final report

Project code: V.SCS.0011

Prepared by: Robert Matindi
Meat and Livestock Australia

Date published: 12 June 2019

PUBLISHED BY
Meat and Livestock Australia Limited
PO Box 1961
NORTH SYDNEY NSW 2059

Quantifying the Impact of MLA's Supply Chain Sustainability On Farm Program in Contributing to the Australian Red Meat Industry's Social License to Operate

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

This project involves the development of a triple bottom line approach to measuring and evaluating the impact of investments made under MLA's Environmental Sustainability On-Farm Sub-Program over the financial years 2016/17 and 2017/18. Economic, environmental, and social metrics, and methods were developed to determine the contribution of the sub-program towards maintaining the Australian red meat industry's social license to operate. This work supported MLA's broader evaluation process for investments made over the period 2015-2020.

Executive summary

This project assessed the impact of MLA investment over the period 2015/16 to 2021/22 inclusive. The industry benefits were evaluated flowing from MLA delivery of the MLA on-farm sustainability program. Industry impact are projected to occur when there are measurable changes in industry practices, management practices leading to a commercial change in net return to the industry. Two main products were assessed for impact including the new species of dung beetle and the Northern Australia Climate program. Given limited time and resources, not all products developed in MLA's Supply Chain Sustainability Program over the period 2015-2020 were evaluated. Further work is required to complete the program evaluation, which MLA is undertaking as part of its broader evaluation process for investments made over the period 2015-2020.

The new species of dung beetle were imported to remediate pastures that have been contaminated by dung. In Australia, there are approximately 24 million hectares contaminated by dung. In order to reclaim the contaminated pastures, the dung beetles were distributed throughout Australia. The ecological benefits of dung beetle were evaluated to assess the potential benefits in terms of improvement of soil productivity, pasture growth, prevention of pasture fouling, nutrient cycling, gastro intestinal parasite control, and it was found that on conservative basis, the benefit cost ratio was (BCR) 3.20 and 5.74 on optimistic basis.

The other product evaluated were a set of forecasting tools developed for the Northern Australia Climate Project Phase 2. In this project the developed tools utilised weather attributes precipitation, temperature, wind, solar exposure and maybe soil moisture including to define flash drought.
The impact of the said tool was assessed based on the number of users utilising it to make some management decisions particularly in regards to stocking and destocking rate based on weather forecast predicted and pasture growth. The two scenarios modelled included full adoption of climate forecasting tool by the livestock producers coupled with perfect skill from the forecasting tool.
It was found that under the conservative scenario, the BCR ranged from 7.7 to 9.3, while under the optimistic scenario, the BCR ranged from 16.3 to 19.5, relative to the baseline scenario.

A qualitative assessment including tools development of the programs under the on-farm environmental sustainability program was conducted to measure the non-market impact factors, and the social dimension of the sustainability framework. The tool can be applied to measure the key performance indicators for any program under evaluation.

A future area of work to be suggested for further research is the role of dung beetle in mitigating against Greenhouse Gases, particularly methane and nitrous oxide and in increasing water infiltration. In order for this to avail measurable results, Mesocism experiments need to be conducted.

Table of contents

1 Background

1.1 Triple Bottom Line Measurement & Evaluation Framework

The triple bottom line approach and development of an evaluation framework was adopted from the concept underpinning AS/NZS 14001-2016 (Environmental Management Systems) and the Council of Rural Research and Development Corporations (CRRDC) Impact Assessment Guidelines. The Australian Standard lends its approach of identifying aspects and impacts for undertakings, which form the structure of the framework. The Impact Assessment Guidelines provide the general principles in the valuation of impacts, the analysis against the counterfactual and identifying attribution effects, and cost-benefit analysis.

The methodology adopted commenced with the selection of suitable and representative indicators, that were necessary to analyse the potential and actualised impacts (social, economic and environmental) on on-farm environmental sustainability at regional and national scale. Indicators were selected according to their ability to describe the pressures of agricultural production systems on sustainability and in line with supply chain sustainability five year business plan.

A detailed literature review was completed and a set of potential indicators used by globally used was created according to the indicators' relevance to this study. Selected indicators were used in several surveys (OECD, 2001a, OECD, 2001b, EEA, 2005) and designed in a way that would allow information to be easily obtained by farmers and also would ensure the quality of data. Indicator selected for the final set are significant in terms of assessing sustainability, relevant to the agricultural activity's description, measurable, based on easily obtainable information, reproducible, and comprehensible to those without specific knowledge.

Following the development of a general framework, the key elements for instance aspects and impacts have been identified in lieu of meat and livestock industry. This was done in order to assist in the direct adoption of framework to MLA's projects.

In order to assign the monetary value to impacts and quantify their effects, previous detailed literature review from previous reports and studies was conducted.

1.1.1 Sustainability indicators

Sustainability indicators for agriculture and in effect livestock have been widely used to understand and measure farm performance; such indicators have included environmental quality, economic viability and employment and social performance (Potter and Erwin, 1999, CEC, 2001, Barnes, 2002).

These indicators can be modelled individually, as a set or in the form of a composite index, whereby individual indicator's score are amalgamated into a single value.

A framework is thus deemed to address sustainability assessment when a holistic approach to the three dimensions are addressed and analysed appropriately (Smith et al., 2000).

Previous research have developed methods that are instrumental in assessing agricultural sustainability, however, there is still no universally accepted method for the creation of indicators and indices (Malkina-Pykh, 2000). An operational approach is presented to assess and compare sustainability in agricultural livestock production systems at the regional level. Data was collected from various farms which was later scaled up to regional and national level through a weighted mean.

The proposed composite indicator aggregates environmental, social, and economic indicators into a unique measure and thus represents the level of agricultural sustainability in a given region/state/country. The aggregation of different indicators is performed using the Multiattribute Value Theory (MAVT) (Keeney and Raiffa, 1976), because of its ability to analyse various and different conditions.

This methodology can therefore be applied to compare regional sustainability and in effect as a "remit" for regional and national planning.

1.1.2 Functional unit

The functional unit represents the primary output from the production system being considered and has close semblance to the system boundary.

On farm emissions covered include emissions from livestock, the use of nitrogen fertilizer, savanna burning and N_20 from legume based pastures.

The preferred functional unit reporting in MLA is 1 Kg of Hot Standard Carcass Weight (HSCW).

Depending on the section of the supply chain being considered, live weight is also used where necessary interchangeably.

Thus for the purpose of this study, the operations and processes being considered are on farm operations, and thus both live weight and HSWC were employed as functional units for reporting (Wiedemann, 2013).

In order to normalize the varied data of different livestock herd, farm was defined as follows using a normalized unit , the Australian livestock unit (ALU), depending on the species and age, and considering an adult animal of the bovine species is 1 livestock unit, a calf more than 9 months old is 1 livestock unit, and a calf under nine months is 0.6 LU, while a calf under nine months old id = cow's feed on the typical dairy farm consists of forage (maize and ryegrass silage and straw) and concentrates (Leitão et al., 2001), totalling an average daily consumption of 41 kg of feed as fed (16.2 kg dry matter) per livestock unit.

2 Project objectives

This project aims to undertake the measurement and evaluation of the impact of the Supply Chain Sustainability Strategy (SCSS) by assessing the impacts of projects within its scope. The overall project objective is to be achieved by the completion of the following tasks:

- Development of a framework through which the triple bottom line measurement and evaluation of MLA's SCSP could be completed
- Measurement and evaluation of the impact of the SCSP over the financial year 2016/17,2017/18,2018/19,2019/20
- Determination of the contribution of the SCSS towards maintaining the industry's social license to operate

3 Methodology

Sustainable farming refers to the ability of agroecosystem to remain productive in the long term and is concerned with the ability of agroecosystems to remain productive in the long term. Sustainable farming derives its definition from the following dimension.

