

Deloitte Access Economics

# Evaluation of CSIRO's research impacts

## **BARLEYmax™ Case Study**



*Photo: Carl Davies, CSIRO*

Commonwealth Scientific and  
Industrial Research  
Organisation (CSIRO)

February 2014

# Executive Summary

## Introduction

Deloitte Access Economics (DAE) was commissioned by CSIRO to recommend, test and validate an appropriate framework and methodologies for the ex-post impact evaluation of CSIRO research. In Stage 1 of the project, DAE presented an ex-post impact evaluation framework, while Stage 2 focused on applying and validating the framework across diverse case studies. CSIRO, with the assistance of DAE, has selected four impact case studies to test the framework and undertake the ex-post impact evaluation. This report presents the 'BARLEYmax™' impact case study.

## Impact case study: BARLEYmax™

CSIRO research developed BARLEYmax™, a natural wholegrain with higher fibre content and enhanced nutritional benefits over regular barley, which is used in breakfast cereals, food wraps, rice mixes, bread and other food products. While most agricultural research has typically focused on increasing productivity of crops and livestock, the main contribution of BARLEYmax™ is to provide health benefits associated with dietary fibre to consumers. Additional economic benefits over the value chain were also identified. BARLEYmax™ has now been in the market since August 2009.

The following key impacts of BARLEYmax™ were estimated in monetary terms (this public version of the case study presents grey shading areas where confidential data is used):

- **Higher farm price delivered:** Given an average farm gate price premium, net of additional costs and yield differentials, of \$190.7 per tonne of BARLEYmax™<sup>[1]</sup> compared with standard barley and given an annual production of 25,000 tonnes at full adoption (expected ten years from now), the additional earnings to growers is \$4.3 million per annum at maturity based on long term growth forecasts and expanding product range.
- **Price premium for final product:** There is a current price premium for the final product of [REDACTED] per cereal packet<sup>[2]</sup> (compared with other similar breakfast cereals on the market). It is assumed that there are similar relative premiums for the other non-cereal products on the market. Assuming that the total volume of sales is equivalent to [REDACTED] packets of cereal containing BARLEYmax™ sold annually with an impact estimated to be \$33.3 million per annum at maturity. This impact estimate assumes that the sales growth in the volume of BARLEYmax™ products will increase proportionally with the cereal grain production.
- **Improved health outcomes:** This impact refers to the welfare gain that individuals experience through improved health status or avoiding illnesses. This impact can be measured as the willingness-to-pay to avoid the burden of a disease with focus on Type II diabetes, which is usually caused and affected by lifestyle and diet.

Assuming 1.4 million regular BARLEYmax™ consumers at maturity<sup>[3]</sup>, a value of a statistical life year (i.e. one year of healthy life) of \$177,848<sup>[4]</sup>, and a 9.7% reduction in

<sup>[1]</sup> DAE estimate based on financial estimates provided by BARLEYmax™ Enterprises

<sup>[2]</sup> Estimate discussed in a workshop with DAE by Flagship participants

<sup>[3]</sup> Refer to footnote 1

the relative risk of developing Type II diabetes through regular consumption of cereal with high fibre content<sup>[5]</sup> (e.g. having a daily portion of 50gr per day with 15gr dietary fibre), BARLEYmax™ customers will see a benefit in avoiding the burden of developing Type II diabetes of \$33.3 million per annum at maturity.

If health benefits further include the impact of increased dietary fibre intake on reduced risk of cardiovascular disease (CVD) and colorectal cancer, the total value of improved health outcomes from consuming regularly BARLEYmax™ could increase to approximately \$305.2 million per annum at maturity. This estimate largely reflects the significant CVD burden of disease that could be reduced and is worth approximately \$241.7 million per annum. Some of this willingness to pay will be reflected by the price premium people place on the BARLEYmax™ cereal, as quantified above, but for a range of reasons the value people place on their health outcomes will be higher than the value captured within the supply chain.

- **Reduced health system costs:** Assuming that regular consumption of BARLEYmax™ reduces the risk of having Type II diabetes by 4,566 cases per year<sup>[6]</sup>, and given average treatment costs of \$463.1 per person per year<sup>[7]</sup> for illnesses associated with having Type II diabetes due to nutritional risk factors such as overweight or obesity, the impact of reduced health system costs is \$2.0 million per annum at maturity. Some, but not all, of this reduced cost is part of the value of improved health outcomes impact above, and the price premium paid for the final product.

A similar analysis for CVD and colorectal cancer indicates that overall reduction in health system costs from increased dietary fibre intake could increase to \$17.3 million per annum at maturity. Of this, \$13.7 million are savings from reduced prevalence of CVD, while a further \$1.6 million correspond to savings in the treatment of colorectal cancer.

Other impacts identified but not estimated in monetary terms include an increase in labour productivity and labour force participation and an improved business performance of the companies in the value chain.

In aggregate and taking into account an attribution factor of 83%<sup>[8]</sup>, the analysis suggests that the supply chain impacts generated by BARLEYmax™ that are attributable to CSIRO research are approximately \$27.6 million per annum. Once broader health related welfare gains and reduced health system costs are included at maturity, impacts are estimated to be slightly more than \$253.3 million per annum<sup>[9]</sup>.

Major uncertainties affecting the estimates relate to underlying assumptions around the annual barley production and cereal consumption levels at maturity, the price premium per cereal pack, the expected reduction of relative risk of developing Type II diabetes, colorectal cancer and CVD (and in particular the latter) and attribution.

---

<sup>[4]</sup> OBPR (2008)

<sup>[5]</sup> This compares with the counterfactual of reducing the relative risk by 0.6% due to regular wholegrain consumption with lower fibre intake. Reduction in relative risk estimates are based on Yao et al. (2013)

<sup>[6]</sup> DAE estimate based on AIHW (2003)

<sup>[7]</sup> DAE estimate based on Access Economics (2008)

<sup>[8]</sup> Based on CSIRO equity in the project

<sup>[9]</sup> We say 'slightly more' because we know that some, but not all, of the – attribution adjusted – \$14.3 million per annum of reduced health system costs can also be added to the \$253.3 million value of improved health.

Although many of the data inputs for this case study were strong, this case study was unique in terms of requiring further analysis in the final stage of impacts aggregation, as is often the case when health impacts are involved. In addition, the economic benefits to specific stakeholders do not represent net impacts across the value chain. It is, therefore, important to note that discrete impacts identified here are neither additive nor are they totally separate.

# Evaluation of research impacts: BARLEYmax™

## 1. Project context

Deloitte Access Economics (DAE) was commissioned by CSIRO to recommend, test and validate an appropriate framework and methodologies for the ex-post impact evaluation of CSIRO research. In the first stage of the project, DAE developed an ex-post impact evaluation framework in collaboration with CSIRO stakeholders and the Performance and Evaluation Team. Appendix A provides an overview of that framework, including the different framework steps and key considerations.

