agriculture and fisheries practice
- reduced impact of weeds and pests on agriculture
- improved management of agriculture and fisheries and the natural resource base
- skilled and capable Landcare community.

The goal of the sustainable agriculture stream is 'to optimise the health and productivity of agricultural landscapes and recognise the contribution that communities make to managing and improving these landscapes' (Australian Government 2012).

These outcomes are delivered through public-private partnerships, including regional natural resource management groups, local, state and territory governments, Indigenous groups, industry bodies, land managers, farmers, Landcare groups and communities.

There have been a number of formal evaluations and critiques of natural resource management policies have examined administrative arrangements, accountability and the effectiveness of program delivery (ANAO 1997; Caring for our Country Review Team 2011; HC Coombs Policy Forum 2011; Pannell & Roberts 2010). However, a formal economic evaluation of the social benefits and costs of Caring for our Country has not been conducted. Because up to 70 per cent of Australia's landscapes are managed by farmers such an assessment would need to focus on the sources of costs and benefits of implementing agri-environmental policy that seeks to provide public good environmental benefits on private land.

Objectives of this report

This report provides a conceptual framework for assessing the benefits and costs of government interventions designed to increase joint production of environmental and agricultural outputs

on private land that collectively contribute to social well-being. The authors acknowledge the difficulty of accurately assessing the contribution of public and private expenditure in the provision of environmental outcomes sought by society.

Landholder consultation undertaken as part of this project and for previous studies indicate that the primary motivation of farmers for taking up natural resource management improvements is to maintain and enhance farm productivity and resilience (Ecker, Kancans & Thompson 2011; Mallawaarachchi & Szakiel 2007). The framework proposed in this report therefore focuses on monitoring the benefits of programs in terms of agri-environmental productivity. Implications for program management and evaluation are considered.

Policy issues in sustainable land management

Problems of sustainable management of environmental resources are complex; they are characterised by externalities and public goods, complicated by incomplete knowledge and are difficult to manage due to the uncertainty and complexity inherent in natural ecosystems and processes. Environmental benefits are particularly difficult to account for and the costs and benefits may be distributed across different entities and different time spans. In 2006–07, 94 per cent of Australian agricultural businesses reported undertaking natural resource management activities to prevent or manage weeds, pests, and land and soil at a cost of around \$3 billion, or \$21 094 per agricultural business (ABS 2008). However, uncertainty relating to the benefits to farm businesses can diminish the incentive for private landholders to invest in some natural resource management activities.

Examples of agricultural production externalities include non-point source pollution entering the Great Barrier Reef, soil erosion from exposed cropping land, or induction of salinity on irrigated land. Although the actions of individual land users can affect the wellbeing of the broader community, the consequences are not immediately reflected in the costs or returns faced by land users. Each land user may only emit small amounts of undesirable by-products; however, at a catchment or regional scale, or over time, they collectively may generate significant levels of material sufficient to cause environmental harm (Mallawaarachchi, Mazur & Lawson 2007). Market failures can arise from the presence of externalities, the lack of clearly defined property rights and the absence of balanced and complete information. From the view of society as a whole, the outcomes these lead to can be inefficient.

These externalities can be addressed through changing land uses and land management practices, such as the adoption of new technology, but this presents some challenges. Land use change is costly and involves risks relating to investment in learning and from any capital costs that need to be recovered over time (Dixit & Pindyck 1994). Uncertainty about costs and benefits, including switching costs and whether it is worth waiting for better technology, can mean the level of technology adoption may be undesirably slow from a public interest viewpoint (ABARE 2005). This viewpoint has led governments to introduce policies to encourage adoption of practices that generate public benefits where it is deemed that privately optimal adoption rates will not lead to publicly optimal conservation outcomes. Sustainable land management policies follow this rationale.

Public policies on sustainable management, such as Caring for our Country, aim to achieve socially optimal outcomes by bridging knowledge gaps, providing incentives for adoption of innovations and cost sharing to underwrite private risk in order to provide public good environmental benefits. While these policies are desirable where they can mitigate the risk of social costs, it is also in the public interest to ensure that the benefits of government interventions exceed the costs.

Governments should support only those programs that are economically efficient, where social benefits exceed social costs—irrespective of who bears those costs.

Program objectives of the Caring for our Country sustainable agriculture stream

In *Caring for our Country: an outline for the future*, the Australia Government describes the objectives of the sustainable agriculture stream:

[It] will focus on increasing the sustainability of agricultural production. Farmers manage up to 70 per cent of the Australian land mass and their actions have direct implications for the Australian community.

Healthy, productive and resilient agricultural landscapes are fundamental to the provision of a range of ecosystem services, continuing sustainable food and fibre production and the sustainability of rural and regional communities.

Caring for our Country aims to optimise the health and productivity of agricultural landscapes and recognise the contribution that communities make to managing and improving these landscapes (Australian Government 2012).

The achievement of these goals will focus on five strategic objectives:

- sustainable production of food
- innovation in Australian agriculture and fisheries practices
- reduced impact of weeds and pests on agriculture
- improved management of agriculture and fisheries and the natural resource base
- skilled and capable Landcare community.

Sustainable production of food

The program will support the role of sustainable and productive farms and fisheries to deliver multiple ecosystem services and act as stewards of a healthier and more resilient natural resource base.

Strategic industry partnerships and the uptake of sustainable and innovative practices will be supported to allow production sectors to meet future demand for food and fibre without compromising the natural resource base.

Innovation in Australian agriculture and fisheries practices

The program will support and promote innovation so that the agricultural and fisheries sectors will be better placed to respond to changing circumstances. It will provide investment for development, testing and adoption of innovative practices so that production sectors have access to tools, knowledge and skills needed to meet the challenges for their industry.

Reduced impact of weeds and pests on agriculture

Weed and pest management will move to national surveillance, coordination and extension for weed and pest management. This aims to mitigate the significant threat to Australia's agricultural production and to the size and quantity of agricultural yields.

Improved management of agriculture and fisheries and the natural resource base

The program will focus on integrated natural resource management outcomes, recognising the reciprocal links between a sustainable and productive resource base and healthy, resilient and productive landscapes. Innovation in sustainable agriculture and adoption of better practices by farmers and fishers will focus on reducing impacts such as run off of nutrients and bycatch.

Skilled and capable Landcare community

The program will support on-ground Landcare activities and the introduction of support mechanisms for training, capacity building and leadership development.

This will contribute to engaging the community, supporting collaboration, providing information, and building community capacity and leadership to implement and promote the systems and processes necessary for sustainable, profitable and productive agriculture.

The sustainable agriculture stream covers the provision of sustainable farm practices, which is the topic of this report. In this context, this report interprets the objectives of the stream as being the encouragement of private investment in on-farm activities to maintain and improve farm productivity in the long run.

2 Economic evaluation of sustainable land management interventions

This chapter outlines some key issues relating to economic assessment of public expenditure programs such as Caring for our Country.

Accounting for economic benefits

Evaluation of a public expenditure program must articulate and account for all sources of costs and benefits so that net economic benefits can be estimated.

Conventional approach

Economic evaluation of environmental interventions has taken the form of either benefit-cost analysis, or cost-effectiveness analysis. Decision support tools for developing and prioritising projects aim to facilitate application of these techniques; an example is the Investment Framework for Environmental Resources (Future Farm Industries CRC 2011; Pannell et al. 2012).

