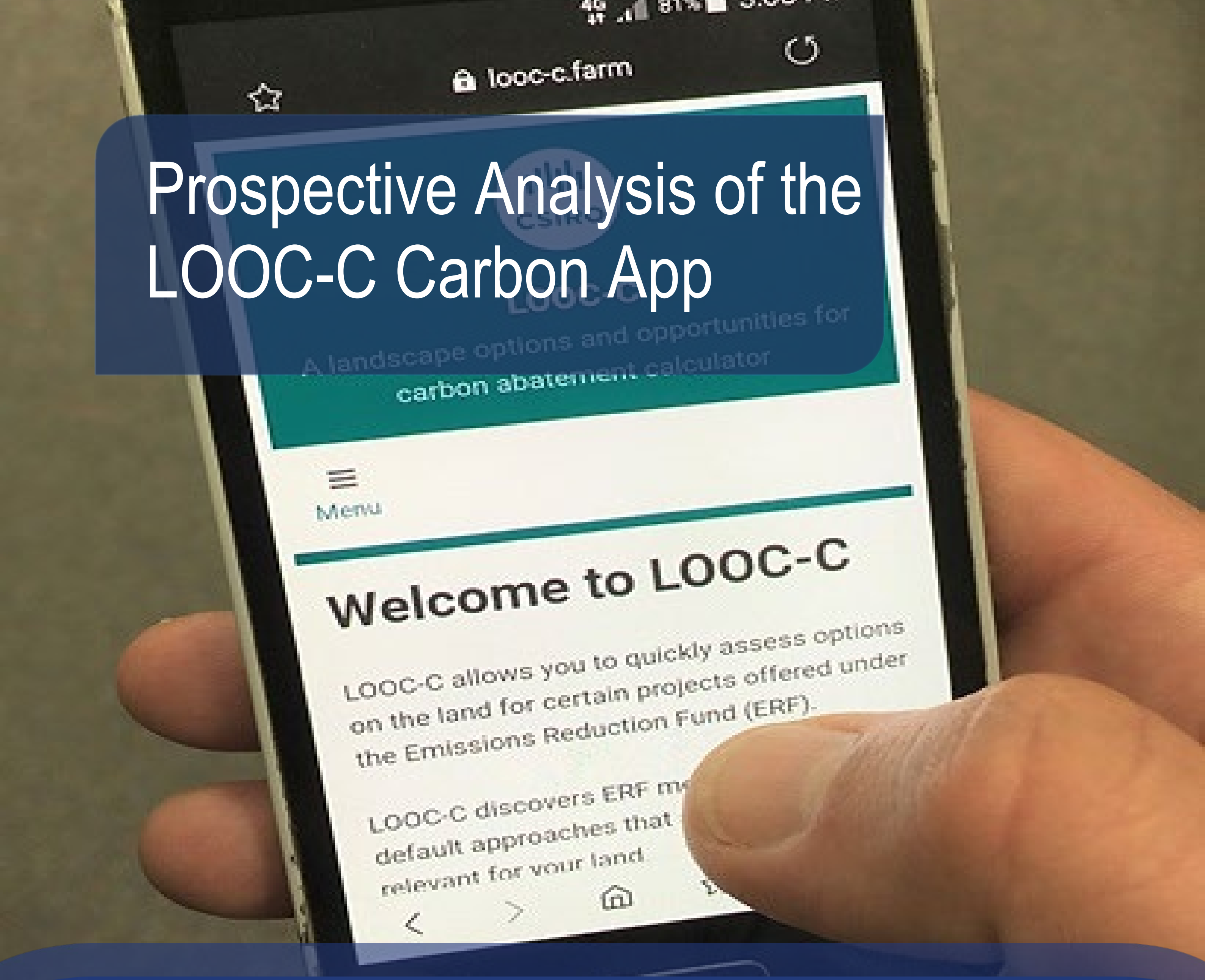
Prospective Analysis of the LOOC-C Carbon App



Prepared for

Anne-Maree Dowd

Performance & Impact
CSIRO
Pullenvale Queensland 4069
Australia

Prepared by

Kemen Austin
Erin Love
Breanna Reingold
Alan O'Connor

RTI International
3040 E Cornwallis Road
Research Triangle Park NC 27709
USA

RTI Project Number 0218098

RTI INTERNATIONAL

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Executive Summary

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) launched the Landscape Options and Opportunities for Carbon Abatement Calculator (LOOC-C) in 2019, with the goal of improving access to independent, credible, and salient information on the potential benefits of carbon farming across Australia. LOOC-C provides landowners with a reliable estimate of the potential credits they could produce on their land via a given mitigation activity and based on land and farm characteristics.

Launching a carbon farming project often means thousands of dollars in consulting fees, data collection and monitoring, and working with carbon service providers. Many farmers have difficulty understanding the impact carbon farming would have on their business and whether engagement in a carbon market would be worth their time and effort. As such, they may not explore their carbon farming options and could miss out on a revenue opportunity.

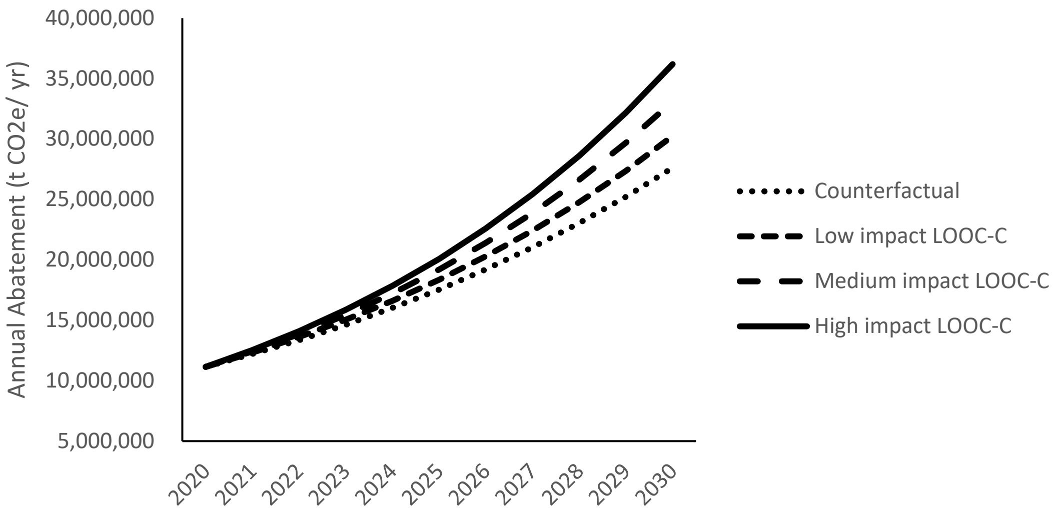
LOOC-C was designed to address this critical information barrier. After the user enters basic information about location and farm characteristics, LOOC-C provides estimates of carbon abatement potential. It was designed using best practices in user-centred design to ensure the LOOC-C experience reflected farmers' needs and preferences.

