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Bridging the gap between science, economics and policy to develop and implement a pilot Market Based Instrument for soil carbon

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Abstract. Increasing soil organic carbon (SOC) has potential to offset greenhouse gas emissions, but the scope for on-farm carbon sequestration is poorly understood. A pilot scheme was developed in Central West NSW, Australia to trial the use of a market-based instrument to encourage farmers to increase soil organic carbon levels. The pilot considered the relationship between land use, management practices and soil carbon levels; offered alternative contract designs to attract landholders; and developed monitoring and reporting protocols. The pilot was rolled-out in 2011 and 2012 and had 11 successful tenders with an average price of \$A37 per t CO₂-e. The results of this conservation tender will assist the design of future programs aimed at encouraging mitigation effort from the agricultural sector.

Keywords: soil carbon sequestration, land use change, soil carbon pilot, carbon price, experimental economics, conservation tender.

Introduction

Increasing soil organic carbon (SOC) has potential to offset greenhouse gas emissions (Lal 2004) and benefit farm production and soil ecosystems (Whitbread *et al.* 1998), but the scope for on-farm carbon sequestration is poorly understood. A pilot scheme was developed in Central West NSW, Australia to trial the use of market-based instruments to encourage farmers to increase soil organic carbon levels. The pilot considered the relationship between land use, management practices and soil carbon levels; offered alternative contract designs to attract landholders; and developed monitoring and reporting protocols. The pilot is also exploring the roles and limitations of both scientists and policymakers in developing and delivering evidence-based policy.

Market based instruments (MBIs) can be an efficient mechanism for improving environmental outcomes (*e.g.* biodiversity, native vegetation, water quality) by introducing economic incentives to encourage changes in landholder management practice (Whitten *et al.* 2004). Conservation tenders are claimed to provide more cost effective outcomes than mechanisms such as fixed price grants (National Action Plan for Salinity and Water Quality

2008). Their advantage in the context of soil carbon sequestration is that they can exploit the heterogeneity in sequestration costs that exists amongst landholders.

Project Overview

The Catchment Action Market Based Instrument pilot (CAMBI) for soil carbon was initiated in 2009 by a team of policymakers, economists and scientists. The key question addressed was “Could we implement a soil carbon trading system – if the government were to implement this as policy?” The team wanted to investigate the potential of soil carbon markets to provide incentives to landholders to store soil carbon and deliver cost effective mitigation. The project preceded the Australian Government’s Carbon Farming Initiative (CFI) policy which provides scope for carbon trading by landholders who undertake practices to mitigate greenhouse gas emissions.

The project had a working group with three components: soil science, economics and delivery, which flowed through to on-ground implementation (Fig. 1).