Although both benefit-cost analysis and cost-effectiveness analysis approaches are useful in prioritising expenditure *ex ante* (before implementation), as commonly practiced they are not practical for a rigorous *ex-post* (after the fact) analysis of sustainable land management interventions. Nor is the conventional approach entirely suitable for evaluating whether practices are truly sustainable in economic and environmental terms. Often the impact of policies is overstated because behavioural changes that sustainable land management interventions intend to create are also influenced by a host of other factors besides the intervention itself.

Benefit-cost analysis involves two components. First, the social costs of a policy are measured in dollar terms; including direct financial outlays, opportunity costs and other administrative costs. These are then compared with the social benefits of the policy, again measured in dollar terms, including both direct and indirect benefits. The appeal of benefit-cost analysis is that by monetising the costs and benefits of the policy, it is possible to compare different kinds of benefits with one another, and with the costs of implementing the policy. This works easily when the program scope can be specified and outcomes clearly enumerated to identify costs and benefits accruing to different parties, as is usually the case for well-specified projects that make up a program.

In the case of environmental goods, it can be difficult to monetise benefits and determine who is receiving them. A variety of techniques have been developed, including hedonic pricing, contingent valuation and choice modelling; however, there remains a large aspect of subjectivity to the analysis, so a relatively high level of uncertainty remains (Box 1). For example, future benefits are usually discounted in the analysis and the selected discount rate requires judgement about how we value enjoyment of the environment by future generations relative to our own welfare.

Cost-effectiveness analysis avoids some of the difficulty in valuing environmental benefits by instead focusing on how effective alternative approaches are in achieving a given outcome at minimal cost. Cost-effectiveness analyses perform well when the objectives of a public policy have been identified and the task is to find the least cost option of achieving the objectives. In that respect, cost-effectiveness analysis does not seek to determine whether the policy is

justified, in the sense that its social benefits exceed its social costs. An example would be to compare the costs of different policies to achieve an additional unit of native vegetation.

Both approaches are important for *ex-ante* (before the fact) analysis to guide initial funding towards the most appropriate endeavours. However, they are often reliant on assumed counterfactuals—what would have happened in the absence of the policy. In some cases the *ex-ante* situation is used as a baseline, but in reality the counterfactual world will also be shaped by many factors, including technological change, climatic variability, changed commodity prices and overlapping interventions. The effects of these factors are often both unpredictable and frequently not obvious even after the fact.

Box 1 Valuing environmental goods and services

The concept of total economic value illustrates how, when policies involve tradeoffs between market goods commonly valued in dollar terms and ecosystem services that are not traded in markets, economic analysis can allow a more informed assessment of tradeoffs based on individual preferences for nature (Mallawaarachchi et al. 2001).

The total economic value of a natural resource includes both use and non-use values. Use values involve direct consumption of various attributes of a resource and include indirect use values (for example, when a resource has positive impacts on other resources such as the atmosphere and hydrosphere) and the option value of retaining the resource for possible use at some future date. Some values may be independent of the consumption or functioning of a resource. Existence values arise when individuals value the mere continued presence of a resource in its current or natural state. Bequest value occurs when benefit is derived from the knowledge that a resource will be available to provide existence value to future generations.

Because these different entities of value are not mutually exclusive, care needs to be taken to avoid double counting when aggregating values.

Economic assessment of ecosystem values attempts to provide people with an empirical value of the services and amenities derived from ecosystems (Randall 2002). Approaches include willingness-to-pay and bio-economic modelling. These approaches focus on understanding the relative costs and benefits of using available resources. In the absence of direct market prices, willingness-to-pay can be derived by observing indirect costs that users are prepared to pay to enjoy the resource. For example, using the travel costs approach to estimate visitor benefits or, in the hedonic pricing method, using nearby property prices. Alternatively, particularly for non-use values, carefully designed surveys are used to derive estimated monetary values of environmental benefits arising from natural resources, either by asking directly (as in the contingent valuation method) or by asking respondents to choose between hypothetical scenarios (the increasingly popular choice modelling method).

The role of economic valuation in environmental decision-making depends on specific criteria used to choose among policy alternatives. If policy choices are based primarily on intrinsic or moral values, quantifying environmental values through economic valuation has little or no role to play. Economic values of environmental resources become particularly useful when policymakers consider tradeoffs in terms of benefits and costs of alternative policy decisions; for example, recognising the value of foregone options where benefit-cost approaches implicitly attribute a zero value (Mallawaarachchi & Quiggin 2001).

Furthermore, applied to broader natural resource management policy implementation, cost benefit and cost-effectiveness analysis seek to guide practitioners into thinking in terms of attribution of costs and benefits of interventions designed to address externalities to different parties; in particular, costs to governments, and the collective benefits to society in contributing to environmental public goods. By contrast, sustainable land management interventions are designed to increase the aggregate net benefits of production land use, including costs and benefits to government, landholders and everyone else. This means that conventional approaches may not acknowledge all the effects that policymakers consider important. If programs successfully internalise positive and negative externalities, the result should be greater output of all society's goods relative to inputs, taking into account both environmental and conventional inputs and outputs. This means programs can be evaluated in terms of their net productive benefit, without needing to consider who in particular benefits.

An alternative approach for *ex-post* (after implementation) analysis is to measure the net agri-environmental productivity benefits associated with sustainable land management interventions. These interventions have important outcomes for landholders, governments and society. If these interventions successfully internalise externalities as intended, the outcome would be greater agricultural and environmental outcomes taken as a whole, relative to total inputs committed. As such, agri-environmental productivity change (total output growth relative to total input growth) can be used to measure the aggregate improvement in outcomes for society.

A way forward

Limitations in previous approaches to economic evaluation have led many commentators to cast doubt on the efficacy of Australian Government environmental expenditure (Pannell & Roberts 2010; Pannell et al. 2012; Thorburn & Wilkinson 2012). A factor that is often ignored in such discussions is the purpose of these interventions, which is to change behavioural patterns in a way to mitigate socially undesirable externalities of legitimate production activities. This is really a mechanism design issue in policy planning.

A robust approach to assessment of the social benefits of sustainable land management interventions would recognise this policy intent and seek to assess whether businesses are managing the use of natural resources and other business inputs so as to minimise total costs, including to the environment. In doing so, as joint producers of agricultural and environmental outputs, their role would be better recognised and environmental management would become an integral part of normal business motivations.

Business owners would be led to change their behaviour to incorporate sustainable practices as part of a package of measures they undertake to achieve long-term business resilience. These are captured in a set of three interconnected and closely related objectives:

- business competitiveness—through profitable business practices
- risk management—through diversification of sources of income
- productivity—through efficient use of resources.

Although a practice must satisfy all three objectives to be adopted, primarily it is through productivity improvements that sustainable land management interventions influence changed behaviour. By encouraging businesses to explicitly account for environmental inputs and outputs alongside conventional inputs and outputs in their production decisions, the interventions are intended to promote the production of agricultural as well as environmental goods, rather than changing from one to the other. Where joint production is not feasible or economically viable, programs offer incentives for businesses to make appropriate trade-offs to produce a bundle of goods and services more highly valued by society.

Attribution problem

In evaluating public programs, irrespective of the approach used, an important consideration for monitoring and evaluation is to identify outcomes of the intervention from what would have happened in its absence. That is, a credible counterfactual needs to be defined.