The app reduces information asymmetries and friction in the carbon market. LOOC-C provides landowners with easily accessible information on potential carbon sequestration or emissions abatement options on their land and enables state and federal government agencies to easily gauge the plausibility of mitigation project applications. Indeed, the Queensland Government requires a PDF of a LOOC-C assessment from applicants applying for participation in its programs. As the tool establishes a common basis of understanding and trust among user groups, including farmers, landowners, carbon service providers, and emissions reduction fund managers, it makes the process of designing, funding, executing emissions reduction projects more efficient.

We estimated the extent to which LOOC-C's role in reducing barriers to entry for farmers and landowners into carbon markets would result in accelerated accrual of benefits to the environment and society. Specifically, we estimated the additional value that LOOC-C will provide over 2021 through 2030, in terms of earlier achievement of land sector emissions reductions. To do so, we modelled the impact of LOOC-C on land-based abatement under four alternative estimates of the pace of technology adoption and corresponding mitigation.

We estimate that LOOC-C will catalyse an additional 11 to 36 million tonnes (Mt) CO_2e of emissions reductions over the 2021 through 2030 period, beyond what we expect would occur in the absence of the tool. We estimate the net present value of this additional mitigation at AUD $200 to 1,293 million over the decade, based on the cost of developing the tool, the current price of carbon in Australia, and a 7% discount rate.

Figure ES.1 Abatement Estimates for the Counterfactual and Low-, Medium-, and High-Impact LOOC-C Scenarios



Our monetised results do not reflect other important co-benefits that LOOC-C conveys. One of the principal co-benefits of the tool will be the protection, improved management, or restoration of native vegetation and habitats, which underpin a wide array of provisioning and regulating services including protecting water and air quality, safeguarding biodiversity, and providing recreational opportunities.

Another value that the LOOC-C tool provides is in the democratization of carbon farming, which makes it possible for a broader and more diverse spectrum of landowners and farmers to participate in and benefit from the market. If LOOC-C is successful in addressing information barriers, it will catalyse the development of a portfolio of mitigation projects which are smaller, more dispersed spatially, managed by a more diverse group of farmers, and linked to a wider range of mitigation activities. This conveys several additional benefits, including wider distribution of benefits for rural communities and risk reduction via diversification.

Our analysis suggests that the benefits provided by LOOC-C will outweigh the costs of development, maintenance, and improvements to the tool over the years 2017 through 2021. Indeed, we expect that the benefits of the tool are an order of magnitude larger than the costs, even under our lowest assumptions about LOOC-C impacts. Further, our analysis does not take into consideration the potentially valuable co-benefits conveyed via the tool, which would boost these estimates of value even higher.

Table ES.1 Summary Analysis Results

	Low-Impact LOOC-C Scenario	Medium-Impact LOOC-C Scenario	High-Impact LOOC-C Scenario
Cumulative additional abatement due to LOOC-C 2021–2030 (Mt CO_2e)	11	23	36
Net present value of social benefits of LOOC-C 2017–2030 with current carbon price (million AUD)	200	416	644
Net present value of social benefits of LOOC-C 2017–2030 with high carbon price (million AUD)	404	835	1,293
Benefit-cost ratio of LOOC-C with current carbon price	50	103	160
Benefit-cost ratio of LOOC-C with high carbon price	100	207	319
Internal rate of return of LOOC-C with current carbon price	74%	98%	115%
Internal rate of return of LOOC-C with high carbon price	98%	127%	148%

1. Introduction and Background

This report presents a case study of the Landscape Options and Opportunities for Carbon Abatement Calculator (LOOC-C). Developed by a team of scientists within CSIRO and launched in 2019, LOOC-C is a simple-to-use application for rapid acquisition of carbon mitigation potential for landowners. The app was developed as a resource for reducing information barriers (and consequently market friction) between landowners, carbon service providers, and carbon markets.

LOOC-C improves access to independent, credible, and salient information on the potential benefits of carbon farming at user-defined property boundaries across Australia. It provides landowners with a reliable estimate of the potential credits they could produce on their land via a given mitigation activity and based on land and farm characteristics. In exchange for a small amount of time, landowners will get a sense of whether pursuing carbon farming further will be viable and an effective use of their time.

This report quantifies the potential value of additional mitigation stemming from LOOC-C. It describes the technology; leverages learnings from the scientific and economic literature; and describes the potential mitigation benefits at varying degrees of adoption and impact. The overall goal is to provide a reasonable assessment both quantitatively and qualitatively of how LOOC-C may generate social value for Australians over the 10-year period from 2021 through 2030.

1.1 Australian National Carbon Mitigation Goals

The Australian Government has committed to reducing greenhouse gas emissions by 26 to 28% below 2005 levels by 2030. Preventing dangerous warming greater than 2ºC will require continued ambitious action toward a net-zero emissions pathway by mid-century (ndevr environmental, 2021). Meeting these goals will require coordinated mitigation efforts across all sectors of the Australian economy, but the land sector is anticipated to contribute a large proportion—nearly 40%—of the national goal (Department of Environment and Heritage Protection Queensland Government, 2017).

Land sector abatement activities include agriculture mitigation, such as reducing cropland soil emissions and improved manure management. They also include land use, land use change, and forest (LULUCF) activities designed to maintain or increase carbon sequestration on a landscape, such as avoided deforestation, improved forest management, and forest restoration.

Notably, land-based mitigation activities in Australia can also confer substantial and unique non-carbon benefits, also referred to as co-benefits. These include the protection of endangered species' habitats, improvement in soil health and reduction in agricultural run-off, and benefits for rural and First Nation communities. Ecological and social benefits co-benefits of mitigation activities can have tremendous value, though are rarely monetised.

1.2 Emissions Reduction Fund and State-Level Funds

The Australian Government and multiple state governments have put in place enabling programs to incentivise and facilitate mitigation activities. This includes the national Emissions Reduction Fund (ERF), which incentivises landowners and farmers to adopt mitigation actions that generate abatement, which can be traded for Australian Carbon Credit Units (ACCUs).

Each ACCU is the equivalent of 1 tonne of stored, or avoided emissions of, carbon dioxide equivalent (CO_2e) due to a project (Organisation for Economic Co-operation and Development, 2001). The $2.55 billion ERF plays a major role in catalysing mitigation in the land sector (Commonwealth of Australia, 2015). In 2019, roughly three-quarters of ERF-registered projects and ACCUs were derived from vegetation, savannah burning, and agriculture projects (Commonwealth of Australia Department of Industry, Science, Energy and Resources, 2019).

There are also several state government funds with a strong focus on land sector abatement and related co-benefits. For example, the Queensland Land Restoration Fund committed over $90 million during their first funding round in 2017 with the aim of supporting land-based mitigation projects that also improve ecosystem health, restore habitats for threatened and endangered species, provide socioeconomic benefits e.g., via trainings or jobs), or are led by First Nation communities (Queensland Government, 2021a). Queensland is currently preparing for a second investment round totalling $25 million for projects (Queensland Government, 2021b).

The Victorian Government 2020–2021 budget includes a $77 million BushBank fund and the $15 million Victorian Carbon Farming Program, both supporting public and private land restoration (Victoria State Government, 2021).