The second stage of the project focused on applying and validating the framework across diverse case studies. CSIRO, with the assistance of DAE, selected four impact case studies to test the framework and undertake the ex-post impact evaluation. This report presents the 'BARLEYmax™' impact case study.

## 2. Background: BARLEYmax™

CSIRO's Food Futures Flagship is using advanced genetic technologies to create differentiated grain, food and feed products, which are either more productive or address growing consumer demands for healthy foods and ingredients. The Food Futures Flagship goal is to transform international competitiveness of the Australian agrifood sector, adding \$3 billion in annual value to the Australian economy and food industries, by applying frontier technologies to high potential industries (CSIRO, 2012).

One of the outputs of the Flagship's research into cereal carbohydrates and nutrition is the development of BARLEYmax™, a natural wholegrain with enhanced nutritional benefits. The barley grain contains twice the dietary fibre of regular grains, four times the resistant starch and has a low glycaemic index (GI). Its attributes mean that it is likely to have significant health benefits to consumers, over and above health benefits associated with the consumption of standard wholegrains.

Having developed a successful product, CSIRO worked with a range of collaborators to bring the first consumer product to market. In 2001, CSIRO entered a joint venture (JV) with Australian Capital Ventures Ltd (ACVL) to manage and develop BARLEYmax™.

A number of licensing agreements followed. In 2008, CSIRO and ACVL entered into a licencing agreement with Austgrains Pty Ltd for BARLEYmax™ production. Austgrains arranges and contracts the growing of BARLEYmax™, with most of the production currently based in NSW and southern Queensland. CSIRO and ACVL also entered into a licensing agreement with Popina Food Services, a Victorian food producer to produce breakfast cereals containing BARLEYmax™. The first commercial crop was grown and supplied to

Popina in 2009, with the first BARLEYmax™ products being put on supermarket shelves under the Goodness Superfoods brand in August 2009.

Popina have been joined by SunRice, Bohdi's and PlusNutrition who now have licensing agreements with CSIRO. Furthermore, the product range has been expanded since its launch: while BARLEYmax™ is still mostly used in breakfast cereals, porridge and as cereal bars, it is also available in bread, as a rice blend product and as a multiple purpose (sprinkle) product.

### 3. Purpose and audience for the evaluation

The evaluation was undertaken to assess the outcomes and impacts derived from a range of CSIRO research projects to support accountability reporting, communication of impacts and continual improvement of their path to impact planning. The main purposes and audiences are:

- **Flagship Review:** The evaluation is to inform an external review of the Flagship, which includes an assessment of the Flagship's objectives and the rate of progress. The ex-post evaluation of BARLEYmax™ is being undertaken to inform the latter.
- **CSIRO review:** The evaluation is to inform CSIRO's (and other external party) reviews of its programs and activities, in particular in relation to achieving its objectives and representing value for money. Audiences may include Ministers, CSIRO at all levels and the general public.

### 4. Status of research and adoption

#### Nature of the impacts

Key impacts identified are in relation to health benefits provided to consumers of BARLEYmax™ cereal products and increased profitability within the cereal supply chain. A total of six impacts of BARLEYmax™ were identified, involving a mixture of economic (an impact that directly affects the economy) or non-economic social impacts:

- Higher farm price delivered (economic impact):** CSIRO research has resulted in higher quality grain, for which growers are paid a higher unit price than conventional barley. The impact at the start of the supply chain is measured by the wholesale price premium paid to growers net of any yield loss and additional cleaning or handling costs.
- Price premium for final product (economic impact):** Due to the improved health properties of BARLEYmax™, at the end of the supply chain a breakfast cereal containing the grain can be sold at a higher price compared with otherwise equivalent breakfast cereals on the market. This impact is measured as the additional retail price premium paid by consumers to access the product. The impact is caused by consumers' willingness to pay for their own improved health outcomes, assuming that no premium is paid for any of the other properties of the product such as appearance or taste. In that sense, it overlaps with the value from improved health outcomes, producing a lower-bound estimate of people's revealed willingness to pay. Note, that this price premium at the end of the supply chain may be shared

throughout the supply chain including Popina and other manufacturers, Austgrains and growers, as well as CSIRO and ACVL as recipients of royalty fees.

- iii **Improved health outcomes (social impact):** People's average willingness to pay for a product with improved health properties may be well above the price premium paid for the final product. An alternative approach to estimating people's full willingness to pay is to look at the cost of lifetime lost that is avoided. This can be done by considering the value people place on avoiding illness discomfort, suffering and early death associated with Type II diabetes, cardiovascular disease (CVD) and colorectal cancer, the main health outcome from daily consumption of BARLEYmax™, and estimating the reduction in the prevalence of these conditions as a result of BARLEYmax™ consumption and the associated reduction in morbidity and premature death.
- iv **Reduced health system costs (economic impact):** Improved health outcomes are also associated with a reduction in health system costs borne by taxpayers. This impact comprises savings in medical treatment to control or manage an illness, which BARLEYmax™ consumption could help prevent, such as Type II diabetes.
- v **Increase in labour productivity and labour force participation (social and economic impact):** The consumption of BARLEYmax™ may also lead to an increase in labour productivity and labour force participation due to reduced risk of illnesses leading to lost earnings, absenteeism, premature death and additional search and hiring costs for replacement workers.
- vi **Improved business performance of food manufacturers (economic impact):** Giving the rights to sell a product containing the higher quality grain has enabled these businesses to move into new products and grow their businesses.

Of the benefits identified, (i), (ii), (iii), and (iv) were estimated in monetary terms, as discussed in Section 5. Given the uncertainty around the magnitude of health impacts, flow-on economic impacts such as increased productivity and labour force participation are noted, but not assessed. The impact on food manufacturers such as Popina is a secondary impact, as it is the result of commercial arrangements rather than the BARLEYmax™ product itself.

Note that Section 5 presents the assessment of the impacts resulting from the research outputs (in this case BARLEYmax™) more broadly. The impacts attributable to CSIRO research are discussed in the aggregation section (Section 6).

## Counterfactual

In the absence of CSIRO research, producers would have grown other barley varieties, which have greater yield but receive lower wholesale prices, while consumers would have purchased alternative wholegrain cereal products without the same level of health benefits, such as oats

## Attribution

100% of the research work was led and undertaken by CSIRO. However, capital was required to finalise the research and development (R&D) and bring the product to market and achieve the benefits outlined above. As a result, of this capital contribution, CSIRO can claim 83% of the total attribution of the research.



It is likely that other inputs (such as marketing) are required to make the full impacts possible. However, insufficient information was available to incorporate those into the analysis.