The outcomes sought are similar across a number of sustainable land management interventions because they collectively follow similar broad objectives. These interventions include Caring for our Country and other related government programs, such as those listed in Table 1.

Outcomes sought in these programs broadly fall into two categories:

- on-farm improvements, such as soil moisture conservation, tillage practices and nutrient management
- landscape scale improvements, such as vegetation management and salinity management.

These programs seek to provide financial and other incentives for landholders to offer environmental services. Financial incentives seek to compensate landholders for the agricultural income they have foregone in providing these services; incentives may take the form of direct support or reduced costs. Without financial incentives, landholders would have only a limited incentive, such as that arising from broader duty of care or social and moral responsibility, to take up certain practices. This means the rate of adoption of new practices or innovations are influenced by relative private benefits to landholders and that achieving a socially optimal level of adoption could involve significant time lags.

This reasoning is supported by consultations with stakeholders performed for this report and prior research conducted in this area. For example, the 2010 ABARES Drivers of Practice Change Survey found that financial and environmental factors rated highly as motivations in land management practice decisions (Ecker, Kancans & Thompson 2011). Additionally, farmers with lower value agricultural output are more likely to change practices where environmental benefits exist. For example, participation in the Higher Level Stewardship Scheme in England was found to be negatively related to cereal yields (Quillérou, Fraser & Fraser 2011), indicating that farmers who self-select to participate in environmental programs are those who will forgo lower value activities by participating.

Table 1 Key rural policies influencing farm productivity

Policy	Carbon Farming Initiative	Natural Resources Management Policy	National Water Policy	Productivity policies
Key elements	- Tradeable carbon offsets - Incentives for sustainable farming - Funds for landscape restoration	- Sustainable land management - Biodiversity - Landcare	- National Water Initiative agreement - Basin Plan - Environmental Water Holder infrastructure investment, etc.	- Drought policy - R&D policy - Farm support policies
Common themes	- Market-based instruments - Stewardship payments - Information and capacity building - Standards and contracts - Collaboration and cost sharing			- Income support - Innovation - Self-reliance

Because of these broader behavioural incentives and the range of behavioural patterns that can be expected from a heterogeneous group of landholders, an *ex-post* (after the fact) analysis could determine the extent to which the program has contributed to improving business resilience through increased productivity. This would put the focus on the direction and patterns of change shown by different program participants for comparison with non-participants.

A carefully designed *ex-post* assessment of agri-environmental productivity will allow a comparison of performance between landholders in areas where a program has been in place with those where it has not, and in many cases will be more cost effective and practical than a conventionally undertaken benefit-cost analysis. To some extent, this enables the effects of the program to be distinguished from effects that would have occurred anyway. Additionally, an evaluation would consider whether changes contribute to business resilience under a range of alternative circumstances that are beyond farmers' control.

Framework design

The framework design involves a number of steps. First, a framework for *ex-post* evaluation is defined, comprising criteria for making evidence-based judgements and recommendations to improve program design. An evidence base for program outcomes must then be established that encompasses both quantitative and qualitative information.

The selection of relevant evidence should be guided by a conceptual model of the various causal pathways through which the intervention is expected to operate, key links in the expected chain of effects, and the outcomes expected. Ideally, this conceptual underpinning should be implicit in the design of the policy and would have already been elaborated and tested for internal consistency during an *ex-ante* evaluation of the intervention. The crucial role *ex-post* is to make an appropriate choice of what evidence to review and what criteria to use for assessing program success (Burrell 2011).

A key challenge in determining the success of sustainable land management is uncertainty about costs and benefits. Consequently, evaluation of economic benefits requires a framework that can accommodate uncertainty, particularly about what changes would have occurred without the policy. The primary challenge relating to public investment to provide public goods on private land is to design programs that encourage innovation that would not otherwise have occurred. This notion of additionality is important to generate private and spillover returns large enough to exceed the total costs, including costs to governments. This is related to the rationale that governments should support only those programs that are economically efficient in the sense that social benefits exceed social costs, but where the inability to capture benefits privately, or other constraints, makes them not attractive for private investors.

This approach to economic assessment is only appropriate for determining the cumulative impact of on-farm improvements such as those in the sustainable agriculture stream of the Caring for our Country framework for 2013–18 (Australian Government 2012). This is because an *ex-post* economic assessment is unlikely to be useful in determining the social benefits of government intervention in activities under the sustainable environmental stream that have a broader landscape scale focus. Landscape scale activities have longer-term sustainability goals and are more consistent with community values for conservation rather than private values for production. Non-use values (Box 1) will predominate, and these are difficult to estimate with the degree of precision at this scale that is relevant for national policymaking. Cultural and ecological factors in landscape management that are valued by the community are best considered through other collective decision-making processes.

3 Proposed approach

This chapter outlines an approach based on assessment of the productivity benefits of land management interventions designed to guide economic evaluation of the Caring for our Country agriculture stream programs.

Assessing the impacts of sustainable land management interventions on farm productivity

This approach is designed to assist evaluations at a program level, rather than at an individual project level.

The approach

The proposed approach to economic assessment aims to identify the effect of interventions on agri-environmental productivity in terms of net social value, rather than taking a narrower view of private or public benefits. That is, the assessment will determine whether an intervention has increased output of agricultural and environmental goods and services relative to both conventional and environmental inputs.

To compare agri-environmental productivity between program participants and non-participants, this approach will use cross-sectional analysis at a point in time. As well as agri-environmental productivity, various components of farm efficiency may be considered, including allocative efficiency, scale efficiency and technical efficiency. An example of sustainable land management measures that increase allocative efficiency is property planning that directs water or land to its most productive use. Increases in scale efficiency may also exist where conducting large-scale operations is more efficient, such as in the adoption of zero tillage that requires large machinery investments; and increases in technical efficiency may exist where efficient farmers find it easier to expand and less efficient farmers have more attractive exit options.

The challenge

One limitation to this analysis is that many factors would have shaped farm decision-making and outcomes, beyond the intervention alone—a problem also found in conventional evaluation methods. Agricultural productivity is shaped by many factors, of which sustainable land management policy is only one (Figure 1). Other influences include technological change, climatic variability, changed commodity prices and other policy interventions.

To isolate the effects of a given sustainable land management intervention from other factors, a variety of alternative methods are considered.