Western Australia’s $15 million 2021 Carbon Farming and Land Restoration Program funding round aims to realise the potential of carbon sequestration through agricultural processes, therefore contributing to the growth of carbon markets. These projects deliver environmental, social, and economic co-benefits in hopes of reaching sustainability levels within the farming industry. This program is separated into two main activity lines: ACCU Plus, which offers a more direct stream of funding for ERF carbon farming projects, and Future Carbon, which provides grants to establish innovative carbon farming projects within universities and similar institutions (Government of Western Australia, 2021).

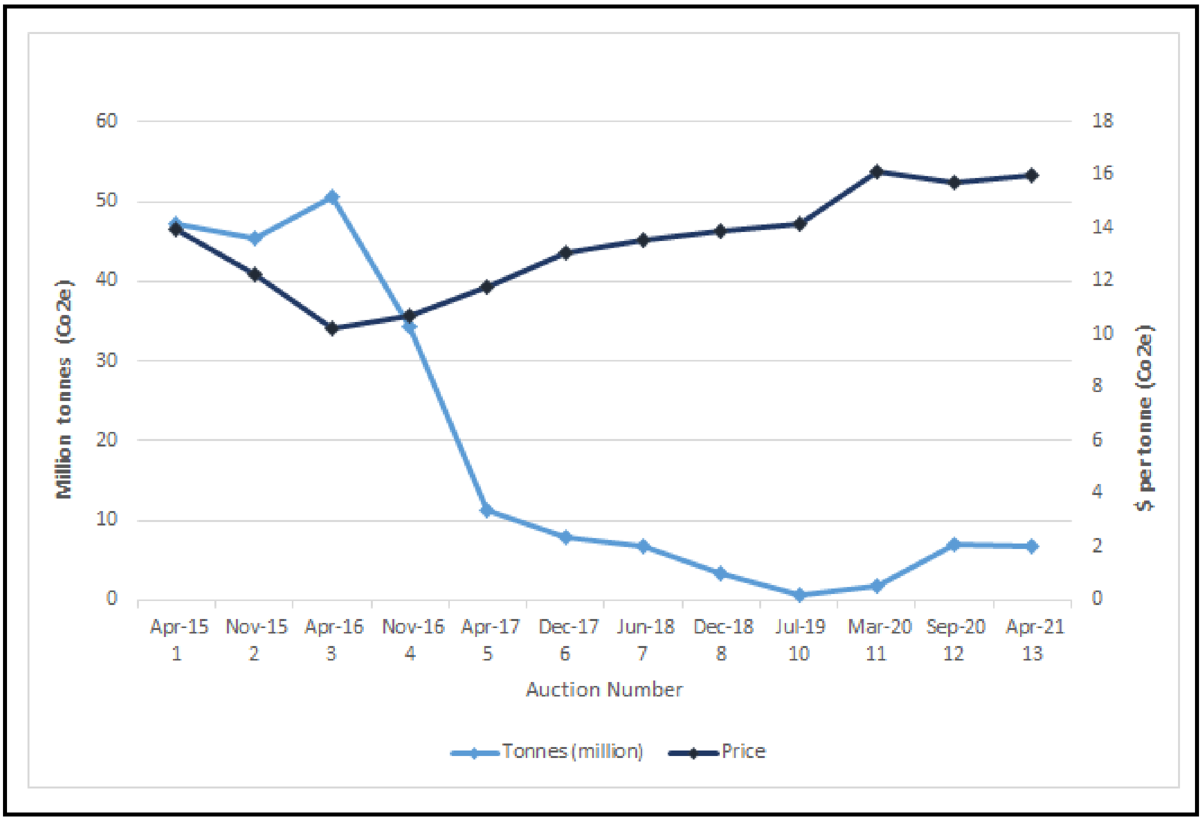
Other states and territories, such as the Northern Territory (Northern Territory Government, Department of Environment and Natural Resources, 2021) and Australian Capital Territory (ACT Government, 2021) are designing similar programs to catalyse land-sector abatement that confers benefits to rural communities, biodiversity, and ecosystem health.

1.3 Land-Based Greenhouse Gas Mitigation Trends

Despite the recognition of land-based mitigation's critical role in achieving national greenhouse gas emission reduction goals and the potential value of corresponding co-benefits, the supply of land-based mitigation credits issued in Australia plummeted dramatically after 2015 (Figure 1.1). This occurred despite an increase in credit prices over the same period.

Reasons for the decline in land sector mitigation credits include numerous information barriers and transaction costs that limit landowner and farmer participation in carbon markets. Launching a land sector mitigation project, also called a carbon farming project, often means thousands of dollars in consulting fees, data collection and monitoring, and working with carbon service providers. In addition to the above, a survey of farmers in Western Australia found that one of the key barriers to participation in the carbon market was a lack of information (Kragt, Dumbrell, & Blackmore, 2017). Many farmers might not understand the impact carbon farming would have on their business and whether engagement in a carbon market would be worth their time and effort.

Figure 1.1. Clean Energy Regulator: Carbon Auction Results



1.4 The Science Behind and Rationale for LOOC-C

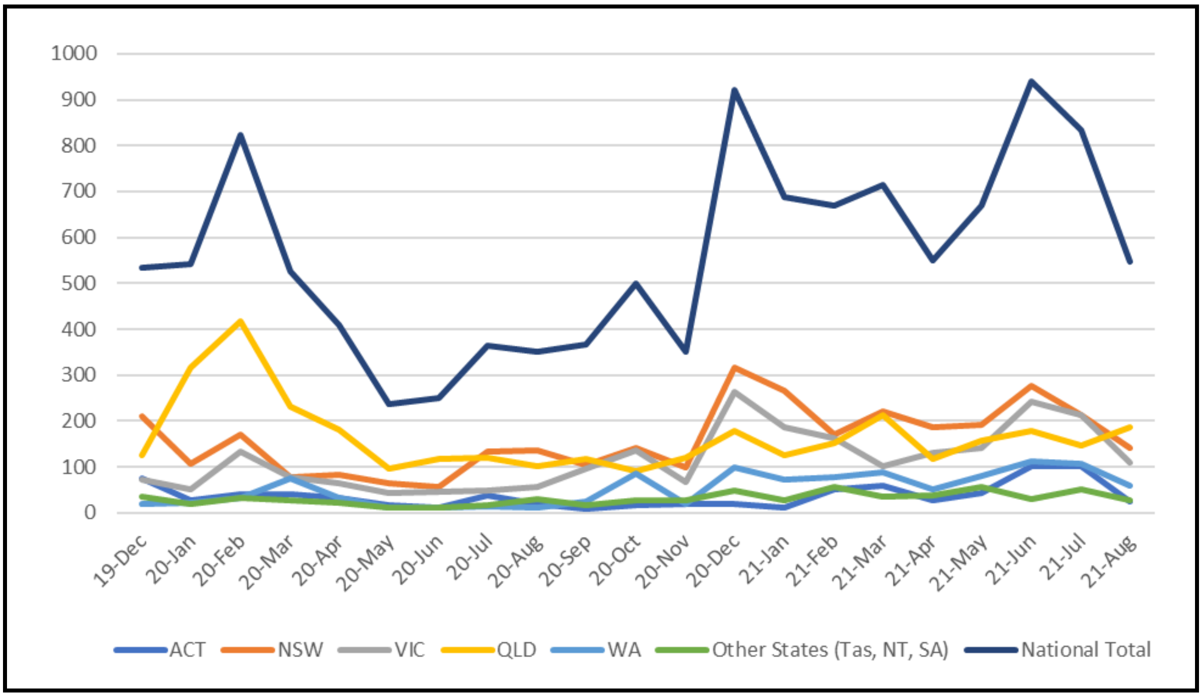
CSIRO prioritised a user-centred focus in the design of LOOC-C to encourage farmers' use and adoption. The development team conducted interviews with farmer to identify their needs and requirements and maintained a user-centric focus throughout the tool design process. Key priorities of LOOC-C design included a user-interface that reduces extraneous detail and minimizes required effort to navigate to salient information. Acquiring an initial estimate of mitigation potential using LOOC-C can take as little as 15 minutes. In response to farmers' preferences for privacy and control over their data, user data are not stored.