## Adoption

The adoption level can be measured in terms of tonnage of grain harvested, assuming it is fully processed into BARLEYmax™ breakfast cereals and an expanded product range. CSIRO and Australian Capital Ventures Limited formed an Unincorporated Joint Venture (UJV), which engaged Austgrains to provide the seeds and arrange contracts with growers to supply the harvested BARLEYmax™ grain to Popina and other food manufacturers. For example, in the agreement, Popina purchases BARLEYmax™ and processes it to produce and sell breakfast cereals from it.

The initial production plans for 2009 and 2010 were of 2,000 and 5,000 tonnes of harvested grain per annum, respectively. According to a previous report by ACIL Tasman (2010), drought and high temperatures led to lower production quantities being suitable for commercial sale than anticipated, which impacted the commercialisation opportunities and slowed down the rollout accordingly. The annual production target across Australia is 25,000 tonnes (this target is a mature market range expected to be realised from 2024).

In January 2014, CSIRO and ACVL spun out the BARLEYmax™ business to an independent company called BARLEYmax™ Enterprises and appointed a Chief Executive Officer to take over the commercialisation of the technology both domestically and internationally.

In addition to the Australian sales, BARLEYmax™ Enterprises has been developing opportunities internationally. These international opportunities could amount to adoption levels significantly higher than the Australian adoption and would include royalties back to Australia and export benefits of both raw grain and finished products, especially into Asia.

## 5. Assessment of the impacts

### Quantified impacts

This section presents DAE's approach to quantify key impacts at maturity levels, based on the best data available to CSIRO for this analysis. Any assumptions and sources used in the analysis are outlined in the relevant tables with the impact calculation. Note that this public version of the case study presents grey shading in areas where confidential data was provided for the analysis.

#### Higher farm price delivered

Given an average farm gate price premium, net of additional costs and yield differentials, of \$190.7 per tonne of BARLEYmax™ compared with standard barley (derived in Table 5.1) and given an annual production of 25,000 tonnes, the additional earnings to growers is \$4.3 million per annum at maturity. The assumptions and sources underpinning this estimate are presented in Table 5.1.



**Table 5.1: Impact calculation of higher farm price delivered**

	Measure	Value	Sources
<b>With CSIRO research</b>			
A <sub>R</sub>	Annual production under target adoption [tonnes]	25,000	ACIL Tasman report (2010)
B <sub>R</sub>	Useable yield per hectare [tonnes per hectare]		BARLEYmax™ Enterprises (2013)
C <sub>R</sub>	Crop area to produce target production [hectares]	= A <sub>R</sub> /B <sub>R</sub>	
D <sub>R</sub>	Seed costs [\$ per tonne]		BARLEYmax™ Enterprises (2013)
E <sub>R</sub>	Seed rate [tonne per hectare]		BARLEYmax™ Enterprises (2013)
F <sub>R</sub>	Total seed costs for target production [\$ per annum]	= C <sub>R</sub> *D <sub>R</sub> *E <sub>R</sub> =\$666,666.7	
G <sub>R</sub>	Costs: Cultivation, fertiliser, harvesting, irrigation, fungicide, freight and levies [\$ per hectare]		BARLEYmax™ Enterprises (2013)
H <sub>R</sub>	On-farm QA costs (sampling, site audit, certified accreditation) [\$ per hectare]		DAE estimate using assumptions in Kent (2011)
I <sub>R</sub>	Average price to growers [\$ per tonne]		BARLEYmax™ Enterprises (2013)
J <sub>R</sub>	Indicative BARLEYmax™ growers' earnings for target adoption [\$ million per annum]	= A <sub>R</sub> *I <sub>R</sub> - F <sub>R</sub> - (G <sub>R</sub> + H <sub>R</sub> )*C <sub>R</sub> = \$9.1m	
<b>Counterfactual</b>			
B <sub>c</sub>	Useable yield per hectare [tonne per hectare]		BARLEYmax™ Enterprises (2013)
C <sub>c</sub>	Crop area to produce target production [hectares]	= A <sub>R</sub> /B <sub>c</sub>	
D <sub>c</sub>	Seed costs [\$ per tonne]		Kent (2011)
E <sub>c</sub>	Seed rate [tonnes per hectare]		BARLEYmax™ Enterprises (2013)
F <sub>c</sub>	Total seed costs for target production [\$ per annum]	= C <sub>c</sub> * D <sub>c</sub> *E <sub>c</sub> =\$89,554.1	
H <sub>c</sub>	On-farm QA costs [\$ per hectare]		DAE estimate using assumptions in Kent (2011)
I <sub>c</sub>	Average price to growers [\$ per tonne]		BARLEYmax™ Enterprises (2013)
J <sub>c</sub>	Gross margin from additional agricultural land use [\$ per hectare]	\$92.6	NSW Department of Primary Industries (2012)
K <sub>c</sub>	Income from additional agriculture returns [\$ million per annum]	= J <sub>c</sub> *(C <sub>R</sub> - C <sub>c</sub> ) = \$0.5m	
L <sub>c</sub>	Indicative growers' earnings [\$million per annum]	= A <sub>R</sub> *I <sub>c</sub> + K <sub>c</sub> - F <sub>c</sub> - (G <sub>R</sub> +H <sub>c</sub> )*C <sub>c</sub> = \$4.8m	
<b>Impact: world with CSIRO research – counterfactual</b>			
	Value of growers' additional earnings before tax [\$ per annum]	= J <sub>R</sub> - L <sub>c</sub> = \$4.3m	
	Average premium paid to growers (net of additional costs and yield differentials) [\$ per tonne]	= (J <sub>R</sub> - (L <sub>c</sub> - K <sub>c</sub> ))/A <sub>R</sub> =\$190.7	

Note: Monetary values are presented in 2013 \$AUD.

### Price premium for final product

Consumers have been shown to have a higher willingness to pay for BARLEYmax™ cereal, as compared with other regular 'comparable' products. This additional value placed by consumers reflects the perceived health benefits provided by BARLEYmax™ (discussed in

more detail in subsequent sections). Other attributes of the product, including taste, brand and nutritional value, are considered to be of lesser relevance.

The additional benefits received by consumers are reflected in a price premium to Popina and the other manufacturers as they use this premium to partly offset some of the higher input costs, royalties and licensing costs they pay. The price premium at the end of the supply chain will also likely reflect some of the price premium to growers being passed on through the supply chain. There are also likely to be other beneficiaries in the supply chain, between the grower and food manufacturers.