Application

Estimating agri-environmental productivity

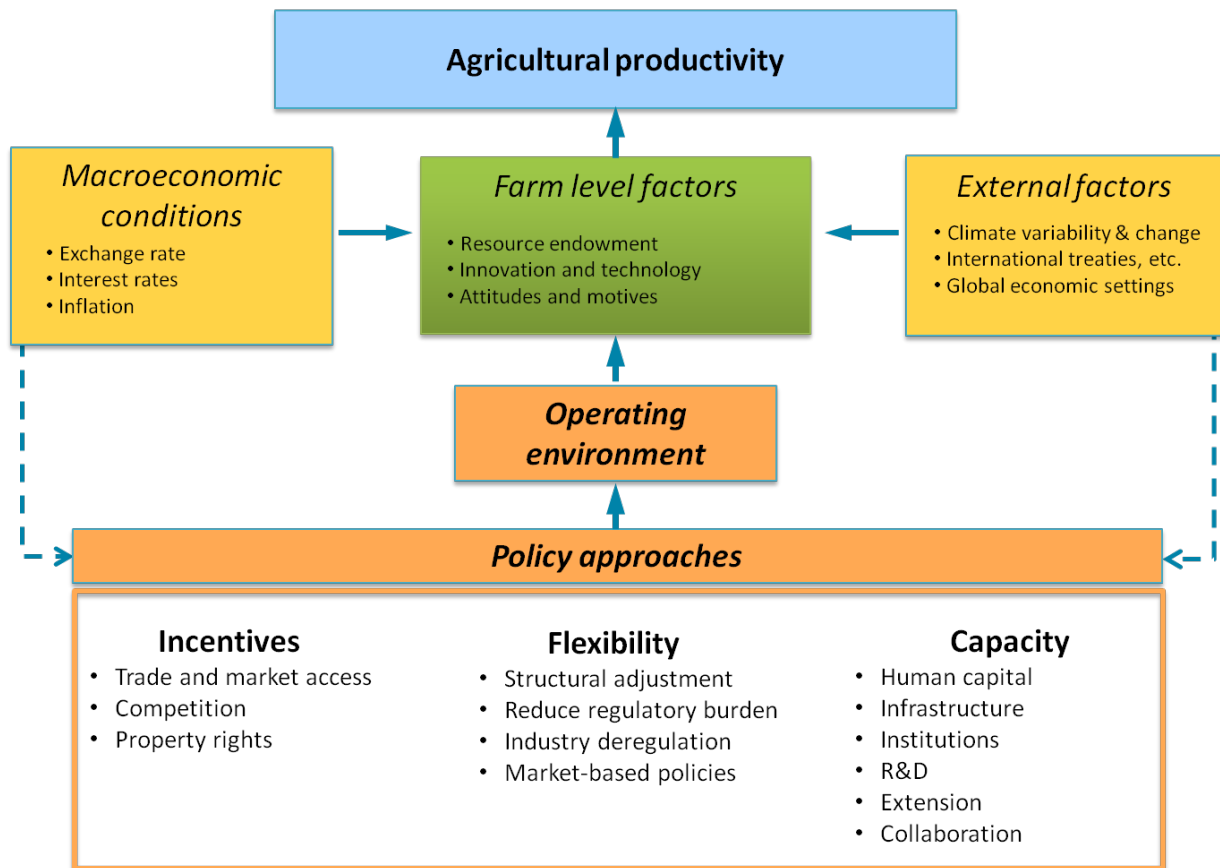
Where participants in a sustainable land management intervention can be identified, ABARES farm survey data enables productivity to be compared between program participants and non-participants. As well as considering agricultural inputs and outputs, data on program inputs and environmental outcomes is also required. This can be found in previous resource management surveys, among other sources.

An analysis of total factor productivity is a necessary starting point for detailed productivity analysis. This would best be undertaken at an industry level, but it can also be targeted at a

particular region where focus on sustainable land management activities may have been undertaken to address a region-specific issue; for example, the Queensland Government’s Reef Water Quality Protection Plan.

Specific factors contributing to productivity can be included in the analysis where there is suitable data. This permits greater confidence when attributing changes to different causes; for example, the approach ABARES used to isolate the effect of climate variability on farm total factor productivity estimates (Hughes et al. 2011).

Figure 1 Conceptual framework guiding economic assessment of sustainable land management



Source: Adapted from Nossal and Gooday 2009

Agricultural productivity is primarily driven by farm-level factors, such as resource endowment, innovation and technology, and attitudes and motives of farm managers. Farm management decisions are also affected by the macroeconomic environment and external factors such as climate change and global economic setting. A policy environment that defines incentives, influences operating flexibility and provides capacity for industries to adapt is also important.

Proposed methods

ABARES regularly conducts productivity analysis to assess the general trend in changes in the total factor productivity of Australian farms. When farm-level data is available, such as in ABARES surveys, it may be possible to expand this standard efficiency estimation technique to include data envelopment analysis and stochastic frontier analysis methods to the assessment of efficiency improvements resulting from a policy change.

An example is the methods used to assess the impact of the National Water Initiative on the efficiency and productivity of water use (Mallawaarachchi et al. 2011). These could be adapted to assess the impacts of sustainable land management practices on farm productivity. The assessment adopted a three-part approach to analysis of efficiency and productivity impacts of water policy reform that resulted from the National Water Initiative. Assessment involved several steps:

- estimating allocative efficiency gains from removal of restrictions on water trade and expressing these in terms of the productivity of water use, such as incentives for more water-efficient technology. These aspects were assessed using the RSMG Water allocation model developed by the University of Queensland Risk and Sustainable Management Group
- conducting a desktop analysis of irrigation allocation in the Murray–Darling Basin over the past decade
- conducting an econometric analysis of productivity trends using ABARES farm survey data, including
 - analysing total factor productivity at an industry level for the irrigated broadacre, horticulture and dairy industries
 - decomposing total factor productivity estimates at a firm business level to investigate the nature of productivity performance.

It is possible that the econometric analysis approach adopted to assess the benefits of the National Water Initiative could be modified to assess the economic impact of sustainable land management interventions.

Productivity decomposition analysis

Productivity decomposition analysis will help identify the relative contribution of different technical change and efficiency change components that drive total factor productivity change (Mallawaarachchi et al. 2011; O'Donnell 2010). This involves unpacking the total factor productivity index into three components:

- **technical change**—expansions and/or contractions in the set of technically feasible input-output combinations (production possibilities set). Such changes are generally due to new scientific discoveries, such as new crop varieties, integrated pest management and minimum tillage, and changes in the bio-physical environment, such as soil quality, levels of pesticide resistance and climatic conditions. Governments can influence the rate of technical change through research and development programs and initiatives.
- **technical efficiency change**—movements by firms/industries towards or away from the boundary of possible production. Agricultural producers can move closer to the production frontier by adopting new technologies (new crop varieties) and innovations that improve a given production process, such as better timing of production operations. Governments can influence the rate of technical efficiency improvement through education, training and extension programs, as well as providing incentives, such as cost-sharing, in the adoption of innovations.
- **scale and mix efficiency change**—changes in productivity due to (dis)economies of scale and scope. If economies of scale exist in agriculture, relatively small producers operating in the region of increasing returns to scale can increase levels of productivity by simply expanding the size of their operations. If firms continue to expand in size, they will eventually reach a point where they experience decreasing returns to scale.

Similarly, changes in the mix of inputs, such as capital to labour ratio, and outputs, such as cropping mix, can lead to productivity changes. Discussions with landholders indicated that the adoption of some sustainable land management practices influences the levels of scale and mix efficiency through changes to the size and structure of their production operations.

Productivity decomposition analysis will allow the relative influence of these factors on observed productivity change to be estimated. Combining this information with the outcomes of the drivers of practice change surveys, desktop review and consultation, for example, will allow conclusions to be drawn on the relative influence of sustainable land management policies on the productivity of agricultural enterprises that have participated in natural resource management improvements.

The focus of the analysis should be to use the derived total factor productivity indices to analyse profitability change, technical change and efficiency change driven by efficient land management. While a range of approaches is available for such work, stochastic frontier analysis is widely used.