Soil science

It can be difficult to predict paddock soil carbon levels

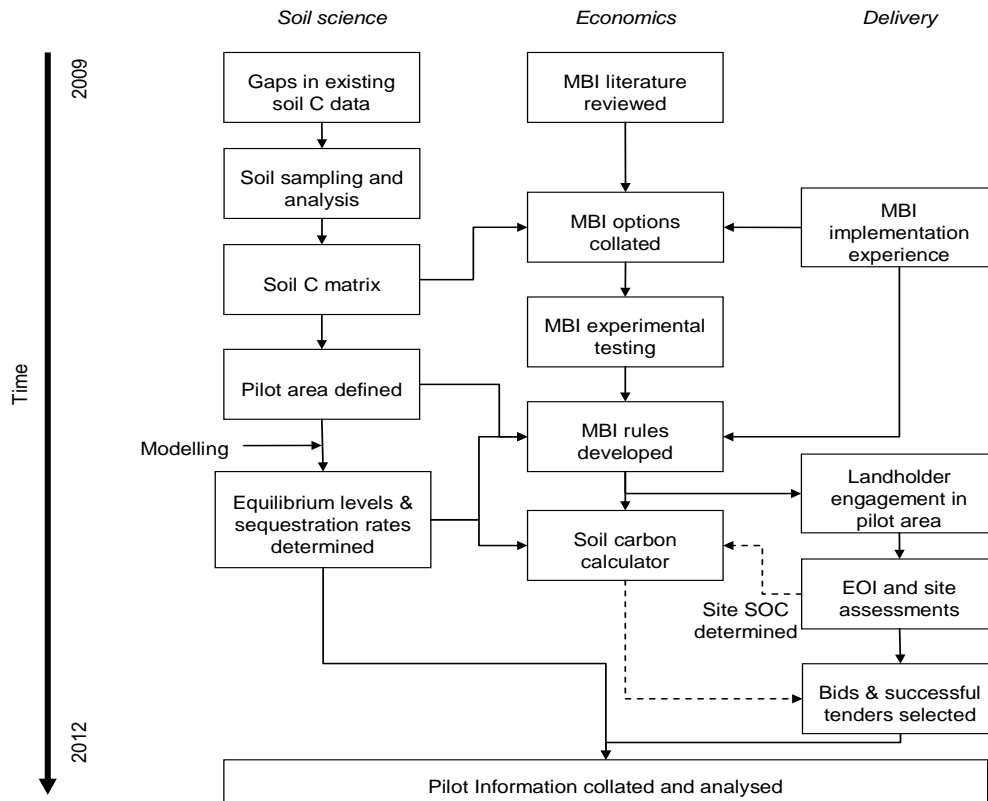


Figure 1. Interrelationships between the different components of the project

using land management history or modelling alone, because landholders rarely manage all their land consistently and the soil's capacity to store carbon varies. The project's soil scientists sampled 196 sites in the Lachlan Catchment to determine relationships between soil carbon, soil type, land use and climate. The resulting matrix of SOC values was used to select a small pilot area with the same soil type (Cowra Trough Red Chromosols). The soil science team supplemented the field observations with FullCAM modelling to determine equilibrium carbon levels for standard management actions, used in the development of a soil carbon metric (soil carbon calculator) to assess the soil carbon sequestration potential of individual sites (Murphy *et al.* 2012). Selection of the Cowra Trough soil unit allowed the use of a locally based pedotransfer function to estimate the soil carbon stocks (t C/ha) at 0-30 cm based on SOC% at 0-10 cm. Soil sampling protocols were also developed to estimate the initial level of soil carbon at a paddock scale and to estimate small expected changes in SOC stocks (1.5 to 2.0 t C/ha, 0-30 cm), for "outcome-based" contracts over the 5 year contract period (Murphy *et al.* 2013).

Economic research and MBI design

The CAMBI project used conservation tenders, inviting landholders to submit a price they wished to be paid for increasing soil carbon on their land. An initial site visit determined the suitability of the site, and SOC levels were measured to predict carbon sequestration potential of land management actions proposed by landholders. The predicted sequestration rates were then given to the landholders so they could incorporate that information

within their bid prices. The tender process enabled the team to assess both landholder willingness to participate in carbon market and the cost effectiveness of on-farm soil carbon sequestration.

Experimental economics, a relatively new economic discipline that investigates operation of markets under experimental (*i.e.*, laboratory) conditions, was used to develop three contract options for landholders. Offering alternative contract types aims to inform future MBIs about the preference of landholders and also ultimately to determine whether one contract type is more efficient than another. The "actions-based" contract pays landholders to adopt standard management practices known to improve soil carbon such as no-till cropping, permanent pastures or tree planting. The "outcome-based" contract pays landholders on the amount of soil carbon they sequestered. The hybrid contract pays landholders partly on actions and partly on soil carbon outcomes. The three contract types were underpinned by a soil carbon metric used to estimate carbon sequestration and therefore assess the cost effectiveness of bids submitted by landholders into the program.

Delivery

The MBI was delivered by the Lachlan Catchment Management Authority (LCMA), a regional natural resource management organization based in Central West NSW, Australia. The LCMA engaged with landholders, assessed potential sites, and managed the contracting of landholders. The LCMA was experienced in the implementation of a previous MBI through their involvement in the Box Gum Woodland stewardship program,

which contributed to the design of the implementation program.

Pilot results

Implementation

The pilot was implemented with landholders from August 2011 to January 2012, with contracts to be completed by late 2016. There were 54 initial expressions of interest submitted from a population of around 300 eligible landholders. A total of 26 tenders were submitted, offering an amount of carbon sequestration of 11,455 t CO₂-e. Bid prices ranged from \$A22 to \$A349 / t CO₂-e and were influenced by landholders' technical scope to store carbon, and benefits and costs of making the required changes. Outcome-based contracts were the most popular choice amongst landholders, accounting for 73% of all bids (19 bids). There were also six actions-based contracts and one hybrid bid. The bids covered the full range of farming systems operating in the Cowra Trough pilot area: sixteen bids (61%) related to pasture establishment and improved pasture management; eight bids (31%) involved changes in cropping systems; and two bids (8%) offered environmental tree plantings.