Environmental sustainability, social sustainability and economic sustainability, this approach to evaluation is popularly known as the triple bottom line measurement.

3.1 Measurement and evaluation of the Supply Chain Sustainability Program

Following the review of the Framework, the measurement and evaluation of projects within the SCSP will be conducted. A list of projects in scope has been prepared and presented in Table 6.3-1

3.2 Determination of the contribution of the Supply Chain Sustainability Strategy towards maintaining the industry's social license to operate

The results of the measurement and evaluation will be presented with the proper context to provide a more meaningful assessment of the industry's social license to operate. Recommendations will be presented. A final report for the evaluation was prepared following the CRRDC Impact Assessment Guidelines (Council of Rural Research and Development Corporations, 2014) and will be incorporated into this project final report.

3.3 Supply Chain Sustainability Strategy Evaluation Framework

3.3.1 **Background**

This project is to measure and evaluate the return on investment (ROI) of funds invested in MLA's Supply Chain Sustainability Program (on-farm) over the period 2015-2020. This is in preparation for the MLA's statutory funding agreement and performance review in 2020.

Specifically the Evaluation Framework is required to: a) Be aligned and consistent with MLA's Strategic Plan; b) Ensure that key performance related information is consistently collected, monitored and reported; c) Include a structured plan for the systematic evaluation of the efficiency, effectiveness and impact of MLA's key investments; and d) Include a means of publishing and disseminating relevant Research, Development and Extension (RD&E) outcomes and the outcomes of evaluations.

The success of the meat industry is dependent on the sustained supply of natural resources, the predictability of climate, and the role of the communities in which MLA operates in, among others. Developments to make meat production more sustainable thus is vitally important since it enables high operational and financial performance while preserving the availability of valuable inputs, mitigating the risks of changing climate and being a good partner to the community.

A cursory analysis of projects under on farm environmental programs shows a diverse cluster of RD&E projects staggered into the following product groups;

1) Sustainability knowledge and enablers - which involves generation of scientific knowledge relating to:

- Water management

- Soil management
- Carbon methodologies enabling participation in the domestic carbon market among others
- The Red Meat Advisory Council's sustainability framework and an industry approach to reporting sustainability
- Providing technical support for Grazing Best Management Practice Program (Grazing BMP) through MLA research projects updating learning/coaching methodologies (e.g. Profitable Grazing Systems) to enable integration of carbon farming methods into on-farm practices

2) Sustainability Technologies and practices which involves the application of outputs generated within sustainability knowledge and tools for practical purposes behind the farm gate, these will involves projects showcasing development and demonstration of:

- Climate forecast products
- Grazing systems that incorporate pastures resilient to hotter and more variable climates
- Novel feedstock with potential to reduce enteric methane emissions and improve productivity
- Supplement delivery mechanisms for reducing enteric methane emissions in extensive grazing systems
- Soil carbon measurement technology
- Improved strain of dung beetles

In 2016, the impacts of MLA projects in the periods of 2010-11 and 2014-15 have been assessed with a methodology aligned with the CRRDC Impact Assessment Guidelines. In this assessment, projects under the Off-farm Environment sub-program were included. These projects are similar to the projects under the current SCSP. The assessment identified key impacts related to resource use efficiency, waste management and value-add to waste, mitigation of greenhouse gas emissions (GHG), environmental stewardship and compliance, and capability, knowledge and adoption of new technologies. Where it was appropriate, monetary value were also assigned to the impacts. From the total actual investment of $16 million for the study period, a total of $40 million of red meat industry (RMI) net income was estimated. This presents a benefit-cost ratio of 2.5 for this portfolio (Impact Assessment of MLA Expenditure 2010-11 to 2014-15, 2016).

In the evaluation of costs and benefits of a project, the economic values are the easiest to determine, because these are almost always included in project proposals and reports. The impact to production, price, cost and subsequently, revenue and profit are readily available due to their importance in justifying investments. Moreover, the value of increased production, reduced inputs or improved efficiencies can easily be determined using their market price. Assigning value to environmental and social impacts are relatively difficult due to the nature by which these impacts occur. For instance, the economic impact of a project that improves efficiency can easily be determined by cost savings or a higher production yield, with likely savings in explicit environmental costs such as waste disposal or water and energy use costs. However, other social and environmental impacts cannot be assigned market values since markets for these quantities do not exist. The milestone was completed by presenting an interim report and doing a presentation to the Industry partner, (MLA), APR Intern representative and the Academic mentor for the project detailing the proposed evaluation framework (Section 6). A sample project (The Dung Beetle Project was assessed fully to determine the applicability of the framework components.

3.3.2 Evaluation and Impact Measurement

Strategic Link

The evaluation and measurement framework is not a standalone process. It should link directly to existing management and planning processes and seek to enhance the outcomes of current sustainability strategies.

This framework relates to the strategic imperatives of the current SCSS. These provide the input to the framework by identifying the priority aspects and their impacts for evaluation and measurement. The priority impacts are highlighted in impact assessment and measurement, and indicators for each impact are reported and assigned value, when appropriate. Non-priority impacts may also be monitored with the appropriate level of detail in consideration of these impacts potentially gaining importance in future. The framework enables a systematic top-to-bottom approach in determining what valuable sustainability performance measures should be evaluated from the portfolio of projects. The framework also facilitates the flow of information from bottom to top in the review of sustainability strategies. The framework presented in this way allows for the change in priorities over time without a drastic change in the framework. The cascade of priorities from strategies to the evaluation and measurement process is presented in the figure below.

Figure 1 Strategic link of sustainability strategy to the values of sustainability impacts.

The Path to Impact box represents the approach taken by MLA to institute a simple approach towards transparent delivery. This was based on an industry 'best practice' framework that provides consistency of project approval, delivery, and assessment. The link from the activities to impacts also facilitate the evaluation of cost-benefit ratios, which demonstrate the value of investment managed by MLA. The Path to Impact approach is shown in the figure below.

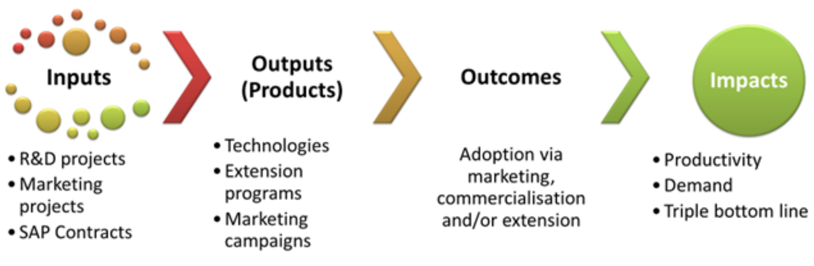

Figure 2 MLA Path to Impact Approach

An aspect, in the context of this framework, refers to a consequence of an R&D output that results in an impact. Aspects can occur just once, a number of times, or continuously. The aspects should be determined for the project or product, keeping in mind there are aspects that can be passive such as land use, which might not be easily identified. For instance, in the process of cattle production, the relevant aspects are fresh water use, methane emissions, solid waste generation, energy use, etc. When identified, these aspects can be easily linked to the sustainability priorities identified in overarching strategies. The aspects bridge the strategic view with the triple bottom line impacts of the activities, as well as across a wide variety of activities that involve the same aspects. On the project level, the aspects provide the targets for monitoring throughout the project. On the strategic level, focusing on priority aspects in evaluation allow for a consistent view across all products and other outputs.