There is a current price premium for the final product of [redacted] per cereal packet (compared with other similar breakfast cereals on the market). It is assumed that there are similar relative premiums for the other non-cereal products on the market and the total volume of sales is equivalent to [redacted] packets of cereal containing BARLEYmax™ sold annually, with an impact estimated to be \$33.3 million per annum at maturity. The impact estimate, outlined in Table 5.2, assumes that upon maturity cereal manufacturing will increase proportionally with cereal production.

**Table 5.2: Impact calculation of price premium for final product**

	Measure	Value	Sources
<b>With CSIRO research</b>			
A <sub>R</sub>	Number of cereal packs equivalents to be sold upon maturity	[redacted]	Calculated from gross sales projections and margin of retail price from IP Pragmatics (2013).
B <sub>R</sub>	Retail price [\$ per 500g pack]	[redacted]	IP Pragmatics (2013)
C <sub>R</sub>	Total revenue from sale of BARLEYmax™ cereal [\$ per annum]	= A <sub>R</sub> *B <sub>R</sub> = \$214.5m	
<b>Counterfactual</b>			
A <sub>C</sub>	Price premium per pack [\$ per pack]	[redacted]	Workshop estimate
B <sub>C</sub>	Retail price of other breakfast cereals [\$ per 500g pack]	= C <sub>R</sub> - A <sub>C</sub> [redacted]	
C <sub>C</sub>	Revenue from manufacturing other common breakfast cereals [\$ per annum]	= A <sub>R</sub> *B <sub>C</sub> = \$181.2m	
<b>Impact: world with CSIRO research - counterfactual</b>			
	Value of additional earnings to food processing due to BARLEYmax™ research [\$ per annum]	= C <sub>R</sub> - C <sub>C</sub> = \$33.3m	

Note: Monetary values are presented in 2013 \$AUD.

### Improved health outcomes

BARLEYmax™ is unique in its high fibre content comprising a mix of the main fibre types. These are delivered to breakfast cereals (bakery products can also be marketed, but are not covered in this case study) via its whole grain. Health claims of BARLEYmax™ include lower cholesterol, low GI, improved laxation and bowel health and possible heart health, insulin and weight control, as identified in the BARLEYmax™ Review (2009). There is evidence that a high intake of dietary fibre contributes to reduced risk of weight gain and obesity, along with Type II diabetes (WHO, 2003). The analysis of this impact focuses on this linkage, in which fibre content directly benefits weight control and reduces the risk of developing Type II diabetes, CVD and colorectal cancer.

More generally, the impact of improved health outcomes refers to the value individuals perceive in improving their health status or avoiding any illnesses. This impact can be measured as the BARLEYmax™ consumers' willingness-to-pay to avoid the burden of a disease – in this case, the focus is on Type II diabetes, which is usually caused and affected by lifestyle and diet. This impact reflects benefits to BARLEYmax™ consumers only.

Assuming 1.4 million regular BARLEYmax™ consumers at maturity, a value of a statistical life year (i.e. one year of healthy life) of \$177,848 (OBPR, 2008), and a 9.7% reduction in the relative risk of developing Type II diabetes (Yao et al. 2013; BARLEYmax™ Joint Venture, 2009) through regular cereal consumption (e.g. having a daily cereal portion of 50gr per day with 15gr dietary fibre), BARLEYmax™ customers will see a benefit in avoiding the burden of developing Type II diabetes of \$33.3 million per annum at maturity. Note that there is a 3.4% prevalence of Type II diabetes in Australia, along with 0.04 years of healthy life lost due to the illness associated with nutrition, as outlined in Table 5.3.

Further health impacts of increased dietary fibre intake on reduced risk of CVD and colorectal cancer can be quantified following the methodology outlined for Type II diabetes in Table 5.3 below. The value of improved health outcomes to avoid prevalence of Type II diabetes, CVD and colorectal cancer is worth approximately \$305.2 million per annum at maturity, with CVD accounting for 79% of it.

This estimated willingness to pay for an improved health outcome of \$305.2 million (based on prevalence of a disease and a value of a statistical life year) is higher than the revealed willingness to pay (revealed in market transactions through the price consumers pay for the final product) of \$33.3 million. This is not unexpected – there are a range of reasons why consumer purchasing decisions at the supermarket shelf do not fully reflect the full social benefits of their healthier food choices. However, the \$33 million price premium and the \$305.2 million willingness to pay are not additive. Rather, they are different ways to measure the same thing – how much people value improved health outcomes.

**Table 5.3: Impact calculation of improved health outcomes**

	Measure	Value	Sources
<b>With CSIRO research</b>			
A <sub>R</sub>	Number of regular BARLEYmax™ consumers under target adoption levels	1,388,170	DAE estimate assuming customers will increase proportionally with target production of 25,000t p.a.
B <sub>R</sub>	Prevalence of Type II Diabetes in Australia	3.4%	ABS Australian Health Survey (2012)
C <sub>R</sub>	Expected reduction in relative risk of developing Type II diabetes <sup>1</sup>	9.7%	DAE estimate based on Yao et al. (2013)
D <sub>R</sub>	Disability adjusted life years (DALYs) attributable to overweight and obesity per person diagnosed with Type II Diabetes <sup>2</sup>	0.04	Calculated from Begg et al. (2007) and AIHW (2003)
E <sub>R</sub>	Value of a statistical life year (VSLY) <sup>3</sup> [\$]	\$177,848	OPBR (2008)
F <sub>R</sub>	Saving in burden of Type II diabetes with BARLEYmax™ [\$ per annum]	$= A_R * B_R * C_R * D_R * E_R$ = \$35.3m	
<b>Counterfactual</b>			
C <sub>c</sub>	Expected reduction in relative risk of developing Type II diabetes with wholegrain only <sup>1</sup>	0.6%	DAE estimate based on Yao et al. (2013)

	Measure	Value	Sources
$F_c$	Saving in burden of Type II diabetes if BARLEYmax™ consumers had eaten wholegrain [\$ per annum]	$= A_R * B_R * C_c *$ $D_R * E_R$ $= \$2.0m$	
<b>Impact: world with CSIRO research – counterfactual</b>			
	Additional savings in the value of lifetime lost due to Type II diabetes from BARLEYmax™ [\$ per annum]	$= F_c - F_R$ $= \$33.3m$	
	Additional savings in the value of lifetime lost due to CVD from BARLEYmax™ [\$ per annum] <sup>4</sup>	\$241.7m	Relative risk from Threapleton et al. (2013). Other sources as listed above
	Additional savings in the value of lifetime lost due to colorectal cancer from BARLEYmax™ [\$ per annum] <sup>5</sup>	\$30.2m	Relative risk from Aune et al. (2011). Other sources as listed above
	<b>Total savings in health systems costs [\$ per annum]</b>	<b>\$305.2m</b>	

Note: Monetary values are presented in 2013 \$AUD. <sup>1</sup>This value includes 28% consumers eating the recommended daily amount of wholegrain from other sources, as discussed in BARLEYmax™ Joint Venture (2013) <sup>2</sup>The burden of disease is typically measured in disability adjusted life years (DALYs). DALYs is the sum of Years of Life Lost due to premature death (YLL) and Years of healthy life Lost due to Disability (YLD) from a disease. <sup>3</sup>The Value of a Statistical Life Year (VSLY) measures how much society is willing to pay to reduce the risk of premature death, or saving a statistical year in a lifetime. The Office of Best Practice Regulation (2008) recommends using a VSLY estimate of \$151,000 (2007 \$AUD). <sup>4</sup>Derived with  $B_R = 4.7%$ ,  $C_R = 29.3%$ ,  $D_R = 0.11$ ,  $C_c = 10%$ . <sup>5</sup>Derived with  $B_R = 1.0%$ ,  $C_R = 21.4%$ ,  $D_R = 0.07$ ,  $C_c = 2.8%$ .