Stochastic frontier analysis

Where there is farm-level data (such as in ABARES farm and irrigation surveys), stochastic frontier analysis can be used to identify specific contributions to inefficiency (Coelli et al. 2005). If this data also indicates participation in a given program, a stochastic frontier analysis may be used to estimate the effect of a given program on a farm's efficiency. Even where this data is not available, the results of a stochastic frontier analysis can be used to control for other factors (including climate variability and technological changes) to adjust total factor productivity estimates of industries where similar programs have been undertaken.

We recommend a pilot study be conducted to further ascertain the merits of this approach (using currently available data) and to assess any gaps in data that may be addressed in developing a robust monitoring and evaluation capacity for this important public expenditure program. Such a pilot study could establish the operational feasibility of this theoretically robust approach to determine the efficacy of public investment on sustainable land management interventions over time and across different spatial scales (at farm level and across natural resource management regions or states).

Data requirements and opportunities

Reliable and accessible data is an essential prerequisite for any evaluation process. This data needs to be both *ex ante* and *ex post*.

Some of the required data can be drawn from existing ABARES farm surveys. These have been used in analysis of productivity trends and in assessing the National Water Initiative. Where necessary, it may be possible to include further questions to elicit more information on participation in Caring for our Country programs.

A rigorous analysis will also require high quality data at a local or even individual level for meaningful comparisons. No consolidated record exists to support robust evaluations of participants in Australian Government programs such as Caring for our Country. While there is high-level government interest in collecting data from participants in government programs, availability of data from program participants is inadequate for analytical purposes.

Australia can learn from the experiences of other developed countries that have sought to create similar frameworks for monitoring and evaluation of public expenditure programs. For example, the United States Department of Agriculture Conservation Reserve Program maintains a record

of all participants in the Conservation Reserve Program Contract File (Sullivan et al. 2004) which has enabled rigorous evaluations (Hansen 2007; Wu 2000). In the United Kingdom, Natural England has maintained a database on contract data for the Higher Level Stewardship Scheme, and this resource enabled subsequent analysis by Quillérou et al. (2011). Evaluation of the second stage of Caring for our Country and similar interventions would benefit from a similar repository of participant data.

International data collections on environmental inputs and outputs can also offer useful insights for improving Australian programs. Evaluation of the US Conservation Reserve Program has been aided considerably by the National Resources Inventory, which includes 800 000 sample points for soil, water and related resources on non-federal grazing, broadacre and forest lands (Hansen 2007; US Department of Agriculture 2009). Developing similar capacity in Australia, where this is feasible, would be beneficial. These can allow efficient measurement and metering of resource use activities. This could include on-site human collection and remote sensing techniques such as those used in constructing the National Resources Inventory, but could also include sensor technology similar to the SenseT program, which will use the National Broadband Network infrastructure to track water quality in Tasmania (CSIRO 2012).

DAFF is a sponsor of the Terrestrial Ecosystem Research Network which has begun the process of collecting, systematising and cataloguing data in a usable form (TERN 2012). Any evaluation or planning of sustainable land management programs would be aided by additional data collection on target outcomes.

4 Stakeholder engagement

As part of this project, the authors conducted unstructured interviews with landholders in the dairy, broadacre and horticultural industries in May 2012. The interviews contributed to development of this framework. They also shed light on how the framework relates to landholder activities and how sustainable land management interventions relate to farm productivity and resilience improvements. This chapter includes key points raised by landholders about motivations for changing their practices and the influence of farm practices promoted by government programs

Individual programs as parts of the broader land management policy

When evaluating sustainable land management practices it is important to consider the wider context of natural resource management effort, including state and Australian Government programs and policies for land, water, agriculture and the environment. This is because it is not easy for farmers or researchers to identify the individual effects on farmer behaviour of different programs, their purposes and their managing agencies. In reality, some landholders perceive government interventions either as red tape or green tape. They hardly distinguish between Australian Government and state agencies, let alone different programs. This blurring of policy identity and influence is captured in Figure 1.

Although not separately identified by landholders, different programs collectively influence the uptake of practices and farm profitability—counteracting resistance to change and reinforcing their willingness to accept change. Landholders in the dairy industry described the motive for increasing native vegetation on their property in terms of objectives that have traditionally fallen under different interventions:

- effluent management, including runoff of pollutants downstream
- managing soil erosion and land quality
- improving biodiversity
- gaining carbon credits under the carbon farming initiative.

Landholders discussed possible biochar adoption in terms of potential carbon credits and reduced water use in response to limiting irrigation diversions to achieve environmental objectives. All these activities influence agri-environmental productivity making separate attribution virtually impossible. However, it may be possible to trace trends and identify their collective influence at different locations and over time as the participation rates often vary across space and over time.

Farm business resilience

During interviews, landholders discussed the impact of practice change on farm business resilience and the management of risk and uncertainty.

A broadacre farmer noted significant improvements in soil quality and moisture retention following the adoption of no-till practices on his property. These benefits made the practice worthwhile in the long run, even without explicit government support such as subsidies. The practice offered significant social benefits in reduced sediment runoff and carbon sequestration.

However, large investments in specialised equipment and materials imposed large capital outlays, forcing the farm to sometimes meet its debt obligations through off-farm income from the family's other enterprises. Smaller farms, however, with lower levels of capital flexibility may face insurmountable constraints to practice change. Presence of these barriers suggests that government intervention can assist in accelerating adoption rates, even when practice change may be of clear benefit to both production and to the environment. This can secure social benefits over and above what is feasible for a farm to provide within normal business motivations.

An intensive horticulturalist described the desire to trial new approaches to managing saline soils that constrain productivity, but noted that uncertainty about its success and the high cost of necessary investments meant he was unlikely to undertake it by himself. However, the same farmer was able to trial a rainwater harvesting system because the risk of failure was within his means and the benefits were more obvious.

Knowledge supply networks

During interviews landowners discussed the importance of networks, for supplying both material inputs and knowledge in the production process. The effect of a practice on a given farmer's decision-making is influenced by the behaviour and attitudes of their neighbours and networks; evaluation of an intervention must recognise the effect on these networks, primarily that the effects of an intervention is not limited to participants, but also their peers and neighbours.

A broadacre farmer interviewed noted that no-till practices rely on access to specialised sowing machinery and the availability of appropriate herbicides and pesticides. Had there not been a sufficient number of other farmers using the practice to allow the continued existence of suppliers, the practice would not have been sustainable. A dairy farmer, who made use of an agronomist one day a fortnight to obtain advice on maintaining soil quality, pointed out that the continuity of this service was conditional on the agronomist having other clients for the remaining nine days.

Farmers also commented on the value of these networks in providing a conduit for the supply of new knowledge and noted that these networks can also address issues relating to uncertainty.

A dairy farmer who discussed biochar adoption during the interview had learned of it from a fellow farmer at a local consulting group. The dairy farmer described his colleague as enthusiastic about the practice's effects on yield and moisture retention, but as having a larger appetite for risk than most landholders. The dairy farmer reported that he and other farmers would monitor the results with interest and noted the value to other observers in a group of risk-taking individuals in exploring new practices that had uncertain prospects.