An impact relates to the effect of the change in an aspect that can be evaluated. For example, a change in water use can be evaluated by measuring the cost of usage, savings from efficient water use, level of water reserves, community reaction, etc. The impacts can be direct or indirect, certain or uncertain, and can occur immediately or in future. Direct impacts pertain to effects that proceed immediately after the variation of the aspect, such as usage or disposal costs, odour, and regulatory fines. Indirect impacts refer to associated effects such as contamination of surface water from run-off. The certainty and timing of impacts are also pertinent in many cases. For instance, costs related to waste management are certain and immediate, while community displeasure after a pollution event can be uncertain and may not happen immediately. Therefore, it is important to identify the most significant impacts by focusing on certain and immediate direct impacts for measurement, to maximise the value of evaluation and subsequent mitigation. This is not to say that indirect, uncertain and/or future impacts are not important, but their values are slightly diminished by their smaller likelihood. Impacts that are related to compliance to legislation are by default, significant.

Mapping the aspects to impacts and indicators helps to demonstrate the value of evaluating a project or product with a particular indicator. The link is usually clear, but there are instances where it is not. A number of indicators can also relate to the same aspect, but can pertain to an economic, environmental or social impact. The applicability of aspects, impacts and indicators will vary across different projects or products, nonetheless, the framework provides for a set of potential items for projects of varying natures. The list of aspects, impacts and potential indicators is included in this framework to provide flexibility in capturing the costs and benefits of a project. The list was created considering the projects in scope for this evaluation and other relevant items can be added in future.

The indicators are chosen to yield measurements of qualitative or, if possible, quantitative nature, matching the industry practice of measuring the impacts. There was also consideration of the ease of quantitative valuation in selecting the indicators. Ultimately, the indicators should serve to meet the objectives for controlling the impact and provide information to the planning feedback loop. A subset of the indicators (in boldface) in the following table will be used for this evaluation. Other indicators included in the table will be considered based on the nature of the project or product.

Table 1. Aspect-Impact-Indicator Mapping

Aspect	Impact	Type	Indicator
GHG emissions	Carbon costs or revenues	Economic	**Carbon revenues (AUD/y)**
	Contribution to climate change	Environmental	GHG emitted (t CO_2e/y)
	Carbon neutral brand	Social	**Carbon footprint (t CO_2e/kg product)**
Low carbon energy use	Net GHG emissions	Environmental	CO_2 abatement (t CO_2e/y)
	Water cost	Economic	**Cost or savings of water use (AUD/y)**

Aspect	Impact	Type	Indicator
Fresh Water Use (extracted or purchased)	Competition of source	Social	Narrative – community view
	Water consumption	Environmental	Water use efficiency (kL water/kg product)
Fresh Water Use (recycled or processed water)	Purchased water costs	Economic	Water savings (AUD/y)
	Water operational reliability	Environmental	**Amount of recycled water used (%)**
Recycled or generated energy	Purchased energy costs	Economic	**Energy savings (AUD/y)**
	Energy reliability	Economic	**Self-generated energy usage (%)**
	Competition in energy	Social	Self-reliance/dependence on grid (%)
Energy efficiency	Energy costs	Economic	Energy savings (AUD/y)
	CO_2e emission abatement	Environmental	CO_2 abatement (t CO_2e/y)
Fossil fuel-based energy use	Energy costs	Economic	Energy costs (AUD/y)
	Net GHG emissions	Environmental	GHG from fossil fuels (t CO_2e/y)
Waste water emission volume	Wastewater treatment cost	Economic	**Wastewater treatment savings (AUD/y)**
	Net wastewater emissions	Environmental	Net wastewater emitted (kL wastewater/y)
	Being viewed as a polluter	Social	Narrative – community view
Solid waste emissions	Solid waste treatment/disposal costs	Economic	**Solid waste treatment savings (AUD/y)**
Odorous emissions	Community complaints	Social	Complaints (#)
	Emission of odorous substances	Environmental	Narrative - measurement/abatement of odorous emissions
Change of land use	Reduced availability for biodiversity	Environmental	Converted land (ha)
	Change in scenic amenity	Social	Narrative – community view
	Reduced availability for pasture	Economic	Available pasture land (ha)
Manpower requirements	Job opportunities	Social	New jobs created (#)
	Capabilities and knowledge	Social	New jobs with new capabilities created (#) or new capabilities created
Information	Adoption of new tech	Economic	Likelihood to adopt
	Capabilities and knowledge	Social	Narrative – list of new skills developed
	Investment risk	Economic	Variance of NPV across options

Among the aspects presented here, the following aspects have been determined the priority aspects aligned with the Supply Chain Sustainability Strategy 2016:

- Greenhouse Gas Emissions
- Water Use
- Energy Use
- Waste Water Emissions
- Solid Waste Emissions

The effects around generating jobs and advancing adoption will also be evaluated, aligned with existing MLA evaluation procedures.

Evaluation

Projects under the SCSP are varied due to the different outcomes these projects present upon completion. One group of projects result in direct economic, environmental and social impacts, while the rest have a direct impact to advancing the adoption of technology or innovations that can then improve the triple bottom line performance. This framework focuses on determining the valuation of the priority aspects to make up the cost-benefit analysis. Where a quantitative market value can be determined, the cost or benefit has been included in the quantitative cost-benefit ratio. The methods in determining the values are described here.

Assumptions

The following are the assumptions considered in the evaluation.

- Lessons learned are more likely to be shared because they are seen as pre-competitive, and thus, there can be underestimations due to spill-over benefits to similar firms and associated industries
- Second-round effects are evaluated to a very limited extent. This is to minimise misattribution of results solely to the projects in scope, in recognition of other significant factors such as market behaviour, regulation, and social trends.
- Valuation methods are selected based on relevance to existing systems and markets.

Scoping

The list of priority aspects are used to assess their relevance to the project evaluated. The aspects can be 'scoped-in' if the project causes a change to the aspect and produces an impact. The impacts of each aspect change are captured in two separate sections. The first section considers market economic, environmental and social impacts, and with monetary costs, used to calculate the benefit cost ratio. The other section considers non-market economic, environmental and social impacts. Although non-market impacts are usually evaluated qualitatively, a monetary value can be assigned to an impact, even if there are no markets where these values can be traded, thus they are considered separately.

The scoping tool requires the documentation of the description of aspect change, the identification of the impact, a determination if the impact is a cost or benefit, a description of the impact, the quantification of impacts and the factors used to convert the quantities of impacts to monetary value. This assists in reviewing the evaluation and preparing reports as needed.

Valuation of Impacts

Impact Assessment

Energy use

For this study, Energy use and specific energy consumption were analysed by system analysis methods, whereby, the energy flow through the functional boundaries defined for an on-farm operation. The inputs for these system are both direct and indirect inputs.

The system under study therefore includes red meat production on Australia on-farm systems, and the production of forage crops (maize silage and rye grass or any other suitable silage).

The animal production system is largely an inefficient energy converter due to double energy transformation.

Firstly, through the photosynthesis process where solar energy and soil nutrients are converted into biomass by green plants, later when the referenced biomass is fed to animals, a large percentage of the energy intake is used in maintaining body metabolism, and only a small proportion is used in meat and by-products production (Frorip et al., 2012).

Direct energy inputs are fuel and lubricants used in feed processing and for energizing of delivery machinery. The electrical energy is used for milking, milk cooling, water heating and pumping, lighting, ventilation, air heating, electrical fencing, manure handling, office and personnel working environment and etc. Conventional electricity consumption represents around 25% of the non-renewable energy use at the dairy farm; the diesel fuel corresponds to 15% of energy consumption (Bulletin of the International Dairy Federation, 2010).

Non-renewable sources of energy used in production, transportation, storage and controlling thermal environment (cooling, heating or ventilation) and animal waste recovery poses a sustainability challenge due to constraints ranging from availability to utilisation efficiency.

Previous research shows that for every 1 kg of high-quality animal protein produced, livestock are fed about 6 kg of plant protein. In the conversion of plant protein to animal protein, there are 2 principal inputs or costs: 1) the direct costs of production of the harvest animal, including its feed; and 2) the indirect costs for maintaining the breeding herds (Pimentel & Pimentel, 2003).