Importantly, LOOC-C addresses information asymmetries. It empowers landowners with information regarding potential carbon sequestration or emissions abatement options on their land. This also allows farmers to have confidence in seeking assistance from carbon service providers (CSPs), as they have a foundation for what mitigation potential their land can offer and what mitigation activities would suit the land best. CSPs continue to play a critical intermediary role in carbon markets, for example, by providing refined estimates of emissions reduction and corresponding costs, benefits, and risks of a given project; project aggregation services to benefit from economies of scale; and assistance with monitoring, auditing, and reporting of emissions reductions. LOOC-C establishes a common basis of understanding and trust between landowners and CSPs, facilitating their interaction and making the process of developing emissions reduction projects more efficient.

LOOC-C is also used by state and federal government agencies to gauge the plausibility of project applications. For example, both the ERF and the Queensland Land Restoration Fund require that project applicants submit the results of a LOOC-C assessment as part of their application process. The information from LOOC-C signals that the landowner has done preliminary due diligence and provides a first-cut assessment of project viability. As in the case of the interaction between CSPs and landowners, the results from LOOC-C establish a common basis of understanding among landowners and government agencies and results in improved market efficiencies.

Based on the past 21 months of LOOC-C usage data, we see increased usage nationally since mid-2020 (Figure 1.2). This initial indication of increasing usage suggests that the tool is gaining traction, though more detailed information on the characteristics of the users of the tool would help determine how user sessions are translating into mitigation projects.

Figure 1.2. LOOC-C User Sessions by Month, December 2019 through August 2021



1.5 Digiscape Future Science Platform

LOOC-C's development was supported by the Future Science Platform (FSP) initiative. FSPs are investments in science that underpin innovation and that have the potential to help reinvent and create new industries for Australia. FSPs are designed to grow the capability of a new generation of researchers and allow Australia to attract the best students and experts.

Digiscape refers specifically to the digital agriculture FSP. According to CSIRO, Digiscape is about harnessing the digital revolution for Australian farmers and land managers. It endeavours to solve multiple real-life knowledge shortfalls in the land sector simultaneously by building a common big data infrastructure to support next generation decision-making and transform agricultural industries and environmental action.

1.6 Case Study Purpose

Case studies are included as a key component of CSIRO's evaluation and performance measurement program for the purpose of evaluating the outcomes and impact of CSIRO research and innovation activities. As outlined in CSIRO's impact evaluation framework, case studies must clearly describe the rationale behind CSIRO's investment, action, and participation in the research, as well as the actual or projected outcomes and impact across social, environmental, and economic dimensions. CSIRO's preferred method for case study evaluation is cost-benefit analysis (CBA).

RTI International, an independent non-profit research institute, was commissioned to conduct the LOOC-C analysis. This case study provides a framework for assessing and quantifying the potential social, environmental, and economic impact of adoption of LOOC-C. The purpose of this analysis is to provide a comprehensive summary of the potential impact of LOOC-C on greenhouse gas mitigation and corresponding societal benefits.

This report presents a prospective impact analysis using CBA to quantify the net potential benefits of the development, adoption, and implementation of LOOC-C from 2021 through 2030. To account for uncertainty, the case study includes three different adoption scenarios (low, medium, high) and two carbon prices reflecting the current price and a high price scenario. The results of this analysis are intended to inform CSIRO's performance management, accountability, communications, and continual improvement.

2. LOOC-C's Potential Benefits

Our objective is to estimate the extent to which LOOC-C reduces barriers to entry for farmers and landowners into carbon markets in Australia, resulting in accelerated accrual of benefits to the environment and society. Specifically, we estimated the additional value that the LOOC-C will provide over the 2021 through 2030 time period, in terms of earlier achievement of land sector emissions reductions. To do so, we modelled the impact of LOOC-C on agriculture and LULUCF abatement under four alternative estimates of the pace of technology adoption and corresponding mitigation. We also conducted a series of interviews with key experts from CSIRO and the Queensland Land Restoration Fund.

Our analysis is prospective; thus, all estimates presented herein are to be interpreted as probable, should adoption, impact, and use cases emerge as hypothesised. Overall, we recommend focusing interpretation on the direction and magnitude of benefits rather than on the specific quantitative value.

2.1 Carbon Farming Adoption Scenarios

One of the primary benefits of LOOC-C is its ability to reduce information asymmetries, thereby shifting the adoption curve for new carbon farming technologies so they happen more quickly. To estimate the impact of the LOOC-C tool, we constructed alternative scenarios representing these differences in rate of adoption. These scenarios were developed with reference to CSIRO's ADOPT Tool as well as historical patterns of technology adoption among agricultural producers. Below we review key methodological points.

First, we assumed that, in the absence of LOOC-C, the rate of increase in LULUCF and agriculture mitigation would continue according to historical trends. Since 2016, the total ACCUs issued under the ERF increased by an average of 9.5% per year (Australian Government, 2021). We therefore constructed the baseline scenario by starting the observed mitigation quantity of 11 million tonnes (Mt) CO_2e of emissions reductions in 2020 and assumed that the quantity of mitigation will increase by 9.5% each year through 2030.

LOOC-C provides farmers with the information needed to determine whether carbon farming could provide a revenue stream, and knowledge of this potential revenue stream accelerates initiation of a carbon farming project. To examine the potential benefits of this acceleration, we designed three LOOC-C scenarios representing faster increase in carbon farming. We constructed these scenarios starting at the same mitigation quantity in 2020 as in the baseline, 11 Mt CO_2e, and assumed that mitigation increases by 10.5%, 11.5% and 12.5% under low-impact, medium-impact, and high-impact LOOC-C scenarios, respectively.

Finally, we calculated abatement due to LOOC-C by subtracting the counterfactual abatement from the relevant scenario's abatement value.

2.2 LOOC-C Costs and Benefits Calculation

We calculated annual social benefits by multiplying the abatement amount due to LOOC-C (defined as the abatement in the counterfactual subtracted from the abatement in the relevant impact scenario) by the price of carbon, based on two carbon price scenarios. We first used the 2021 carbon price of AUD 25 and next tested a high carbon price of AUD 50, assuming price increases of 3% annually 2022 through 2030 in both cases.