## Reduced health system costs

Another impact is the reduced health system costs that occur following any improved health outcomes at full maturity, i.e. with regular consumption of BARLEYmax™ products at target adoption levels.

The impact of reduced health system costs at full maturity is calculated similarly to the previous assessment, but instead of valuing the burden of disease per person, it estimates potential savings to the healthcare system from preventing the treatment costs of Type II diabetes.

Assuming that regular consumption of BARLEYmax™ reduces the risk of having Type II diabetes by 4,566 cases per year, as opposed to 260 cases if BARLEYmax™ consumers had only access to wholegrain, and given average treatment costs of \$463.1 per person per year for Type II diabetes attributed to nutritional risk factors, such as overweight or obesity, the impact of reduced health system is \$2.0 million per annum at maturity. The assumptions and sources behind this estimate are presented in Table 5.4.

A similar analysis for cardiovascular disease (CVD) and colorectal cancer indicates that overall reduction in health system costs from increased dietary fibre intake could increase to \$17.3 million per annum at maturity. Of this, \$13.7 million are savings from reduced prevalence of CVD, while a further \$1.6 million correspond to savings in the treatment of colorectal cancer.

**Table 5.4: Impact calculation of reduced health system costs**

	Measure	Value	Sources
<b>With CSIRO research</b>			
$A_R$	Number of regular BARLEYmax™ consumers under target adoption levels	1,388,170	DAE estimate assuming customers will increase proportionally with target production of 25,000t p.a.
$B_R$	Prevalence of Type II Diabetes in Australia	3.4%	ABS Australian Health Survey (2012)

	Measure	Value	Sources
$C_R$	Expected reduction in relative risk of developing Type II diabetes <sup>1</sup>	9.7%	DAE estimate based on Yao et al. (2013).
$D_R$	Number of cases averted/reduced	$=A_R * B_R * C_R$ = 4,566	
$E_R$	Health costs per person diagnosed with Type II Diabetes attributed to overweight or obesity [\$]	\$463.1	Calculated based on Access Economics (2008)
$F_R$	Saving in health system costs of Type II diabetes with BARLEYmax™ [\$m per annum]	$= D_R * E_R$ = \$2.1m	
<b>Counterfactual</b>			
$C_C$	Expected reduction in relative risk of developing Type II diabetes with wholegrain only <sup>1</sup>	0.6%	DAE estimate based on Yao et al. (2013)
$D_C$	Number of cases averted/reduced	$=A_R * B_R * C_C$ = 260	
$F_C$	Saving in in health system costs of Type II diabetes with wholegrain consumption only [\$m per annum]	$= D_C * E_R$ = \$0.1m	
<b>Impact: world with CSIRO research – counterfactual</b>			
	Additional savings in health system costs of Type II diabetes due to BARLEYmax™ [\$m per annum]	$= F_C - F_R$ = \$2.0m	
	Additional savings in health system costs of CVD due to BARLEYmax™ [\$m per annum] <sup>2</sup>	\$13.7m	Relative risk from Threapleton et al. (2013). Other sources as listed above
	Additional savings in health system costs of colorectal cancer due to BARLEYmax™ [\$m per annum] <sup>3</sup>	\$1.6m	Relative risk from Aune et al. (2011). Other sources as listed above
	<b>Total savings in health systems costs [\$ per annum]</b>	<b>\$17.3m</b>	

Note: Monetary values are presented in 2013 \$AUD. <sup>1</sup>This value includes 28% consumers eating the recommended daily amount of wholegrain from other sources, as discussed in BARLEYmax™ Joint Venture (2013) <sup>2</sup> Derived with  $B_R = 4.7\%$ ,  $C_R = 29.3\%$ ,  $E_R = \$1,089.4$ ,  $C_C = 10\%$ . <sup>3</sup> Derived with  $B_R = 1.0\%$ ,  $C_R = 21.4\%$ ,  $E_R = \$624.0$ ,  $C_C = 2.8\%$ .

## Further impacts

The following impacts were also considered and discussed during the workshop held with DAE and relevant Flagship members on the ex-post impact evaluation of BARLEYmax™. This section provides an overview of the causal linkage from the adoption of BARLEYmax™ to generate other non-quantified impacts, along with examples evidencing the extent to which they have been realised to date.

### Increased labour productivity and labour force participation

Adverse health impacts not only generate direct financial costs to the health system and non-financial costs of the burden of disease, but a range of additional costs to the Australian economy. Some of the additional flow-on impacts are described by Access Economics (2006) as follows:

- Productivity losses – short and long-term employment impacts and premature mortality;
- Carer costs – the value of community care services provided primarily by informal carers;
- Deadweight Loss (DWL) from transfers – taxation revenue foregone, welfare and other government payments; and,

- Other costs – aids, equipment and modifications, transport and accommodation costs, respite and other government programs and the bring-forward component of funerals.

In this case study, increased labour productivity and labour force participation are flow-on effects from BARLEYmax™ consumption in reducing the prevalence of Type II diabetes. For instance, a healthier workforce is more productive and spends less time out of work due to illnesses. Moreover, complications from nutrition-related conditions may be avoided, allowing people to stay longer in the workforce.

An obesity study by Access Economics (2006) indicated that productivity losses due to obesity-related conditions impose a significant cost on the Australian economy. In the specific case of Type II diabetes due to obesity, for instance, health system costs in 2005 amounted to \$116 million, while productivity costs were \$442 million (including lost earnings, absenteeism, premature death and search and hiring costs for replacement workers). Evidence of the general linkage between health and productivity are available in the literature, such as Robinson et al (1989), American Diabetes Association (2003), Von Korff et al (2005).