The absence of knowledge supply networks can negatively affect productivity and sustainability. A horticulturalist described the reluctance of fellow horticulturalists to share knowledge for fear of increasing their colleagues' farm yields, which would potentially reduce their own profitability through price effects. This may mean substantial gains foregone in the industry. For example, the same horticulturalist participated in a program that provided knowledge that helped him reduce irrigation water use (and thus salinity impacts) and increase yields by a reported 50 per cent. He said he would not have learnt of the benefits of these practices through existing networks and consequently would have continued to use more water despite foregoing the higher yields.

Integration

The Australian Government, state agencies and a number of non-government organisations are involved in a range of activities designed to improve the take-up of sustainable land management practices. The purpose of this effort is to modify landholder behaviour consistent with a social expectation to reduce land degradation and other social costs associated with agricultural land use.

From an economic perspective the ultimate objective of these activities is an improvement in the efficiency of resource use and, therefore, the productivity of enterprises involved in the use and management of land.

The productivity approach to assessing the benefits of land management proposed in this paper provides a theoretically robust and operationally feasible approach to determine the efficacy of public investment on sustainable land management interventions over time and across different spatial scales, from farm paddocks to administrative units such as natural resource management regions or states.

Farmers undertake improvements in land management practices with the primary objective of staying in business, while striving to improve productivity to achieve business resilience as circumstances change.

The profit decomposition approach to evaluating sources of productivity improvements at the farm level may provide a robust basis to ascertain how farmers at different stages of farm development, resource endowment and technology and in different locations have benefited from sustainable land management.

Information from these assessments could be combined with careful *ex-ante* assessments of specific projects, using the benefit-cost analysis frameworks, to offer valuable insights into future program development.

5 Implications and way forward

Development of future programs

The data requirements of economic evaluation are considerable, as discussed in Chapter 4. As far as possible, future programs conducted under Caring for our Country should ensure sufficient data is collected for evaluation purposes. This could be gathered from the proponents or agencies implementing programs, but would require program managers to incorporate the data requirements into the bidding process and contracts with service providers.

The collection of data could be a condition of receiving financial incentives. For example, as part of the bidding process a third party seeking funding for a sustainable land management program could be required to make a case that environmental outcomes could be improved by participation in the program, or provide evidence that the party's existing work has improved outcomes and that expanding it will improve outcomes further. The third party may have data to support their case, which can then be retained for *ex-post* evaluation. Care must be taken that existing conditions and outcomes are not exaggerated to secure funding.

When an organisation is funded, it can be a condition of funding that data on participants is made available for the purposes of evaluation. Ideally, this can be at the level of individual farmers, including the precise location of the farm, using geocoding data. While farmers are often wary of providing sensitive data, ABARES has established rigorous protocols for protecting the privacy of landholders who provide data in the Australian Agricultural and Grazing Industries Survey (AAGIS), Australian Dairy Industry Survey (ADIS) and irrigation surveys.

Where farm-level data collection is not feasible, the requirement may only extend to larger spatial units; for example, aggregate collection at the program or natural resource management region level. There will inevitably be some trade-offs between the excess burden to be placed on providers and meeting the data needs to ensure rigorous subsequent evaluation. Some aggregation may be required in all instances to capture spillover effects as landholders learn from each other.

Implementation

This section of the report provides directions for implementing the proposed approach to meeting program evaluation objectives for the Caring for our Country agriculture stream.

Pilot study

The method of evaluating economic impacts of government intervention on sustainable land management proposed in this paper differs from the conventional benefit-cost approach to evaluation. Therefore, it would be instructive to undertake a pilot project to demonstrate the feasibility and effectiveness of this approach and its advantages for policy evaluation. Based on insights gained during limited landholder consultations for this project, ABARES suggests a pilot be undertaken in the Northern and Yorke natural resource management region in South Australia, where practices such as no-till cropping have been promoted as part of Caring for our Country. However, the same process could be applied to a pilot in other areas if data is available.

ABARES could conduct a trial using existing AAGIS data sets. This trial would provide proof of concept and reveal any problems that could be addressed in a larger evaluation effort. However,

ABARES would not be able to use the full range of data that will be available for second-round programs should they be rolled out with this evaluation in mind.

The proposed pilot study, based on total factor productivity analysis, would focus on the first round of Caring for our Country, with an aim to account for two types of benefits from natural resource management investment:

- **direct impact on total factor productivity**—the taking up by farmers of different natural resource management practices may increase the efficiency of land use in agricultural production. This will increase conventional and non-conventional output for a given level of inputs; for example, by increasing yields
- **indirect, or substitution effect, on total factor productivity**—natural resource management practices undertaken by farmers may reduce the need for other inputs, such as fertiliser, water and tillage machinery, to produce a given unit of output.

Using the ABARES total factor productivity estimation approach, it is possible to examine the impact of natural resource management activities from both direct and indirect channels. Specifically, one can split farmers into subgroups (according to their different natural resource management activities) and estimate input, output and productivity for each sample group. A comparison among the group (or a further regression of the productivity performance across groups on the disparity in natural resource management activities) can be used to provide the assessment of benefits and losses due to farmers' specific activities in carrying out natural resource management practices.

To develop the assessment capacity for the second phase of Caring for our Country, we propose to use data from AAGIS surveys to implement the above exercise for broadacre farms in the selected region of South Australia. As a pilot study, the data used for this exercise only covers 2007–08 to 2011–12. Three procedures can be carried out in sequence:

- grouping farms according to their natural resource management activities
- estimating agri-environmental productivity using ABARES productivity model for each group
- identifying benefits and costs related to corresponding natural resource management practices through
 - comparing land productivity or land user costs (unit costs) across regions and by sample groups for the direct impact
 - comparing total factor productivity across regions and by sample groups for the indirect impact
 - using regression techniques to specify the marginal impact of natural resource management activities on each farm's value of production or productivity measure (if the sample size allows).

This exercise can be replicated for different farm groups (crop specialists, sheep specialists and beef specialists) to identify differences across sectors.

The pilot study would be used to identify data gaps and how data collections can be improved to better represent participation rates.

Critical data for future program evaluations

To illustrate how data for future programs might be collected, this section of the report extends the example outlined here into a hypothetical second round to describe how program management protocols might be adjusted to allow the collection of suitable data for evaluation.

Organisations applying for funding could be asked to provide data on current practices and environmental outcomes in the region, and estimates of how much the program will change these practices and outcomes. These data can be stored in a secure database, and made available to DAFF and ABARES for the purpose of evaluation.

Data requirements would vary according to the type of program being implemented and what is feasible, but if we use the example of no-till cropping, potential variables could include *ex-ante* and *ex-post* collection of:

- farm geographic location, with geocodes if available
- current practice
- use of no-till, by area and by any individual farmers that become involved
- land practices on a property, classified by soil quality—that is, if more than one practice is used or the same practice is followed in different parcels of land that forms the property, the soil quality in the areas of each use (if possible).
- current usage of cover crops
- current seasonal conditions, such as soil moisture, organic carbon and yield per hectare
- changed practice, such as *ex-post* use of no-till, cover crops and changed land practice, classified by the soil quality on the land used
- changed conditions, such as soil moisture or organic carbon, yield per hectare.

While some of these variables may seem costly to gather, such as soil quality and organic carbon, many landholders will have this data readily available or through their agronomists. The additional cost of passing this on to program providers may be very modest. In this way Caring for our Country can act as a catalyst for the collection of information that is already being measured (such as by contract agronomists), but is not available to policymakers. Program providers bidding for funding may be encouraged to provide data they possess for program evaluation purposes.