We incorporated the investment costs of LOOC-C into our analysis (Table 2.1). CSIRO invested in the LOOC-C technology for 4 years before our starting reference year of 2021 and then for 1 additional year. Project costs for 2017 through 2020 were inflated to 2021 values using the Australian consumer price index (Australian Bureau of Statistics, 2020).

We discounted the annual social benefits and costs at a 7% social discount rate with 2021 as the base year (Appendix A), as per the CSIRO Impact Evaluation Guide.[1] We subtracted the discounted costs from the discounted benefits for each year and summed net benefits across years to estimate the cumulative net present value of LOOC-C benefits through 2030.

We calculated the benefit-cost ratio (BCR) by dividing total discounted benefits by total discounted costs. We calculated the internal rate of return (IRR) by setting the net present value of the project to zero and solving for the corresponding discount rate.

Table 2.1. CSIRO's Investment in the LOOC-C Tool

Year	Funding (AUD)	Historical Funding Inflated to 2021 AUD	Funding with Discount Factor Applied (Base Year = 2021)
2017	395,540	419,181	549,460
2018	948,355	987,420	1,209,631
2019	921,960	942,589	1,079,170
2020	763,013	773,430	827,570
2021	397,918	397,918	397,918

Source: CSIRO.

2.3 Results

When we applied our projected rates of abatement, we observed a range of mitigation pathways over the period of interest (see Figure 2.1, Table 2.2).

Under the counterfactual, we estimate that mitigation increases from 11 Mt CO_2e in 2020 to 28 Mt CO_2e in 2030. Notably, this counterfactual estimate of mitigation in 2030 is very

[1] Descriptions of CSIRO's impact evaluation methodology are available at https://www.csiro.au/en/about/corporate-governance/ensuring-our-impact/evaluating-our-impact.

close to the quantity of mitigation from LULUCF and agriculture proposed in Australia's Nationally Determined Contribution (Commonwealth of Australia, 2020b).

Figure 2.1. Abatement Estimates for the Counterfactual and Low-, Medium-, and High-Impact LOOC-C Scenarios

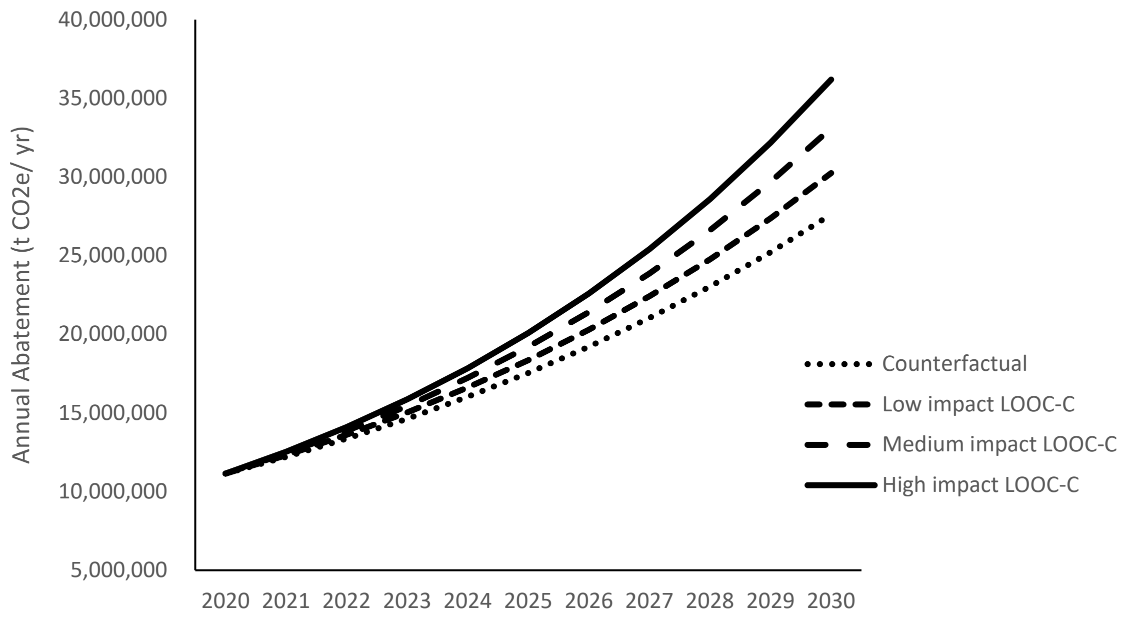


Table 2.2. Abatement across the Counterfactual and Low-, Medium- and High-Impact LOOC-C Scenarios (Columns A–D), and the Difference between the Counterfactual Abatement and each LOOC-C Scenario (Columns E–G)

Year	A) Counter-factual Abatement (Mt CO_2e/ year)	B) Low-Impact LOOC-C Abatement (Mt CO_2e/ year)	C) Medium-Impact LOOC-C Abatement (Mt CO_2e/ year)	D) High-Impact LOOC-C Abatement (Mt CO_2e/ year)	E) Difference between Counter-factual and Low-Impact LOOC-C (Mt CO_2e/ year)	F) Difference between Counter-factual and Medium-Impact LOOC-C (Mt CO_2e/ year)	G) Difference between Counter-factual and High-Impact LOOC-C (Mt CO_2e/ year)
2020	11.2	11.2	11.2	11.2	0.0	0.0	0.0
2021	12.2	12.3	12.4	12.5	0.1	0.2	0.3
2022	13.4	13.6	13.9	14.1	0.2	0.5	0.7
2023	14.6	15.0	15.5	15.9	0.4	0.8	1.2
2024	16.0	16.6	17.2	17.9	0.6	1.2	1.8
2025	17.6	18.4	19.2	20.1	0.8	1.7	2.5
2026	19.2	20.3	21.4	22.6	1.1	2.2	3.4
2027	21.0	22.4	23.9	25.4	1.4	2.8	4.4
2028	23.0	24.8	26.6	28.6	1.7	3.6	5.6

(continued)

Table 2.2. Abatement across the Counterfactual and Low-, Medium- and High-Impact LOOC-C Scenarios (Columns A–D), and the Difference between the Counterfactual Abatement and each LOOC-C Scenario (Columns E–G) (continued)

Year	A) Counter-factual Abatement ($Mt\ CO_2e$/ year)	B) Low-Impact LOOC-C Abatement ($Mt\ CO_2e$/ year)	C) Medium-Impact LOOC-C Abatement ($Mt\ CO_2e$/ year)	D) High-Impact LOOC-C Abatement ($Mt\ CO_2e$/ year)	E) Difference between Counter-factual and Low-Impact LOOC-C ($Mt\ CO_2e$/ year)	F) Difference between Counter-factual and Medium-Impact LOOC-C ($Mt\ CO_2e$/ year)	G) Difference between Counter-factual and High-Impact LOOC-C ($Mt\ CO_2e$/ year)
2029	25.2	27.4	29.7	32.2	2.2	4.5	6.9
2030	27.6	30.3	33.1	36.2	2.6	5.5	8.6
Total					**11.1**	**23.0**	**35.5**

Under scenarios in which LOOC-C accelerates carbon farming, we estimate that mitigation rises from 11 Mt CO_2e in 2020 in all scenarios to 30, 33, and 36 Mt CO_2e in 2030 in the low-, medium-, and high-impact LOOC-C scenarios, respectively (Table 2.2, Columns A through D).