Lamb and beef production have been shown to have the most inefficient livestock production system with data showing that the fossil energy expended for lamb and beef production as 57 kcal and 40 kcal of fossil energy for each I kcal of lamb and beef protein produced i.e. ration of 57:1 and 40:1 respectively, but with efficiency improving with more than half by using improved-good pastures (Pimentel & Pimentel, 2003).

The activities related with beef production on farms require an effective evaluation of their environmental impact. This study evaluates the global environmental impacts associated with beef production on for on-farm operations in Australia and classifies the processes that have the highest environmental impact by using life cycle assessment (LCA) methodology.

The determination of a functional unit in LCA, which ideally refers to a measure of the function of the studied system and provides a reference to which the inputs and outputs can be related to was determined (Finkbeiner et al., 2006) .

The main factors involved in on farm beef production were included, specifically: the farm, maize silage, ryegrass silage, straw, concentrates, diesel and electricity. The results suggest that the major source of air and water emissions in the life cycle of beef is the production of concentrates.

The activities carried out specifically on farms were the major source of nitrous oxides (from fuel combustion), ammonia, and methane (from manure management and enteric fermentation).

The on-farm activities which includes manure management, enteric fermentation and diesel consumption, make the greatest contributions to the categories of impact considered.

The study investigated energy demand, water use, land occupation, eutrophication potential, soil depletion potential and greenhouse gas emissions.

The specific focus for the supply chain for this study, was the production of live weight beef at the farm gate.

At the farm gate, energy, water and GHG were found to have significant environmental impact in the Australian beef industry other international studies (Castanheira et al., 2010; Wiedemann, 2013).

Energy demand as primarily associated with purchased inputs (i.e. feed supplements and services) and farm energy use (i.e. diesel and electricity use). Water use was primarily associated with direct drinking water requirements for livestock, and storage losses (evaporation) from farm dams.

The production of concentrates and maize silage are the major contributors to the abiotic depletion category, accounting for 35% and 28%, respectively, of the overall abiotic depletion potential (1.4 Sb eq. per tonne of milk).

Water use

Water use assessment was based on the Bayart et al. (2010) model that covers all sources and losses associated with the on farm operations (cradle to farm gate before processing). The categories of fresh water used in the beef production (for on-farm operations) included the livestock drinking water requirements and the irrigation water used to grow feed or on pastures in drought in the referenced regions.

Livestock drinking water for cattle was predicted using Ridoutt et al. (2012) model which is based on live weight (LW), feed intake and moisture content among other variables.

Irrigation water use was based on records of irrigation water used on specific farms, lack of specific farm on irrigation, an interpolation of national data sourced from ABARES survey which provided the irrigated pasture used for beef cattle and sheep was used together with irrigation use for production of hay, grains and supplements (ABARES, 2016).

For purposes of assessing the impact on the implemented projects touching on water, the change in water use due to implementation of measures that necessitate efficient use or reuse was used as an impact indicator.

Therefore change in water use due to recycling or reuse was recorded as a cost or benefit depending on the impact the project had on water use (positive or negative),which was calculated as shown below:

$$B_Q = W_Q * UC_q$$

Where

B_Q *is the benefit or cost accrued due to change in water use* (AUD)

W_Q *the amount of water saved or additional water used due to project implementation* $(Litres)$

UC_q *the unit cost of water* $(\frac{\$}{l})$

Equation 3.3-1

Solid waste and waste water

The values used in solid waste and water waste will be the values incurred due to increased or reduced waste volume relative to the base scenario (if the project had not been implemented).

Further, the changes due to the quality of flow where applicable was also assessed, and included in the analysis.

Thus the changes to waste costs due to the implementation of initiatives geared towards reducing wastes were considered annually (annual CAPEX and OPEX), saved or accrued due to product/technology adoption.

The quantities or waste produced were derived from the herd model and the previous project reports.

Other costs and Benefits

There are other relevant benefits that are implicitly gained from adoption of technology, for instance reduced use of fertilizer, fly control and GHG emissions control accrued by using tunneling dung beetle are also quantified and included in the analysis.

The values used to normalise the environmental impact to products unit value were 0.61 Kg/head/day ,0.64 Kg/head/day for SW Queensland gain for herd bull North Queensland, 255 kg for HSWC of cattle and 20 Kg for the HSWC of lamb (Wiedemann, 2013).

In order to determine the total feed requirements (Dry matter intake) for grazing herd (cattle), Minson and McDonald (1987) model was used**,** while and the feed requirements for sheep was adopted from the Australian NGGI (DCCEE, 2012).

Cost Benefit Analysis

Cost-benefit analysis (CBA) was the technique employed to compare the total costs of a programme/ project with its benefits, using common metric (most commonly monetary units). However, for this assignment, both markets and non- market benefit costs were modelled in order to enable project evaluation.

The profitability and attractiveness of the project was assessed using the conventional Net Present value (NPV) together with the profitability index.

The system value is thus derived by the incremental benefits or costs relative to baseline scenario (Counterfactual).

Direct impacts were also assessed the Market BCA i.e. impacts arising from the direct implementation of the project, which in effect implies that the costs and benefits incurred are solely due to the project being developed.

The net benefits to the red meat industry are thus derived from subtracting the annual operating costs and adoption costs from the accrued or projected annual revenues as shown in the following equations.

$$NetB_i = \left(Market_{benefits} - Operating_{costs}\right)$$ *Equation 3.3-2*

$$NCF_i = (NetB_i - Adoption_{costs} - Operating_{costs})$$ *Equation 3.3-3*

$$ICF_i = NCF_i(1+r)^i$$ *Equation 3.3-4*

$$DisICF_i = ICF_i(1+d)^{-i}$$ *Equation 3.3-5*

$$NPV = \sum_i^n DisICF_i$$ *Equation 3.3-6*

$$BCR = \frac{NPV - R\&D\ Cost}{R\&D\ Cost}$$ *Equation 3.3-7*

Where

- $NetB_i$ is the total benefit for year i
- NCF_i is the cash flow for year i
- $Adoption_{costs}$ Adoption costs
- $Operating_{costs}$ Operating costs
- *R&D cost* is the MLA investment for the product
- r is the inflation rate

- i the current year
- d is the discount rate set at 5%
- NPV is net present value over project lifetime
- n project lifetime (years)
- BCR is the benefit-cost ratio for the red meat industry

The analysis considers different adoption rates and period, when the new products/technology will commence its adoption (implementation period). Thus the R&D Costs and the capital costs are by default spent on year zero, but operating costs and revenues start accruing after the first product roll out which by default has been set to year 1.

When the adoption model is incorporated, the number of installations for a given year serves as a multiplier for $NetB_i$. NCF_i is then calculated by deducting the capital investment from the total benefit for a year i when a product is installed or technology adopted.

The evaluation tool provides some options to model a constant adoption rate (years between adoption or its reciprocal, installations per year), or a variable rate, where the list of installations can be provided manually. A calculation of the project benefit-cost ratio (i.e. one installation or assets roll-out) is provided as a reference. For this evaluation, the BCR calculated was based on one roll-out (colony of dung Beetles) on the year specified in the adoption list.

The Net Present Value (NPV) including R&D costs was calculated, as well as an NPV excluding R&D costs.

Non-market costs and benefits were modelled using qualitative techniques, due to their inherent challenges of lacking monetary values to be assigned to them. Most of these factors were social factors/impacts (the third bottom line).

The incremental benefit/costs relative to base scenario (reasonable counterfactual) was used to evaluate the impacts of non-market factors.

Similar to the qualitative measures, the quantitative measures was reported as percent reduction or improvement from baseline scenario /pre-project values (i.e. the incremental benefit/costs) for implementing the project. The social impacts were also quantified using a tool developed in excel spreadsheet, together with a corresponding user guide. The developed integrated tool in effect used to quantify both the social aspect of the projects implemented for the referenced period together with economic and environmental impacts.