Variables such as soil quality, if they are feasible to collect, allow the analysis to control for selection effects. For example, farmers may first use no-till on lowest quality land where the downside risk is lowest, but even if it has very positive effects on yield, a comparison with tilled land would be unfavourable. This would underestimate the economic benefits of the practice. Unfortunately this kind of information is often not available to evaluators.

ABARES could collate this data with existing survey data for the region, and other sources, especially for environmental data. Collaboration with projects such as the Terrestrial Ecosystem Research Network may provide further information at a regional level. For example, remote sensing (from aerial photography) intended to monitor native vegetation may also differentiate tilled from non-tilled cropping land in the planting season, with minor additional cost.

6 Conclusion

Farmers' adoption of land management practices is motivated by many factors. The most important being the ability to offset costs with increased productivity, increased asset value and improved business resilience. By preventing harmful externalities, such as land and water degradation, sustainable farm production also benefits the wider community through flow-on impacts of production and complementary benefits of cleaner production.

The desktop review and limited consultations undertaken for this study revealed that both profitability and business resilience influence farm decision-making. The main way these are influenced, is through adjustments in farm outputs and input use, that is, through changes in productivity. Sustainable land management practices are adopted by farmers as part of a package of measures usually aimed at interconnected objectives relating to business competitiveness, productivity and risk management.

The sustainability of practices also relies on the availability of related inputs and services, some of which are often expensive and require specialised material, equipment, infrastructure and expertise. This means the rate of adoption of new practices or innovations is influenced by the magnitude of the private benefit to landholders, so achieving a socially optimal level of adoption could involve significant time lags.

In assessing the economic benefits of government intervention in sustainable land management, the analysis needs to take a long-term focus and be able to control for factors that are outside the program focus, but nonetheless influence changes in productivity. In that way the influence of policy levers used in sustainable land management interventions can be better understood.

In choosing an appropriate assessment framework, consideration was given to the fact that Caring for our Country sustainable land management programs, as well as a number of related programs, provide incentives for practice change. Therefore, independent assessments of how individual programs influence adoption of sustainable land management may only be possible when program-specific data have been collected.

The proposed approach to *ex-post* analysis suggests a focus on the contribution of the program to improved agri-environmental productivity. This can be possible by *ex-post* comparison of productivity between landholders in areas where a program has not been undertaken with those where it has. Using this approach, the effects of the program can be distinguished from effects that would have occurred anyway.

A pilot study is required to test feasibility of the proposed approach and assess data availability and requirements. This should be conducted before the approach is employed as an ongoing component of the monitoring and evaluation program for the Caring for our Country sustainable agriculture stream.

While this paper focuses on sustainable land management practices, the methods proposed will work equally well for fisheries and forestry enterprises where appropriate data is available.

Appendix A—Farmer case studies

This appendix provides details of discussions with two landholders interviewed as part of this project in May 2012.

South Australian dairy operation

One of the dairy farmers interviewed provided particular insight into the way multiple, overlapping programs collectively influence the adoption of sustainable land management practices.

At the time of being interviewed, his South Australian dairy farm business was in a mature stage and the farmer was highly engaged with issues of sustainability and the institutions of national resource management. His business had more than 600 cattle producing 4 million litres of milk a year on 370 hectares, of which 40 hectares were under a heritage agreement.

He described how various programs and other factors over several decades had led him to increase the level of native vegetation on the property and integrate a range of dairy and pasture management techniques to match his expectations for sustainable farming.

An early influencing factor was the ending of policies designed to promote land clearing. He noted neighbouring properties that were not used for productive purposes, but cleared to meet legislated requirements or tax concessions. The ending of these concessions meant there was no active incentive away from natural vegetation. In the 1980s this situation was reversed, with concessions on land rates providing a positive incentive for farmers to revegetate. The dairy farmer recently investigated the possibility of gaining credits for revegetating his property under the Carbon Farming Initiative.

The recent prolonged drought provided further motivation. The farmer noticed that pasture under the returned vegetation remained productive in the very dry periods. This was a benefit that was not anticipated, but one that contributed to farm resilience.

These various motivations highlight that a given natural resource management program is only one input, and natural resource management policies as a whole played only a limited part in the mix of inputs driving the motivations for sustainable farming. Maintaining the profitability of the farm business over the long term was paramount. In the dairy farmer explained, what farmers do is ‘manage as best you can in the short term while aiming to live for a hundred years’.

The dairy farmer noted there was also an intrinsic motivation to do the right thing regarding the environment, but that financial incentives could undermine this, both by rewarding those who had previously done nothing, or by rewarding inappropriate actions. He felt some interventions—notably requiring offsets for cleared land—involved large compliance costs but did not provide a framework in which farmers could or should manage their land optimally in regard to economic and environmental affects. The offset requirement was seen to have made clearing land for operational reasons difficult, while not promoting native vegetation in places that supported resilient natural systems.

The farmer raised some points about how prior actions and policies have affected what policies would now be most optimal. This path dependence meant that in managing a dynamic system such as a farm there are always trade-offs. ‘Sometimes it may not be worthwhile saving a species that is on the way out’ when the resources committed could protect or maintain other species

more effectively. A triage system to identify natural assets that would benefit most from interventions was his answer to prioritisation.

South Australian broadacre dryland farming operation

At the time of being interviewed, the South Australian dryland broadacre farmer was managing a partly vertically integrated enterprise that switched to conservation farming practices based on no-till, low-till methods around twenty years ago. Their experience highlights the importance of diversifying activities to manage risk and to maintain the long-term sustainability of a farm business. In their business, adoption of improved land management was integral to farming sustainably and to making the most of opportunities.

The tillage system he adopted involves leaving crop residue without burning, placing seeds in the soil and allowing inter-row sowing into the previous season's stubble. This approach makes better use of soil moisture and enables organic matter build-up and improved germination and growth rates. For a business to be viable over the long term, while meeting shorter-term fluctuations, four conditions have to be met: right tools, correct timing, appropriate scale and the right mix of enterprises.

The right mix is achieved through a larger operation that allows managing trade-offs between economies of scale and scope—right size of the paddock to make the best use of land and, the right mix of crops that allows the spreading of risks.

The business farmed 2500 hectares of land, comprising a main property and another property some 80 kilometres away. Of this land, roughly 1400 hectares was owned, with a further 300 hectares leased and the remaining 800 hectares under a sharecropping arrangement. The main cropping activities were wheat, including durum wheat, faba bean, oaten hay and canola. Some of the land operated was under sharecropping arrangements and some crops (including part of the durum wheat crop) were grown under contract for a large corporate processor.

On this property, the adoption of these practices resulted in notable improvements in soil moisture retention and, consequently, an increase in soil organic carbon. These practices led to low yield variability across seasons, improving both the average yield and supply reliability. However, a large investment was required in specialised seeding equipment and in herbicides and fungicides to remove weeds and fungi that would otherwise be controlled through tillage. Despite these large outlays, the take-up of these practices led to numerous other refinements that have collectively improved farm productivity, while continuing to improve long-term profitability. These practice changes represent rational choices even when positive externality benefits, such as those derived from a reduction in runoff and increased carbon sequestration, are not rewarded through policy interventions.