When we calculated the difference between the counterfactual in the absence of LOOC-C and the scenarios in which LOOC-C stimulates participation in carbon farming, we estimate that the tool accelerates additional mitigation on the order of 11 to 36 Mt CO_2e over the 10-year study period (Table 2.2, Columns E through G).

Using the current carbon price, we estimate that the net present value of costs and projected mitigation benefits over the study period is AUD $200 million for the low-impact scenario, AUD $416 million for the medium-impact scenario, and AUD $614 million for the high-impact scenario (Table 2.3a). These values correspond to an average annual net benefit of AUD $20 to 64 million over the study period. When we used the high carbon price, the net present value is AUD $404 million for the low-impact scenario, AUD $835 million for the medium-impact scenario, and AUD $1.29 billion for the high-impact scenario (Table 2.3b). These values correspond to an average annual net benefit of AUD $40 to 129 million over the study period. Importantly, these mitigation benefits reflect the *additional* mitigation due to the LOOC-C and not the full value of mitigation over the study period.

Plotting annual abatement due to LOOC-C allows us to visualize the relatively small size of the initial investment compared to the benefits that accrue in subsequent years (Figures 2.2a and b). We also observe that as time passes, the difference in benefits among the three scenarios widens, from less than AUD $5 million in 2021 to approximately AUD $47 million between the low- and medium-impact scenarios and an additional AUD $51 million between the medium- and high-impact scenarios in 2030 (all using the current price of carbon). Under a high carbon price scenario, the initial gap widens from AUD $9 million to AUD $95 between the low-impact and medium-impact scenarios and an additional AUD $103 between the medium-impact and high-impact scenarios in 2030.

Table 2.3a. Net Present Value of Social Benefits of LOOC-C through 2030 for Three Levels of Impact and Current Carbon Price in Millions (AUD)

Year	Low Impact LOOC-C Net Annual Social Benefit with Current Carbon Price (Millions AUD)	Medium Impact LOOC-C Net Annual Social Benefit with Current Carbon Price (Millions AUD)	High Impact LOOC-C Net Annual Social Benefit with Current Carbon Price (Millions AUD)
2017	(0.5)	(0.5)	(0.5)
2018	(1.2)	(1.2)	(1.2)
2019	(1.1)	(1.1)	(1.1)
2020	(0.8)	(0.8)	(0.8)
2021	2.2	4.8	7.4
2022	5.5	11.1	16.7
2023	8.8	17.7	26.8
2024	12.4	25.1	38.1
2025	16.4	33.3	50.9
2026	20.8	42.6	65.3
2027	25.7	52.8	81.5
2028	31.1	64.2	99.5
2029	37.0	76.9	119.7
2030	43.6	90.9	142.1
Total	199.8	415.7	644.3

Table 2.3b. Net Present Value of Social Benefits of LOOC-C through 2030 for Three Levels of Impact and High Carbon Price in Millions (AUD)

Year	Low Impact LOOC-C Net Annual Social Benefit with High Carbon Price (Millions AUD)	Medium Impact LOOC-C Net Annual Social Benefit with High Carbon Price (Millions AUD)	High Impact LOOC-C Net Annual Social Benefit with High Carbon Price (Millions AUD)
2017	(0.5)	(0.5)	(0.5)
2018	(1.2)	(1.2)	(1.2)
2019	(1.1)	(1.1)	(1.1)
2020	(0.8)	(0.8)	(0.8)
2021	4.8	10.0	15.2
2022	11.0	22.2	33.4
2023	17.5	35.4	53.5
2024	24.7	50.1	76.3
2025	32.7	66.7	101.9
2026	41.6	85.1	130.6
2027	51.4	105.7	162.9

(continued)

Table 2.3b. Net Present Value of Social Benefits of LOOC-C through 2030 for Three Levels of Impact and High Carbon Price in Millions (AUD) (continued)

Year	Low Impact LOOC-C Net Annual Social Benefit with High Carbon Price (Millions AUD)	Medium Impact LOOC-C Net Annual Social Benefit with High Carbon Price (Millions AUD)	High Impact LOOC-C Net Annual Social Benefit with High Carbon Price (Millions AUD)
2028	62.2	128.5	199.0
2029	74.1	153.7	239.3
2030	87.2	181.7	284.3
Total	403.6	835.4	1,292.7

Figure 2.2a. Net Present Value of LOOC-C Social Benefits Under Three Impact Scenarios with Current Carbon Price (2017–2030)