4 Results

The following Table 3.3-1 shows the mapping and classification of outputs prior to the evaluation.

Table 3.3-1 Project – Output Mapping

Output List	Projects	Enabler/ tool?
New Species of Dung Beetle	B.ERM.1106 B.ERM.1104 B.ERM.1102 B.ERM.1103 B.ERM.1101 B.ERM.1100 B.ERM.1000 B.ERM.0216 B.ERM.0214 B.ERM.0213 P.PSH.1134	Product
New BOM Prototype Flash drought forecasting tool for Northern Australia Climate Product	P.PSH.0951	Products
The Northern Rainfall Onset (NRO) forecasting tools		
Australia Drought Monitor Prototype		
Model for forecasting of extreme climate events	B.CCH.8000	Products
SCAN System Software	P.PSH.0945	Product
SCANS soil carbon measurement (CSIRO/Carbon Link)	P.PSH.1145 P.PSH.0918	Tool/Enabler
Part 1 - Wambiana Grazing Trial Phase 3: Stocking Strategies for Improving Carrying Capacity, Land Condition and Biodiversity Outcomes	B.ERM. 0105	Product

4.1 Products

4.1.1 New Species of Dung Beetle – P00282

The CSIRO's 1965-1985 Dung Beetle Project successfully introduced 23 species of South African and European dung beetles to Australia, improving the quality and fertility of Australian cattle pastures, and reducing numbers of pestilent bush flies by around 90%.

Meat & Livestock Australia will receive $9.2 million under Round 3 of the Rural Research and Development (R&D) for Profit Program for a project looking at ways to use dung beetles to increase farm productivity and profitability. The project will help farmers harness the potential of dung beetles as 'ecosystem engineers', which can improve soil health, reduce the spread of flies, pests and diseases, increase pasture health and reduce nutrient run off into waterways.

MLA will collaborate with 12 project partners with the shared goal of realizing the value of the 80 million tonnes of dung produced by Australian livestock every year.

To quantify the economic value of ecosystem services offered by dung beetles for the red meat industry in Australia, scenarios were modelled based on four predicted potential benefits. The impacts were estimated, of changes in the provision of the predicted benefits on pasture productivity and animal health. The potential economic benefits of dung beetles modelled were: reduction in pasture fouling and in effect increase in pasture productivity, gastrointestinal parasite reduction, and increased nutrient cycling benefits.

To assess the impacts of these potential benefits, the daily live weight gain was used (and dead weight carcass price according to cattle age), together with the value of land tenure and mineral fertilizer prices as indicators, to derive the value of the ecosystems services provided.

***Control of pest flies**.*

This benefit was modelled as an avoidance control mechanism of horn and face fly which breeds in dung. The effect is normally the energy expended in trying to fend them off (McKenzie & Byford, 1993).

Face flies are also known as the main agents for transmitting *Moraxella bovis* a key causative agent for bovine pinkeye disease (Krafsur & Moon, 1997).

These vectors were shown to indirectly lead to reduction in live weight gains.

The mediating relationship of this benefit is shown in the equation below.

$$c_a * c_{fp} * P_{wg} = d_{lwg} * p_{lwg} = BD_{pr} \qquad \textit{Equation 4.1-1}$$

whereby c_a corresponds to livestock number (cattle) (by age) treated, or not treated, with anthelmintic that has lethal effect on dung beetles; c_{fp} corresponds to the percentage of beef cattle and sheep affected by pest flies; P_{wg} represents the period in days over which daily live weight gain, is affected; d_{lwg} is the reduction in daily live weight gain; p_{lwg} is the value of prevented daily live weight gain reduction, and BD_{pr} represents the indirect benefit of cost reduction ($/year) accrued by deploying dung beetles in the referenced scenarios (high performing scenario and low performing scenario).

Gastrointestinal parasite control.

Sheep and cattle are infected with gastrointestinal parasites when grazing, which negatively impact on daily live weight gain, feed intake and hot carcass weight (Rose et al., 2015). Their propagation is through eggs and larvae that pass out from infected animals to pastures. Dung beetles however, can mediate this effect by tunneling dung to the subsoil, thereby reducing impacts (Gregory et al., 2015; Nichols & Gomez, 2014).

The model developed to simulate this effect was based on dung beetle activity where faster tunneling of dung to the surface was associated with 35 % reduction of gastrointestinal parasite, and 5 % reduction of gastrointestinal parasite for low tunneling beetle corresponding to scenario where dung emanated from cattle that had been treated with the lethal chemical that can decimate dung beetle.

To estimate the meditated benefit of controlling gastrointestinal parasite by dung beetles, the following relationship was used whereby c_{at} represents the number of anthelmintic treatments/animal/year (by age). When

$$c_{at} * c_{fp} * P_{wg} = d_{lwg} * p_{lwg} = BD_{pr}$$ *Equation 4.1-2*

Reductions in pasture fouling.

To assess the economic benefits mediated by dung beetles on reduced pasture fouling. The following model was developed as shown in Equation *4.1-3* where area of pasture covered in dung (Ac_{dp}) corresponds to the number of dung pats per day produced by an individual cow (by age) (dp_{pd}) multiplied by average dung pat area (m^2) (by age) (d_{pa}), multiplied by the number of days cattle spend on pasture/year (d_{py}) which is equal to dung pat area per cow (by age) per hectare per year (d_{pypc})

$$Ac_{dp} * dp_{pd} * d_{pa} * d_{py} = d_{pypc}$$ *Equation 4.1-3*

Equation four, the shows the computation for the total area covered by dung we assumed that the total area covered (TAc_{dp}) is equal to ac multiplied by the number of cattle (by age) treated, and not treated, with anthelmintic (which affect dung beetles) in a sufficient concentration to impact dung beetles:

$$TAc_{dp} = d_i * dp_{pd}$$ *Equation 4.1-4*

***Increased nutrient cycling*.**

In order to model the benefits of increased nutrients on soil exposed to dung beetles, the key essential macronutrients i.e. Nitrogen, Phosphorus, Potassium, Calcium and Magnesium contained in fresh dung as determined by the methods recommended in the study by Haynes et.al. (Haynes & Williams, 1993).

This was accomplished by determining the area (hectare) covered in cattle dung per year (and thus nutrients per hectare per year being tunneled into the soil by dung beetles under 'Low' and 'High' functioning dung beetles - the two scenarios).

Consequently, we used the following calculation for dung beetle effects on nutrient cycling:

$$c_{age} * DAc_{py} = Tc_{age} \quad \text{Equation 4.1-5}$$

Where c_{age} (cattle (by age) treated, or not treated, with anthelmintic that affect dung beetles] was multiplied by DAc_{py} (Dung area covered) per cow (by age) per year. This derived Tc_{age} (Total area covered by Dung)) per hectare per year.

$$ND = Tc_{age} * nd_{ha} \quad \text{Equation 4.1-6}$$

ND (Total nutrients deposited) which equates to Tc_{age} multiplied by nd_{ha} (kg nutrients ha−1) for nitrogen *n*, phosphorus *p*, and potassium *k*.

$$ND = Tc_{age} * lfd_s \quad \text{Equation 4.1-7}$$

$$ND = Tc_{age} * hfd_s \quad \text{Equation 4.1-8}$$

The value of the commercial fertilizer for the above elements (NPK) was used to put a dollar value per Kg.

4.1.2 Product Status

Table 4-1 : Product Status (New Species of Dung Beetle)

Product 1 (P1): New Species Dung Beetles
This product entails importation and mass rearing of deep-tunneling dung beetles, which has potential implicit benefits to most cattle producers in Southern Australia through increasing pasture production, reducing fertilizer costs, fly control, gastro-intestinal parasites, pasture fouling control and nutrients cycling and improving water use efficiency. The general public will also benefit through reduced water pollution and elevated levels of Phosphorus.
Deployment status: R&D The project will utilise established networks from the partners in the project as well as engaging with the numerous offers received by MLA with the release of new dung beetles. Rearing and release information has previously been developed by Dung Beetle Groups and Landcare. Dung Beetle solutions Australia provides commercial service for ongoing access to Dung Beetles.