### Improved business performance of food manufacturers

Popina and other food manufacturers, as the first movers to process cereals from higher quality seeds, may have experienced financial and brand benefits. Popina was the first manufacturing company engaged in the joint venture between CSIRO and ACVL to have the rights to process the BARLEYmax™ grain delivered by Austgrains and market any products from it. More generally, any major provider currently engaged by the joint venture could have similar benefits from bringing an innovative product to the market first. In economic terms this could be measured as increased sales and value added as compared with other products in food manufacturing business.

Based on the information provided to DAE, there is insufficient quantitative evidence to substantiate this argument. In the case of Popina, the first two BARLEYmax™ products (Digestive 1<sup>st</sup>, Protein 1st) were launched in August 2009 under the Goodness Superfoods brand, with a further cereal product being expected in the market end of 2010.

### Distributional effects on users

Although distributional effects were not considered to be a significant issue, a number of such effects may be worth considering. They include the following:

- The affluent demographic who can most afford the price premium are more likely to purchase and consume the product and experience the health impacts than the rest of the population.
- Health impacts also depend on the wellbeing of the individual prior to the consumption of BARLEYmax™. Not all consumers are set to benefit to an equal amount: those more at risk at developing diseases such as Type II diabetes are more likely to benefit than those with a lower risk profile.
- Not all barley growers can produce BARLEYmax™ and experience the higher farm price delivered. Currently, selected BARLEYmax™ growers are mostly based in Northern NSW, but as far South as Northern Victoria and South Australia. The choice of growers

is based on relationships with Austgrains, irrigation access and being known as a 'good grower'.

### Externalities or other flow-on/spillover effects on non-users

Across all impacts, DAE found no relevant environmental externalities (e.g. pollution, noise) to address, as the production/consumption of the cereal is not different to any other wholegrain product and so, it will not cause any additional externality benefits or disadvantage to society.

In terms of the flow-on effects, the inputs required for BARLEYmax™ grain harvesting and processing are similar to other wholegrain products (except for the need to keep the grain separate throughout the supply chain). Therefore, it is unlikely to find substantial changes in current value added and employment generated through BARLEYmax™'s processing use of intermediate products across diverse industries in the Australian economy.

## 6. Aggregation of research impacts

### Aggregation of impacts and attribution to CSIRO research

In the BARLEYmax™ impact case study, most impacts identified correspond to economic benefits in the value chain and health benefits to regular consumers. Note that some of the benefits estimated in monetary terms in the first category are transfers between intermediaries in the value chain. For the purpose of the evaluation of the impact in the economy as a whole, it is necessary to understand that some of the benefits accrued (or costs borne) by different stakeholders in the value chain can be passed on to the next stage of production. For example, the benefits of the premium paid to growers are effectively a cost for Austgrains, which can then be passed on to the cereal manufacturers (such as Popina). So, the price premium enjoyed by food manufacturers at the end of the supply chain is partially offset by higher input prices, which reflects price premiums along the supply chain (including for growers).

In addition, note that the price premium paid by consumers is likely to reflect, at least partially, the impact from 'improved health outcomes'. They are different ways of measuring the same thing, so aggregation of those impacts would mean double-counting the same impact.

As previously discussed, the economic impacts quantified, i.e. impacts (i) to (iv), cannot be added up directly in this case study, unless it is possible to quantify the net economic gains to all stakeholders over the value chain consistently. For the purpose of this case study, an indicative estimate of \$33.3 million for impact (ii) is provided as the lower bound of the additional economic value obtained at the end of the supply chain, but then being distributed throughout intermediaries and including growers (under the assumption that no significant additional costs are created as compared with the counterfactual). Hence, adding impact (i) would be double-counting the same impact at a different part in the supply chain.

However, the economic value of \$33.3 million reflects only the additional value reflected in commercial transactions to purchase the product because of its health benefits. Avoided



health systems costs could be in most part additional to it, as they are not fully borne by the consumer (partly borne by the government and taxpayers). Alternatively, \$305.2 million for impact (iv) could be an upper bound estimate, as it provides the value that consumers are willing to pay for specific health benefits that BARLEYmax™ provide. Most of this value, however, is not observed or revealed in the market.

In aggregate and taking into account an attribution factor of 83%<sup>[8]</sup>, the analysis suggests that the supply chain impacts generated by BARLEYmax™ that are attributable to CSIRO research are approximately \$27.6 million per annum. Once broader health related welfare gains and reduced health system costs are included at maturity, impacts are estimated to be slightly more than \$253.3 million per annum<sup>[9]</sup>, as shown in Table 6.1.

**Table 6.1 : Summary of BARLEYmax™ impacts at full maturity (\$m per annum)**

	Impact	Quantified in monetary terms?	Type	Annual value
i	Higher farm price delivered	yes	Economic	\$4.3m
ii	Price premium for final product	yes	Economic	\$33.3m
iii	Improved health outcomes	yes	Social	\$305.2m
iv	Reduced health system costs	yes	Economic	\$17.3m
v	Increased labour productivity and labour force participation	no	Social/economic	-
Vi	Improved business performance	no	Economic	-
	<b>TOTAL</b>			<b>\$33.3m- \$305.2m</b>
	<b>TOTAL ATTRIBUTABLE TO CSIRO (83%)</b>			<b>\$27.6m- \$253.3m</b>

Note: Monetary values are presented in 2013 \$AUD.

## Risks and uncertainties

Estimates are surrounded by a significant degree of uncertainty. Some of the most significant risks and issues affecting the impact estimates include variations to the assumptions around:

- Annual production and consumption levels at maturity (the current assumption of 25,000 tonnes per annum is based on long-term targets);
- Price premium per cereal pack (the price premium is based on CSIRO estimates rather than premiums observed at maturity);
- Expected reduction of relative risk of developing Type II diabetes, colorectal cancer and CVD (particularly the latter due to the large overall burden of disease) due to regular consumption of dietary fibre; and
- Attribution (the current estimate does not take into account all other inputs required to realise the impacts).

<sup>[8]</sup> Based on CSIRO equity in the project

<sup>[9]</sup> We say 'slightly more' because we know that some, but not all, of the – attribution adjusted – \$14.3 million per annum of reduced health system costs can also be added to the \$253.3 million value of improved health.