The pilot had a budget constraint of \$A300,000 and the most cost-effective bids were selected until this constraint was reached. A total of 11 bids were accepted, involving 7,819 tonnes of CO₂-e, or 68 per cent of the total offered. As the soil carbon pilot is a competitive tender, one of its objectives is to achieve soil carbon sequestration at the lowest possible cost. The average price offered from all bids submitted was \$A116, while the average price of successful bids was \$A37 per t CO₂-e. Although prices received are significantly higher than the current Australian carbon price of \$A23/t of CO₂-e, some care needs to be taken with the interpretation of this finding. Issues of policy uncertainty, the timing of the pilot, and a range of factors specific to the case study region (*e.g.* land uses, starting soil carbon levels, the direct costs of land use change as well as the opportunity costs of change) may mean that prices submitted are not a true reflection of the likely costs of soil carbon sequestration. Efforts to secure soil carbon sequestration in other locations and at other times may reveal different costs.

Project costs

There are two major types of costs associated with policies that address greenhouse emissions; direct cost of sequestration activity and transaction costs (*e.g.* costs of measuring, monitoring, reporting and verifying). Project results to date suggest that transaction costs are likely to be significant given landscape variability and the complexity of designing a suitable soil carbon measurement strategy. Full costs of the carbon sequestered will not be known until the end of the pilot in 2016 when results will show whether the sampling used was adequate for the level of variability in the case study region.

Soil carbon sampling and assessment

Soil samples were collected before contracts were implemented to establish existing SOC levels. Samples will be taken five years after contract signing to measure SOC

sequestered during the pilot. Final soil sampling for outcome-based contracts will be particularly important because SOC levels will determine payment. At the end of the pilot, the project team will determine whether changes in SOC can be measured over a five year period, and which contract is the most effective for SOC sequestration. The team also plans to assess which contracted land management practices influence SOC levels, and assess the farm net emissions to determine whether they increase in other areas (*e.g.* methane from increased livestock numbers) when there is a focus on SOC.

Discussion

Soil carbon levels and land management vary due to climate and soil type. The error in estimating soil carbon at the paddock scale is a major issue that requires further investigation and is critical to determine how sampling strategies influence confidence levels for SOC and transaction costs. The detection of change in soil carbon is constrained by two factors. Existing land management practices were already maintaining reasonable soil carbon levels, which limit the scope for increase. As well, the five year contract period makes it difficult to monitor SOC changes due to the natural variability across paddocks and the errors associated with SOC sampling. These constraints need to be considered when extrapolating results to other areas.

Economic research led to three possible contracts being made available to landholders to address possible impediments to participation including payment risk and transaction costs. Landholders had a clear preference for outcome-based contracts despite the payment risk associated with this contract type. It is unclear whether this preference is a reflection of: landholders in the region already undertaking 'carbon friendly' management practices (covered in the actions-based contract); a genuine desire by landholders to have some flexibility over how they pursue sequestration; or perhaps optimism about likely sequestration outcomes. Nevertheless, some consideration of how a preference for outcome-based contracts might be best catered for within the CFI seems warranted in the light of these findings. Further work is required to explore the merits of alternative contract options in terms of landholder support and ways to reduce the transaction costs, particularly measurement and monitoring costs.

The integration of science, economics and extension in the development of an MBI was a major feature of this project. The integration of biophysical soils research with economic considerations involved a process of both disciplines gaining an understanding of each other's area to develop a practical program for the project. The participatory research, with a flexible work plan, allowed the project to develop in response to the new information generated in each discipline. Also, feedback from the delivery agent and extension staff helped tailor the MBI to be workable and appealing to the target landholders. It is important to note that the pilot is continuing until 2016, and at the end of this period it will be possible to comment on the actual level of soil carbon sequestration under the nominated land uses, assess whether the monitoring protocols were adequate and to assess the transaction costs and systems level emissions.

Conclusion

This project successfully developed and delivered a MBI soil carbon pilot, supporting the value of a multi-disciplinary, participatory approach to project development. Results of the conservation tender approach used in the project will assist design of future programs aimed at encouraging mitigation effort from the agricultural sector. However, we will have to wait until the end of the pilot in 2016 to see whether SOC levels on agricultural land were increased and how cost-effectively this was achieved. Experience to date suggests that soil carbon sequestration may not be such an attractive mitigation option for landholders as widely believed. There are direct costs associated with implementing carbon sequestration on farm as well as opportunity costs of 'locking-in' particular land uses and practices. Transaction costs incurred in measuring, monitoring, reporting and verifying SOC levels are also likely to be high. Innovation is critically needed to reduce the size of these costs so that they are able to be absorbed within a market. For the Carbon Farming Initiative, or similar, to consider soil carbon as part of a market approach, the issues with currently used land management practices being accepted as 'additional', and impermanence as a result of carbon cycling, are still significant challenges that need to be addressed.

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