Product 1 (P1): New Species Dung Beetles
Value for money assessment This project offers significant value addressing multiple production and environmental benefits that will accrue at scale. It leverages matching cash from traditional and new partners, and the MDC funding allows a project to progress that would not be likely with levy funds. The DAWR funds are critical to success and without them the scale of the work would not be progressed. Relevant to this project, the MLA importation project BCA was conservative and included $600k downstream costs over 4 years. Scenarios modelled reported an NPV range of $3.4 m to $ 9.81m, and BCR range of 0.26 to 5.74.

4.1.3 Northern Australia Climate Forecasting - P00443

Northern Australian Climate Project (NACP) will deliver innovative research, development and extension outcomes to improve the capacity of the red meat industry to manage drought and climate risk across northern Australia.

Product 2 (P2): New BOM Prototype Flash drought forecasting tool for Northern Australia Climate Product
Product Description The modelled forecasting tool will utilise the following weather attributes **precipitation**, **temperature**, **wind**, **solar exposure** and maybe **soil moisture** including to define flash drought. The tool will guide in defining what flash drought means for N. Australia, and how to monitor it in real time. The predictive capability in ACCESS-S will be utilised to model the start of drought (Long tail extreme minimum events), and guide in making decision of the likelihood of an occurrence (e.g. flash drought in particular months) for Northern Australia. **Beef** Heat extremes affect beef cattle by reducing the rate of weight gain or increasing weight losses, particularly in combination with dry conditions (St-Pierre et al. 2003). Low weight gain is amplified when overnight temperatures remain above 21°C as the cattle cannot lose excess heat (Al-Haidary et al. 2001). This can occur at any time of the year, particularly in the north of Australia and in feedlots.

Product 2 (P2): New BOM Prototype Flash drought forecasting tool for Northern Australia Climate Product
Deployment status: R&D To be determined
Value for money assessment To be determined

Product 3 (P3): The Northern Rainfall Onset (NRO) forecasting tools
Product Description This product is supposed to predict the chances of an early or late northern rainfall onset in Northern Australia. The modelled forecasting tool will utilise the following weather attributes **precipitation**, **temperature**, **wind**, **solar exposure** and maybe **soil moisture** including to define flash drought. The tool will guide in defining what flash drought means for N. Australia, and how to monitor it in real time. The predictive capability in ACCESS-S will be utilised to model the start of drought (Long tail extreme minimum events), and guide in making decision of the likelihood of an occurrence (e.g. flash drought in particular months) for Northern Australia. **Beef** Heat extremes affect beef cattle by reducing the rate of weight gain or increasing weight losses, particularly in combination with dry conditions (St-Pierre et al. 2003). Low weight gain is amplified when overnight temperatures remain above 21°C as the cattle cannot lose excess heat (Al-Haidary et al. 2001). This can occur at any time of the year, particularly in the north of Australia and in feedlots. **Sheep** The primary impact of heat extremes on sheep is reduced fertility (Lees et al, 2017). Fertility is known to decrease due to unusually hot conditions but affects ewes and rams differently. Ewes are less fertile at the time of the hot weather, though rams can be less fertile six weeks after the event. Heat can also impact animals during live transport when subjected to confined areas and reduced

Product 3 (P3): The Northern Rainfall Onset (NRO) forecasting tools
airflow. This can result in degraded condition or mortality and has significant consequences for the sheep meat industry due to poor media and public outcry.
Deployment status: R&D To be determined
Value for money assessment To be determined

4.1.4 Climate App risk Assessment tool – P00635

The Australian CliMate app is a risk assessment tool for agricultural decision makers by using long term and recent weather data combined with seasonal forecasts to inform decision makers of system status (soil water, heat sum, season progress) and probability of future events (planting opportunity, rainfall).

The investment into this decision support application and product is aimed at giving farmers information in more convenient and accessible formats to support their on-farm climate risk management decisions.

4.1.5 Managing Climate Variability (MCV) – Kelpie - P00625

This product is issued to the farmers to aid them in accessing information in more convenient and accessible formats to support their on-farm climate risk management decisions.

Investment in production of this climate product is geared towards assisting in translation of climate forecasting research outputs into climate forecasting products and services for Australian agriculture.

Further the social aspect of this investment is to boost the knowledge and communication activities by increasing awareness and promoting adoption of climate risk management practices on-farm through the Climate Kelpie website and other communication products.

Approach

The investments analysed in this study includes both secured investment for the financial year as well as new future investment resources likely from the participating partners. The evaluation used program logic to identify pathways to impact from the likely R&D investment in program priority areas. This involved a description of the activities and outputs, outcomes and impacts that could occur from new investment in the stated R&D priority areas. Once the qualitative aspects of the logical framework were completed, attention turned to a cost-benefit analysis of the investment.

Outputs

Improved knowledge of producer climate forecast and decision making needs.

The principal expected outputs includes the identification of the climate forecast information needs of farmers in red meat industry, as well as improvements to how risky decisions are made by using information from climate forecasts. This includes improved understanding of current decision making under climate risk, associated non-climate related risks in decision making, demonstration of use of forecasts in red meat industry, developing examples of decision types and use of forecast information in those decisions, and demonstration to farmers of the likely magnitude of potential gains.

Improvements in climate forecasts

A range of forecasts are expected to be produced that are beyond current weather time scales and that are more relevant to red meat industry. Improvements are expected to include improved accuracy and reliability, improved spatial resolution, rainfall and heat and frost prediction, and more grower-friendly and usable forecasts for producers.

Assumptions for outcomes/impacts/valuing impacts

Assumptions were made for the increase in use of forecasts by primary producers driven by the improved targeting of climate information needed by producers, a more extensive product range and greater confidence in forecasts due to demonstrated skill and accuracy of new and developing forecasts. Assumptions were made also regarding an increased profit gain by users of forecasts due to an improved understanding by producers of how climate forecasts can be better used in decision making.

4.1.6 Forewarned is forearmed project – Products (yet to be determined)

Product 2 (P2): Model for forecasting of extreme climate events
Australian farmers and agribusiness operate in the most variable climate of any country in the world. This project will deliver forecasts of climate extremes such as heatwaves, frost, floods, and drought beyond the 7-day weather forecast out to seasonal timescales (6-12 months), providing options and tools for farmers to proactively plan and manage for extreme events. The changing climate patterns indicate that extreme events will occur more frequently. The project will research and develop new forecast systems, products and outputs in an operationalised program as an ongoing Bureau of Meteorology service, develop proactive management packages, as well as extension and training of producers and advisors.
Deployment status: Commercial
Value for money assessment The MCV5 ex post and ex ante analyses conducted by AgTrans gave a BCA of 8:1 to research outputs from the MCV program of work. This extremes project is a high priority project that will deliver benefits within the 5 year time frame of the project.

4.1.7 Other Products yet to be determined includes

Product 6 (P6): Regional pasture growth systems
This project entails testing a range of systemic and transformational adaptation options for sheep meat and/or grass fed beef aimed at delivering a sustained agreed annual return on asset, under a range of future climate conditions .The project will be rolled out in three regions of eastern Australia. The three target regions are (central Queensland, northern New South Wales and northern Victoria), and eventually and to determine the impact of incorporating climate extremes into future climate scenarios using the approach described by Harrison *et al.* (2016).
Deployment status: R&D The project will collaborate with regional producer groups to guide the research and ensure that it is relevant. In each region, a producer reference group who will work with the research team to identify a representative case study farm and relevant adaptation options. The project will work with the MLA's research councils in Northern (NABRC) and Southern Australia (SAMRC), and other interested groups, to establish the regional producer groups.