## References

- ABS 2012, Australian Health Survey: First Results, 2011–12. Cat. 4364.0.55.001
- Access Economics, 2006. The economic costs of obesity. Report for Diabetes Australia, Canberra.
- ACIL Tasman, 2010. Assessment of CSIRO Impact & Value. Report prepared as input to CSIRO's Lapsing Program Review. Prepared for CSIRO. July 2010
- AIHW, 2003. Data available in <http://www.aihw.gov.au/2003-annex/>
- Aune, D, Chan, D, Lau, R, Vieira R, Greenwood, DC, Kampman, E, Norat, T, 2011. Dietary fibre, whole grains, and risk of colorectal cancer: systematic review and dose-response meta-analysis of prospective studies. *BMJ* 2011; 343:d6617
- BARLEYmax™ Joint Venture, 2009. The BARLEYmax™ Better Nutrition Report.
- BARLEYmax™ Enterprises, 2013. Personal communication.
- Begg S, Vos T, Barker B, Stevenson C, Stanley L, Lopez AD, 2007. The burden of disease and injury in Australia 2003. PHE 82. Canberra: AIHW.
- CSIRO, 2012. Annual Report 2011–12. Australia.
- CSIRO, 2013. 'Impact @ CSIRO PM&C Discussion'. Impact slide pack presentation prepared by Strategy, Performance and Flagships. Friday 24 May 2013.
- Deloitte Access Economics (DAE), 2013. Decision making framework for ex-post impact evaluation of CSIRO's research impact – Stage 1. Report provided to CSIRO, Australia.
- Global Reporting Initiative (GRI) 2011. Sustainability Reporting Guidelines, Version 3.1. Available in <https://www.globalreporting.org/reporting>
- IP Pragmatics, 2013. Assessment of Business Plan, Valuation & Optimal Commercial Strategy for BARLEYmax™™ Opportunity. Final report to CSIRO. June 2013.
- Kent, T, 2011. BARLEYmax™™ Supply Chain Study. Report by TASK Advisors Pty Ltd. 2 July 2011
- Marks et al., 2000. Type 2 Diabetes Costs in Australia - the potential impact of changes in diet, physical activity and levels of obesity. Australian Food and Nutrition Monitoring Unit.
- Office of Best Practice Regulation (OBPR), 2008. Best Practice Regulation Guidance Note – Value of statistical life.
- Threapleton, D E, Greenwood, D C, Evans, C, Cleghorn, C L Nykjaer, C, Woodhead, C, Cade, J E, Gale, P L, Burley, VL, 2013. Dietary fibre intake and risk of cardiovascular disease: systematic review and meta-analysis. *BMJ* 2013;347:f6879

World Health Organisation (WHO), 2003. Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation, Geneva, 28 January -- 1 February 2002.

Yao, B, Fang, H, Xu, W, Yan, Y, Xu, H, Liu, Y, Mo, M, Zhang, H, Zhao, Y, 2014. 'Dietary fiber intake and risk of type 2 diabetes: a dose-response analysis of prospective studies'. European Journal of Epidemiology <http://dx.doi.org/10.1007/s10654-013-9876-x>

# Appendix A: Evaluation framework

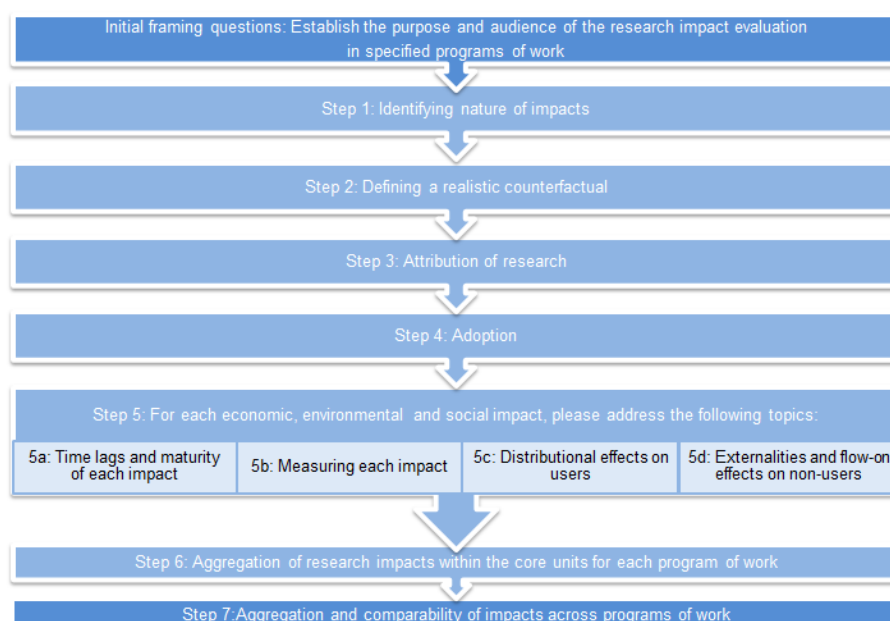
## Ex-post impact evaluation framework

In order to comprehensively and consistently evaluate research impacts, and taking into account CSIRO’s methodological challenges, DAE developed a framework that consists of the following four groups of steps:

- **Initial framing – Purpose and audience of the impact evaluation:** The starting point is to identify the primary purpose and audience of the ex-post impact evaluation. This needs to be clarified early on as it will determine the most appropriate methodologies and the types of impacts to focus on.
- **Steps 1-4 – Status of research and adoption:** These steps are used to identify the nature of the main impacts from the research being evaluated and the status of adoption.
- **Step 5 – Assessment of the impacts:** This step quantifies and estimates impacts in monetary terms, where possible.
- **Steps 6-7 – Aggregation of research impacts and comparability:** These steps aggregate diverse impacts from individual programs of works to a single evaluation measure or indicator when appropriate.

The four parts, which consist of the seven more detailed evaluation steps as outlined in Figure A.1, comprise the framework structure [and are explained in more detail in Deloitte Access Economics *Decision making framework for ex-post impact evaluation of CSIRO’s research impact – Stage 1* (DAE, 2013).

**Figure A.1: Steps in the ex-post research impact evaluation framework**



To ensure a consistent understanding of the framework and its application, this section outlines a number of key considerations underpinning the evaluation framework.

### What does ‘ex-post’ mean in the context of the framework?

An **ex-post** evaluation refers to the assessment of a program of research, such as of an individual flagship, theme, or a group of individual projects, after it has occurred. As such, an **‘ex-post research impact evaluation’** refers to the evaluation of the impact attributable to a program of research after the research has been completed and outputs have occurred. In order to be ex-post, while research has to be complete, adoption may be incomplete and some impacts may be still be in the future. Ex-post impact evaluation contrasts with ‘ex-ante impact evaluation’, which refers to the evaluation of prospective impacts and is undertaken before the research has produced outputs.