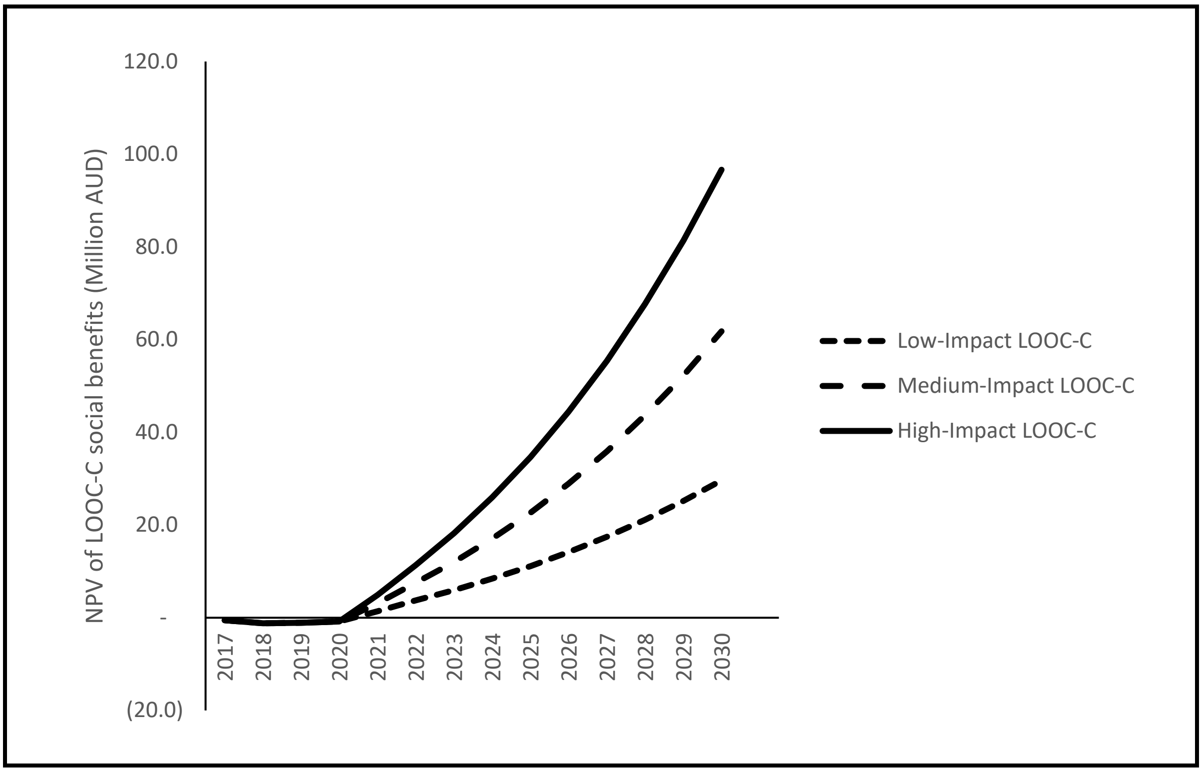
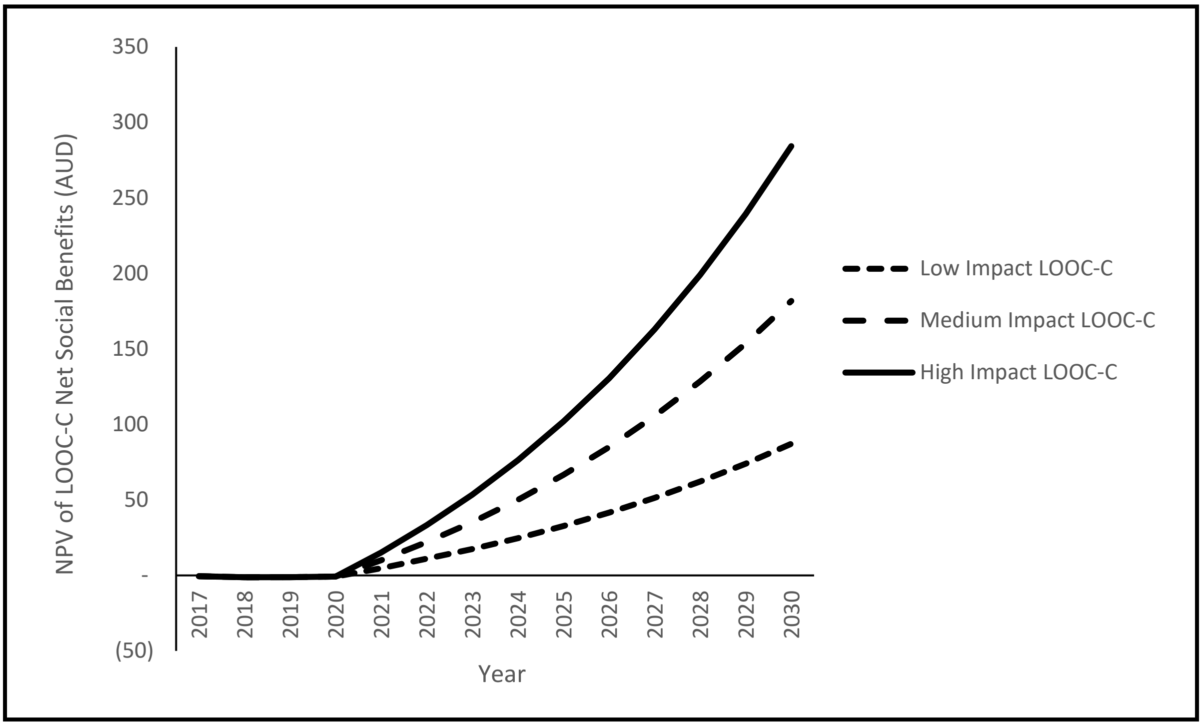


Figure 2.2b. Net Present Value of LOOC-C Social Benefits Under Three Impact Scenarios with High Carbon Price (2017–2030)



3. Discussion

Although only a short period of time has elapsed since LOOC-C's launch, our review of LOOC's usage, feedback from fund managers, and the simplicity of the app suggests that that there is substantial value generation relative to the investment needed to develop it. This section reviews summary quantitative impact measures and benefits that, while not monetised, are significant.

3.1 Summary Quantitative Impact Analysis Results

We project that LOOC-C will catalyse an additional 11 to 36 Mt CO_2e of emissions reductions over the 2021 through 2030 time period, beyond what could occur in the absence of the tool (Table 3.1). We value the net present value of this additional mitigation at AUD $200 to $644 million using the current price of carbon or AUD $404 million to $1.29 billion using the high price of carbon over the decade, based on the cost of developing the tool and a 7% discount rate (Table 3.1).

We estimate that the benefit-to-cost ratio is at least 50, meaning that for every $1 invested in LOOC-C, at least $50 in social benefits are expected to accrue. While it is too early to pinpoint a central point estimate, a conservative result of at least 50 and as large as 319 is substantial.

Table 3.1. Summary of Scenario Results

	Low Impact LOOC-C Scenario	Medium Impact LOOC-C Scenario	High Impact LOOC-C Scenario
Cumulative abatement due to LOOC-C 2020–2030 (Mt CO_2e)	11	23	36
Net present value of social benefits of LOOC-C 2017–2030 with current carbon price (2021 base year)	200	416	644
Net present value of social benefits of LOOC-C 2017–2030 with high carbon price (2021 base year)	404	835	1,293
Benefit-cost ratio of LOOC-C with current carbon price	50	103	160
Benefit-cost ratio of LOOC-C with high carbon price	100	207	319
Internal rate of return of LOOC-C with current carbon price	74%	98%	115%
Internal rate of return of LOOC-C with high carbon price	98%	127%	148%

Several elements of our assessment are uncertain, such as the pace of LOOC-C adoption and use from 2021 through 2030, the translation of tool use into achieved mitigation over this period (i.e., the earlier engagement of a farmer in carbon farming relative to the counterfactual), and the value of those emissions reductions.

3.2 Consideration of Co-benefits

Importantly, this present assessment of LOOC-C's value does not reflect other important values that LOOC-C conveys. LOOC-C has the potential to not only accelerate the quantity of mitigation projects, but also to improve their quality in terms of additional co-benefits beyond what would have otherwise occurred. A new version of LOOC-C will provide users with more detailed information and ratings on potential co-benefits of a given mitigation activity. The more detailed information and ratings will provide farmers and landowners with a more nuanced understanding of the potential value of a given change in land management and help them design projects with greater environmental and social benefits.

One of the principal co-benefits of the tool will be the protection, improved management, or restoration of native vegetation and habitats. Forest restoration and protection comprise a substantial proportion of the mitigation projects currently funded under the ERF and other state funds (Commonwealth of Australia, 2015) and are likely to continue to play a large and important role in Australia's mitigation portfolio. These ecosystems underpin a wide array of provisioning and regulating services, including protecting water and air quality, safeguarding biodiversity, and providing recreational opportunities.

Another value that LOOC-C provides is the democratization of carbon farming so that a broader and more diverse spectrum of landowners and farmers can participate in and benefit from the market. If LOOC-C is successful in addressing information barriers, it will catalyse the development of a portfolio of mitigation projects that are smaller, more dispersed spatially, managed by a more diverse group of farmers, and support a wider range of mitigation activities. This heterogeneity conveys several additional benefits, including wider distribution of benefits for rural communities.