These capital outlays required ready access to financial capital that may be beyond the reach of many farms and an ability to carry debt in bad years. When circumstances are different, say where firm size is smaller or climate variability greater, financial institutions may not grant much flexibility. The dryland broadacre farmer interviewed noted that the business survived the recent drought largely because of off-farm income from other businesses. His family had also recently ventured into processing part of their own product to increase their value added and introduce income streams that are less correlated with their primary production activities. To spread risk they had bought another property away from their main property, because 'rainfall patterns can vary between properties'.

This move toward diversification was prompted by the collapse of the wool industry in 1992. Grazing was not optimal for the land in question—from economic or environmental perspectives—but had provided a hedge against shocks where rainfall variability was high. In the farmer's view the current management practice will continue unless a more optimal practice, or set of practices, can be shown to be more useful in managing risks and in maintaining long-term resilience in the business.

References

- ABARE 2005, *Economic incentives to improve water quality in the Great Barrier Reef*, Australian Bureau of Agricultural and Resource Economics, Canberra.
- ABS 2008, *Natural resource management on Australian farms, 2006–07*, cat. no. 4620.0, Australian Bureau of Statistics, Canberra, available at abs.gov.au/AUSSTATS/abs@.nsf/mf/4620.0S, accessed 6 November 2012.
- ANAO 1997, *Performance audit—Commonwealth natural resource management and environment programs*, Australian National Audit Office, Canberra.
- Australian Government 2012, *Caring for our Country: an outline for the future, 2013–18*, Caring for our Country, Commonwealth Government, Canberra.
- Burrell, A 2011, 'Evaluating policies for delivering agri-environmental public goods', paper presented to OECD workshop on evaluation of agri-environmental policies, Braunschweig, Germany, 20–22 June 2011, Organisation for Economic Co-operation and Development, Paris, available at oecd.org/document/0/0,3746,en_2649_33793_47107456_1_1_1_1,00.html.
- Caring for our Country Review Team 2011, *Report on the review of the Caring for our Country Initiative*, Australian Government Land and Coasts, Caring for our Country Review Team, Canberra.
- Coelli, TJ, Rao, DSP, O'Donnell, CJ & Battese, GE 2005, *An introduction to efficiency and productivity analysis*, 2nd edn, Springer Science, New York, NY.
- CSIRO 2012, *Ensuring sustainable water resource use: SenseT: a Sensor Network for Tasmania*, CSIRO, Canberra, available at csiro.au/Outcomes/Water/Water-for-the-environment/SensorsAndWaterUse/SenseT.aspx, accessed 23 August 2012.
- Dixit, AK & Pindyck, RS 1994, *Investment under uncertainty*, Princeton University Press, Princeton, New Jersey.
- Ecker, S, Kancans, R & Thompson, L 2011, *Drivers of practice change in land management in Australian agriculture: preliminary national survey results*, Australian Government, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.
- Future Farm Industries CRC 2011, *INFFER—Investment Framework for Environmental Resources*, Future Farm Industries, Melbourne, available at inffer.org, accessed 6 November 2012.
- Hansen, L 2007, 'Conservation Reserve Program: Environmental benefits update', *Agricultural and Resource Economics Review*, vol. 36, no. 2, pp. 267–80.
- HC Coombs Policy Forum 2011, *Synthesis of broad issues and opportunities: Document I*, The Australian National University, Canberra.
- Hughes, N, Lawson, K, Davidson, A, Jackson, T & Sheng, Y 2011, *Productivity pathways: climate adjusted production frontiers for the Australian broadacre cropping industry*, ABARES research report 11.5, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Mallawaarachchi, T, Adamson, D, Hughes, N, O'Donnell, C & Quiggin, J 2011, *An economic analysis of the impact of the National Water Initiative on the efficiency and productivity of water use*, Risk and Sustainable Management Group, University of Queensland, Brisbane.

Mallawaarachchi, T, Mazur, K & Lawson, K 2007, 'Modelling environmental risk and land management tradeoffs in the Great Barrier Reef catchment', paper presented to 51st Annual Conference of the Australian Agricultural and Resource Economics Society, Rydges Lakeland, Queenstown, New Zealand, 13–16 February, available at ageconsearch.umn.edu/bitstream/10377/1/cp07ma03.pdf (298.83kb).

Mallawaarachchi, T & Szakiel, S 2007, *Non-broadscale land clearing in southern Australia: economic issues in managing native vegetation on farm land*, Australian Bureau of Agricultural and Resource Economics, Canberra.

Mallawaarachchi, T, Blamey, RK, Morrison, MD, Johnson, AKL & Bennett, JW 2001, 'Community values for environmental protection in a cane farming catchment in Northern Australia: a choice modelling study', *Journal of Environmental Management*, vol. 62, no. 3, pp. 301–16.

Mallawaarachchi, T & Quiggin, J 2001, 'Modelling socially optimal land allocations for sugar cane growing in North Queensland: a linked mathematical programming and choice modelling study', *Australian Journal of Agricultural and Resource Economics*, vol. 45, no. 3, pp. 383–409.

Nossal, K & Gooday, P 2009, *Raising productivity growth in Australian agriculture*, Australian Bureau of Agricultural and Resource Economics, Canberra.

O'Donnell, CJ 2010, 'Measuring and decomposing agricultural productivity and profitability change', *Australian Journal of Agricultural and Resource Economics*, vol. 54, no. 4, pp. 527–60.

Pannell, DJ, Roberts, AM, Park, G, Alexander, J, Curatolo, A & Marsh, SP 2012, 'Integrated assessment of public investment in land-use change to protect environmental assets in Australia', *Land Use Policy*, vol. 29, no. 2, pp. 377–87.

Pannell, DJ & Roberts, AM 2010, 'Australia's National Action Plan for Salinity and Water Quality: a retrospective assessment', *Australian Journal of Agricultural and Resource Economics*, vol. 54, no. 4, pp. 437–56.

Quillérou, E, Fraser, R & Fraser, I 2011, 'Farmer compensation and its consequences for environmental benefit provision in the Higher Level Stewardship Scheme', *Journal of Agricultural Economics*, vol. 62, no. 2, pp. 330–9.

Randall, A 2002, 'Valuing the output of multifunctional agriculture', *European Review of Agricultural Economics*, vol. 29, no. 3, pp. 289–307.

Sullivan, P, Hellerstein, D, Hansen, L, Johansson, R, Koenig, S, Lubowski, R, McBride, W, McGranahan, D, Roberts, M, Vogel, S & Bucholtz, S 2004, *The Conservation Reserve Program: economic implications for rural America*, Agricultural Economic Report no. AER-834, United States Department of Agriculture Economic Research Service, Washington, DC.

TERN 2012, *Terrestrial Ecosystem Research Network*, Brisbane, viewed 23 August 2012, tern.org.au/What-is-TERN-pg22570.html.

Thorburn, PJ & Wilkinson, SN 2012, 'Conceptual frameworks for estimating the water quality benefits of improved agricultural management practices in large catchments', *Agriculture, Ecosystems & Environment* (in press).

US Department of Agriculture 2009, *Summary Report: 2007 National Resources Inventory*, Natural Resources Conservation Service, Washington, DC and Center for Survey Statistics and Methodology, Iowa State University, Ames, Iowa.

Wu, J 2000, 'Slippage effects of the Conservation Reserve Program', *American Journal of Agricultural Economics*, vol. 82, no. 4, pp. 979–92.