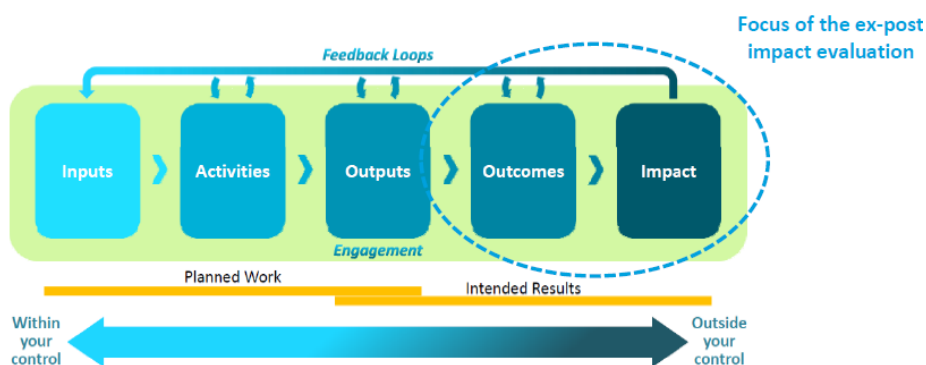
### What are ‘impacts’ in the context of this framework?

In an ex-post impact evaluation of research, CSIRO (2013) has defined **impact** as:

*An effect on, change or benefit to the economy, society or environment, beyond those contributions to academic knowledge. Impact includes, but is not limited to an effect on, change or benefit to the activity, attitude, awareness, behaviour, capacity, opportunity, performance, policy, practice, process or understanding of an audience, beneficiary, community, constituency, organisation or individuals in any geographic location whether locally, regionally, nationally or internationally. Impact also includes the reduction, avoidance or prevention of harm, risk, cost or other negative effects.*

An impact is typically an external effect or change beyond the organisation that produced it. It is the culmination of the CSIRO’s impact pathway, as illustrated in Figure A.2.

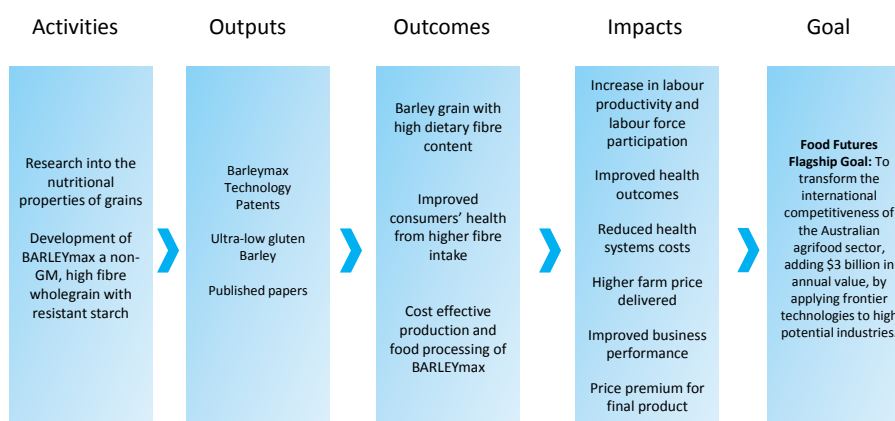
**Figure A.2: CSIRO’s Impact Pathway**



An Impact Pathway diagrams for the BARLEYmax™ impact case study is provided below. It illustrates the process by which planned research work translate into tangible outcomes and impacts to society.

Figure A.3: CSIRO’s Impact Pathway for the BARLEYmax™ case study

### BARLEYmax– Impact Pathway Overview



### What types of impacts are being evaluated under the framework?

The ex-post impact evaluation framework guides the evaluation of the effects, changes or benefits generated by completed research to the economy, society and the environment. It includes **the valuation of realised and projected economic, social and environmental impacts**. It excludes the valuation of potential impacts that cannot yet be expected or realistically projected, as well as the valuation of other research aspects such as research quality.

Stage 1 of the project presented the following definitions for economic, social and environmental impacts in line with latest GRI Performance Indicators (2011):

- **Economic impacts:** Economic impacts are impacts on an economic system at a local, national or global level such as changes in revenue, operating costs, profitability, gross domestic product (GDP), employment or investment returns.
- **Social impacts:** Social impact refers to how an activity affects the surrounding community. This includes impacts on health, community engagement, skills and labour practices.
- **Environmental impacts:** Environmental impacts are impacts on living and non-living natural systems, including ecosystems, land, air and water.

### What is being evaluated?

Research at CSIRO is organised in a matrix in which groups, programs or divisions provide research capabilities to address research priorities defined in national flagships. Research projects are the smallest component within research portfolios, however most single projects are unlikely to lead to an impact in their own right. For this reason, the core unit of research evaluation for CSIRO is a **‘program of works’**, which refers to related activities in a portfolio of research activity leading to the one outcome. A program of works encompass entire themes or flagships, group of projects, or those programs of work whose planned impact is summarised in Impact Statements (DAE, 2013; CSIRO, 2013).

## **Limitation of our work**

### **General use restriction**

The report has been prepared at the request of CSIRO for the purpose of demonstrating the value of CSIRO's research through ex-post impact evaluation. This report may be released into the public domain, but we accept no duty of care to any other person or entity who chooses to rely on this report other than CSIRO.



## Contact us

Deloitte Access Economics  
ACN: 149 633 116

Level 1  
9 Sydney Avenue  
Barton ACT 2600  
PO Box 6334  
Kingston ACT 2604 Australia

Tel: +61 2 6175 2000  
Fax: +61 2 6175 2001

[www.deloitteaccesseconomics.com.au](http://www.deloitteaccesseconomics.com.au)

**Deloitte Access Economics** is Australia's pre-eminent economics advisory practice and a member of Deloitte's global economics group. The Directors and staff of Access Economics joined Deloitte in early 2011.

### About Deloitte

Deloitte refers to one or more of Deloitte Touche Tohmatsu Limited, a UK private company limited by guarantee, and its network of member firms, each of which is a legally separate and independent entity. Please see [www.deloitte.com/au/about](http://www.deloitte.com/au/about) for a detailed description of the legal structure of Deloitte Touche Tohmatsu Limited and its member firms.

Deloitte provides audit, tax, consulting, and financial advisory services to public and private clients spanning multiple industries. With a globally connected network of member firms in more than 150 countries, Deloitte brings world-class capabilities and deep local expertise to help clients succeed wherever they operate. Deloitte's approximately 200,000 professionals are committed to becoming the standard of excellence.

### About Deloitte Australia

In Australia, the member firm is the Australian partnership of Deloitte Touche Tohmatsu. As one of Australia's leading professional services firms, Deloitte Touche Tohmatsu and its affiliates provide audit, tax, consulting, and financial advisory services through approximately 6,000 people across the country. Focused on the creation of value and growth, and known as an employer of choice for innovative human resources programs, we are dedicated to helping our clients and our people excel. For more information, please visit our web site at [www.deloitte.com.au](http://www.deloitte.com.au).

Liability limited by a scheme approved under Professional Standards Legislation.

Member of Deloitte Touche Tohmatsu Limited

© 2014 Deloitte Access Economics Pty Ltd