Product 6 (P6): Regional pasture growth systems
Value for money assessment The impact of climate change on livestock production is estimated to be high over the next 20 years as identified in the MISP2020. This project will provide detailed analysis on this the climate adaption issue and will lead to identifying highest potential adaption options. The value for this project is as a start to identifying worthwhile options, and these will likely require be further investment for development and delivered to industry. This project will further offers significant value in addressing realistic pastures profitability and resilience through determination of farm scale production, profitability, economic risks and farm scale green gas emission intensity.
Technical Success: High Adoption of current best practice is likely to result in producers being able to cope with the more modest changes associated with future projections but not the more extreme possible futures identified (Ghahramani and Moore 2015; 2016). It is widely acknowledged that it is not the modest or average future climate that will have the major impact, but increasing climate variability, extreme events and sequences of poor years where farming systems need to be prepared to manage and remain profitable (Thornton et al. 2015). This may mean that future farming systems need to be designed to be more flexible to take advantage of good years, and have the increased resilience necessary to cope better with sequences of poor years.
Adoption/Commercial Success: Medium **Requirements for further research or development or extension costs until there is a usable or commercial product:** This project will develop and demonstrate a suite of adaptation options that will serve to raise productivity or mitigate productivity losses as well as reduce GHG intensity. To ensure optimal adoption of these adaptation packages further extension activities would be required. These extension activities would include broader community engagement as well as possible management of on-farm trials to test the adaptation options under current climatic conditions
Expected/Actual Benefits and Costs: Medium <u>Per firm</u> To deliver a sustained 3% annual return on asset, whilst accounting for both GHG emission intensity and possible changes in pest and weed risk. **On-farm productivity impact**: The outcomes of this research are likely to maintain or enhance farm level productivity in the face of modest climate change. For example, research published by Gharamani and Moore (2013) showed that adaptation served to raise productivity at 12% of farms modelled for 2030 and return productivity to historical baseline levels for 68% of farms simulated. At more extensive levels of climate change, adaptation was shown to return productivity to 52% of farms simulated. This clearly demonstrates the positive impact this research could have if fully adopted.

Product 6 (P6): Regional pasture growth systems
1. **Farm level costs**: In the description of adaptation benefits above the associated adoption costs were accounted for. This would suggest that in spite of increased farm level costs there is still significant value to be gained from adopting these management practises. 2. **Adoption of the innovation**: adaptation has been determined to provide the greatest future benefit in the moderate to high rainfall zones of Australia's grazing lands. This research will apply a transect approach from drier to wetter grazing lands in order to show the relative benefits across rainfall gradients. 3. **What are the likely environmental, animal welfare and social outcomes:** This project specifically seeks to examine adaptation options that will reduce the feed gap and hence serve to maintain surface cover. This is likely to have a number of co-benefits including reduced soil erosion and improved livestock carrying capacity. In addition the GHG intensity associated with each of the adaptation options will be evaluated allowing the producer to select options that have both a productivity and GHG mitigation outcome. No impacts on animal welfare or social factors are anticipated.

4.1.8 SCANS soil carbon measurement software (CSIRO/Carbon Link) - P00382

The CSIRO SCANS system is in two parts. The core scanning system (CSS) uses non-destructive proximal sensing to analyze soil attributes, including soil organic carbon (Viscarra-Rossell, Lobsey, Sharman, Flick and McLachlan (2017)). The first commercial model is being constructed and operated under license to Carbon Link Limited. Initial plans were provided by CSIRO in 2016, but these were inadequate to build it and more detailed plans were done by local engineers. Instruments for the Carbon Link Unit were purchased in 2016 but construction was not continued because the 2014 Grazing Soil carbon methodology did not allow its use and the new methodology was taking longer than anticipated to be released.

The Agricultural soil carbon methodology was released in February 2018, which specifically allowed the use of the SCANS system, and the Carbon Link Board decided to proceed with the construction of the CSS.

The second part of the SCANS system is the software which provides stratification, statistical analytics and modelling to characterize soil at fine depth resolutions and across landscapes. It integrates the mapping data with the CSS data to provide carbon yield and certainty estimates

4.1.9 Evaluation tools

The cost benefit ratio was modelled in Excel Spreadsheet, where the quantified magnitude of impact to market value was developed.

The production process, operating costs and capital costs were simulated based on the model data, experimental data, and literature data plus the internal proprietary reports. The measures used to evaluate the economic bottom line for projects producing products of interest e.g. In the waste to profit project the Minimum product selling price (MPSP) for methane and other bioproducts, and maximum investment cost (MIC) coupled with the net present value (NPV) were used to evaluate and compare the economic performance of various portfolios with the default internal rate of return (IRR).

Other spreadsheets were also provided to facilitate the documentation of qualitative impacts and consolidate the impact statement into one document.

Due to the nature of the markets and regulations on which the quantities are based, the tools given in this framework needs to be periodically updated to ensure accuracy of the values.

5 Discussion

5.1 Dung Beetles

Results are presented for the economic benefits of four main ecological services mediated by dung beetle in Australia.

These benefits are stipulated in *Table 5.1-1*, below.

The results further point to the conservative and optimistic scenario of using dung beetle to offer the referenced services.

By using that approach, a business case was established whereby low breeding of dung beetles was found to offer marginal benefits and return on investment of up to 3.20 return on investment, whereas an optimistic scenario benefits of up to 5.74 (BCR) could be realized relative to baseline scenario.

Table 5.1-1 Economic benefits of Dung Beetles

Ecological services offered	Benefit (M$/Year)
Fly Control	0.09
Gastro parasite control	0.03
Pasture fouling	0.02
Nutrient Cycle	0.07

5.2 Results – Environmental Benefits

The overall approach to assess the overall global warming from dung pats are summarised in the supplementary procedure. However, these benefits can further assessed to determine the mitigation potential of dung beetle in removal of methane (CH_4) and nitrous oxide (N_2O) based on daily fluxes.

5.3 Results – NACP2

All new investment costs and associated benefits were expressed in 2019-2020 dollar terms.

All costs and benefits were discounted to the 2019-2020 year using a real discount rate of 5%. The base analysis used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the assumptions. Investment criteria were estimated for both the total investment and for that of the current phase of investment i.e. funding for the current financial year alone.

Given the assumptions made, the table below shows the investment criteria for different benefit periods for the total investment. The 30 year benefit period is the primary period to which later references to the investment criteria are made.

Table 5.3-1 : Investment Criteria for NACP 2 investment and Benefits for each benefit period (Discount rate 5%)

Criterion	Number of years after first year of investment						
	0	5	10	15	20	25	30
Present value of benefits (million $)	0.10	0.153	13.606	93.367	215.960	320.088	320.088

Present value of costs (million $)	13.49	13.49	13.49	13.49	13.49	13.49	13.49
Net present value (million $)	-5.36	66.64	91.96	91.96	91.96	91.96	91.96
Benefit-cost ratio	0.60	5.94	7.82	7.82	7.82	7.82	7.82
Internal rate of return (%)	negative	44.3	46.0	46.0	46.0	46.0	46.0

The annual benefit cash flows for total investment in NACP 2, for the 30 year period from the year of first investment, are shown in *Figure 55.3-1*