Another key value of this heterogeneity will be risk reduction. Large, aggregated land-based mitigation projects are at greater risk of reversal due to natural disturbances (e.g., wildfires), which may be exacerbated in the face of climate change. By facilitating broader participation and a resulting diversity in project types, location, and management, LOOC-C may hedge against carbon market investment risks.

Additional efforts to expand on the current prospective evaluation of the costs and benefits of LOOC-C should consider detailed assessment of these and other benefits of the tool. Assessment of the co-benefits of mitigation requires information not just on the quantity of emissions reductions, but also on the location, area, and management change of a mitigation project and the corresponding spatial information on environmental and social metrics of interest. Improving our estimate of the co-benefits catalysed by LOOC-C could, for example, entail a review of the extent to which LOOC-C is accelerating the adoption of projects that protect or restore more valuable habitat for target species or landscapes that protect priority watersheds. Because these co-benefits are especially location specific, without finer spatial detail it is not possible to quantify what these impacts may be at this time, but we know from the literature and experience that these co-benefits do, in fact, accrue.

3.3 Concluding Remarks

Our goal in this case study is to provide a reasonable assessment both quantitatively and qualitatively of how LOOC-C may generate social value for Australians over the 10-year period from 2021 through 2030.

We base our analysis on plausible scenarios of LULUCF and agriculture mitigation through 2030 both with and without the catalysing influence of LOOC-C. These sectors already provided roughly 11 Mt CO_2e of emissions reductions in 2020, and we expect that they will contribute 27 Mt CO_2e in 2030 under a counterfactual scenario. Our analysis further suggests that the LULUCF and agriculture sectors could contribute 10 to 31% more to land-based mitigation in 2030 if carbon farming increases by an additional 1 to 3% annually.

The analysis presented here suggests that the benefits provided by LOOC-C will outweigh the costs of development, maintenance, and improvements over the 2017 through 2021 time period. Indeed, we expect that the benefits of the tool are an order of magnitude larger than the costs, even under our lowest assumptions about LOOC-C impacts. Further, our analysis does not take into consideration the potentially valuable co-benefits conveyed via the tool, which would boost these estimates of value even higher. Additional efforts to expand on the current prospective evaluation of the costs and benefits of LOOC-C should consider detailed assessment of these and other benefits of the tool.

A key recommendation for CSIRO will be to continue to promote the tool among target users. One example of this could be a series of case study vignettes illustrating real-world examples of how farmers and landowners have used the tool to take steps through a project pipeline to the point of generating revenue or co-benefits. By encouraging broader use of LOOC-C, the quantity and quality of carbon farming mitigation projects are likely to increase, leading to greater benefits for environment and society.

References

ACT Government. (2021). *Carbon neutral ACT government framework*. https://www.environment.act.gov.au/__data/assets/pdf_file/0007/1163239/Carbon-Neutral-ACT-Government-Framework_Accessible_2014.pdf

Australian Bureau of Statistics. (2020). *Consumer price index, Australia*. https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/consumer-price-index-australia/latest-release#data-download

Australian Government. (2021, July 21). *Emissions Reduction Fund*. *Australian carbon credit units issued*. http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register/Historical-ACCU-data

Commonwealth of Australia Department of Industry, Science, Energy and Resources. (2019). *National greenhouse accounts 2019*. State and territory greenhouse gas inventories: Data tables and methodology. https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-2019/state-and-territory-greenhouse-gas-inventories-data-tables-and-methodology

Commonwealth of Australia. (2015). *Emissions reduction fund fact sheet*. https://pmc.gov.au/sites/default/files/publications/fact_sheet-emissions_reduction_fund.pdf

Commonwealth of Australia. (2020a). *Australia. 2020 National inventory report (NIR)*. United Nations Climate Change. https://unfccc.int/documents/228017.

Commonwealth of Australia. (2020b). *Australia's nationally determined contribution communication 2020*. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Australia%20First/Australia%20NDC%20recommunication%20FINAL.PDF.

Department of Environment and Heritage Protection Queensland Government. (2017). *Unlocking value for the Queensland economy with land and agriculture offsets*. https://www.qld.gov.au/__data/assets/pdf_file/0017/67310/unlocking-value-qld-from-offsets.pdf.

Government of Western Australia. (2021). *Western Australian Carbon Farming and Land Restoration Program*. https://www.agric.wa.gov.au/carbon-farming/western-australian-carbon-farming-and-land-restoration-program

Kragt, M. E., Dumbrell, N. P., & Blackmore, L. (2017). Motivations and barriers for Western Australian broad-acre farmers to adopt carbon farming. *Environmental Science & Policy*, *73*, 115–123.

ndevr environmental. (2021). Tracking 2 degrees report quarterly report for March 2021—Q3/FY2021. Tracking 2 degrees—FY 2021 Q3. Tracking 2 degrees—FY 2021 Q3.

Nordhaus, W. D. (2017). Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences, 114*(7), 1518–1523.

Northern Territory Government, Department of Environment and Natural Resources. (2021). *Northern Territory Aboriginal carbon industry strategy*. https://denr.nt.gov.au/__data/assets/pdf_file/0006/584439/Aboriginal-Carbon-Industry-Strategy_A4_Digital.pdf

Organisation for Economic Co-operation and Development. (2001). *Environmental indicators for agriculture* (Vol. 3: Methods and Results), 389–391. https://stats.oecd.org/glossary/detail.asp?ID=285#:~:text=Carbon%20dioxide%20equivalent%20is%20a%20measure%20used%20to,potential%20for%20methane%20over%20100%20years%20is%2021

Queensland Government. (2021a). *Land Restoration Fund investment Round 1 projects*. https://www.qld.gov.au/environment/climate/climate-change/land-restoration-fund/funded-projects/projects-2020

Queensland Government. (2021b). *Investment Round 2. Land Restoration Fund Investment Round 2*. https://www.qld.gov.au/environment/climate/climate-change/land-restoration-fund/2021-investment-round-2/apply

Victoria State Government. (2021). *Nature restoration for carbon storage – BushBank program*. https://www.environment.vic.gov.au/bushbank

Appendix A: Discount Factor Calculations

We used a social discount rate of 7% to calculate the discount factor for benefits and costs used in net present value calculations (Table A.1).

Table A.1. Discount Factor Calculations

Year (Base Year = 2021)	Discount Rate	Period Benefits	Discount Factor for Benefits	Period Costs	Discount Factor for Costs
2017	0.07	-	-	−4	1.311
2018	0.07	-	-	−3	1.225
2019	0.07	-	-	−2	1.145
2020	0.07	0	1.000	−1	1.070
2021	0.07	1	0.935	0	1.000
2022	0.07	2	0.873	-	-
2023	0.07	3	0.816	-	-
2024	0.07	4	0.763	-	-
2025	0.07	5	0.713	-	-
2026	0.07	6	0.666	-	-
2027	0.07	7	0.623	-	-
2028	0.07	8	0.582	-	-
2029	0.07	9	0.544	-	-
2030	0.07	10	0.508	-	-

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