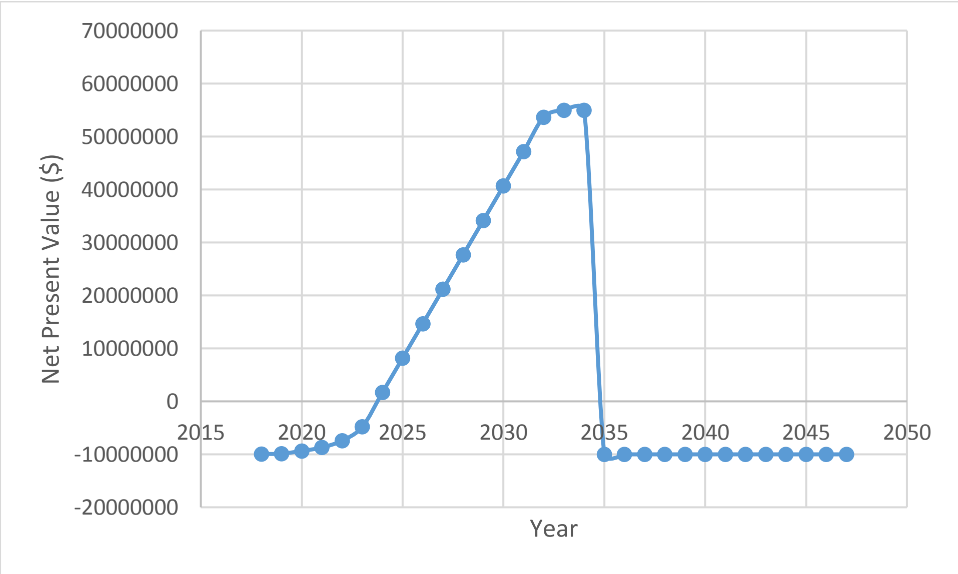

Figure 55.3-1 Annual Benefit Cash flow

This ex-ante economic analysis of Northern Australia Climate Program (NACP 2) investment has been undertaken to give an indication of the magnitude of values of the expected impacts compared to the investment being made.

A preliminary economic analysis is made on the following basis that Northern Australia Climate Program (NACP) will provide considerable benefits through improved drought risks management practices by:

- Making climate sensitive decisions with confidence due to more accurate and reliable sub-seasonal, seasonal and multiyear climate forecasts;
- Upscaling practice change through a comprehensive suites of communication outreach programs, that will lead to – improved adoption and in effect increased net profit

By assessing the response variable (change in net return/profit) per animal equivalent, and the number of producers engaged as indicator of the adoption level, the economic modelling indicate significant benefits to northern Australia red meat industry.

Based on the deterministic model developed, the decision support system of changing the stocking rate based on the output of seasonal was found to generate a benefit cost ratio (BCR) of 9.3, and with increased forecast skill (20% profit) a BCR of 19.5, as shown in *Table 5.3-2*

Table 5.3-2 : Value Proposition - NPV,IRR and BCR for project expenditure $ 7.7 Million if producer change practice and use (New forecast with improved skills) in management decisions (i.e. stocking rate)

Change in profit (%)	Number Engaged	Producer's adoption during 5 years (%)	Producer's adoption after 5 years (%)	NPV ($)	IRR	BCR
Conservative scenario						
10	500	5	15	52352136	167	7.7
10	1000	5	15	63199973	327	9.3
Optimistic Scenario						
20	500	5	15	111528939	357	16.3
20	1000	5	15	133224614	647	19.5

Previous reports shows that pastoral enterprises in northern Australia that show an increase in profitability of 10-26% by using seasonal forecasts make decision on stocking rates. By utilising perfect knowledge of the developed tools, there output leads to an increase in profit of 10% on conservative scenario, and perfect forecast of on the optimistic scenario leads to an increase in profit of 19.5% subject to adoption level.

5.3.1 **Results –farm gate (per kilogram of live weight – LW)**

Based on the two scenarios the indicative energy demand ranged from 4.3 ± 5% to 4.7 ± 8% MJ / kg LW. Consumptive water use ranged from 184-248 ± 35% L / kg LW. This assessment of water use included drinking water requirements and water supply losses (evaporation from dams), together with water use associated with the production of inputs such as electricity. Stress weighted water use was considerably lower than consumptive water use, ranging from 7.7-45.9 L H2O-e / kg LW. Stress weighted water use is a measure of the impact of using water. Where pressure on water resources was considerably lower than the global average, the apparent water use is considered to be lower.

Consumptive water use and stress weighted water use assessed using LCA generated results that were orders of magnitude lower than most estimates of 'virtual water' or the water footprint for beef cattle.

The main difference in these methodologies was the handling of rainwater used to grow crops and pastures (so called 'green' water associated with water loss by evapotranspiration), which is included in a virtual water / water footprint assessment but is not considered a source for estimating consumptive water use in LCA, or in the general understanding of water use used in society.

Land resource use was assessed, dividing land into arable and non-arable land occupation. Data have not been reported by other researchers using these categories. Arable land occupation ranged from 0.5-3.9 m^2 / kg LW for the Northern Australia farms, while non-arable land occupation was considerably higher because of the low stocking densities used on each farm.

Total land occupation (the combination of arable and non-arable land use), was higher than values reported in the literature for European beef production, though we consider this measure to be of less relevance for assessing the use of scarce land resources or impacts on biodiversity, because of the considerable differences in management and impacts from grazing on largely unmodified rangelands compared to cultivation. Further work is required to understand the impact of land occupation in the Australian agricultural industries.

Greenhouse gas emissions ranged from 11.2-12.9 kg CO2-e / kg LW, with the lower emissions coming from the scenarios where supply chain which utilised grain finishing and had higher levels of herd productivity (weaning rates and growth rate to slaughter). A number of GHG mitigation strategies were investigated, providing reductions of up to 31% in GHG emissions. Where sequestration potential was included, the mitigation potential was higher. Most sequestration scenarios relied on utilising other resources such as energy, arable land, grain or water to achieve productivity improvements and subsequent reductions in GHG.

The farm gate results were broadly similar to previous Australian beef LCA research for GHG emissions intensity and water use.

6 Conclusions/recommendations

The triple bottom line measurement and evaluation framework is presented in this report. Including the models developed to evaluate the impact, and the proposed tools for qualitative assessment of the social impacts. The two frameworks highlights the priorities of the current SCSP to present measures that are relevant to evaluating the contribution of the projects under the program.

Merging of the two frameworks including further refinement of the framework will be conducted in the remaining project period by considering feedback from relevant stakeholders and the experience from assessing the projects in scope.

A future area of work to be suggested for further research is the role of dung beetle in mitigating against Greenhouse Gases, particularly methane and nitrous oxide and in increasing water infiltration. In order for this to avail, measurable results Mesocism experiments need to be conducted.

7 Bibliography

Council of Rural Research and Development Corporations, 2008. *Measuring economic, environmental and social returns from Rural Research and Development Corporations' investment,* Canberra: CRRDC.

Council of Rural Research and Development Corporations, 2014. *Impact Assessment Guidelines,* Canberra: CRRDC.

Department of the Environment and Energy, 2015. *Carbon Credits (Carbon Farming Initiative - Domestic, Commercial and Industrial Wastewater) Methodology Determination 2015.* Canberra: Federal Register of Legislative Instruments.

Department of the Environment and Energy, 2015. *Carbon Credits (Carbon Farming Initiative— Industrial Electricity and Fuel Efficiency) Methodology Determination 2015.* Canberra: Federal Register of Legislative Instruments.

Department of the Environment and Energy, 2017. *National Greenhouse and Energy Reporting Scheme Measurement Technical Guidelines for the estimation of emissions by facilities in Australia,* Canberra: Department of the Environment and Energy.

Department of the Environment and Energy, 2018. *The Renewable Energy Target (RET) scheme.* [Online]
Available at: http://www.environment.gov.au/climate-change/government/renewable-energy-target-scheme
[Accessed 23 March 2018].

Red Meat Advisory Council, 2015. *Meat Industry Strategic Plan 2020,* Canberra: Red Meat Advisory Council.

The Centre for International Economics, 2016. *Impact Assessment of MLA Expenditure 2010-11 to 2014-15,* Sydney: Meat and Livestock Australia.