

# The Value of CSIRO

## The Broader Impact of CSIRO's Portfolio of Activities

**2020 Update**

RTI Project Number 0217323

February 2021



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# Executive Summary

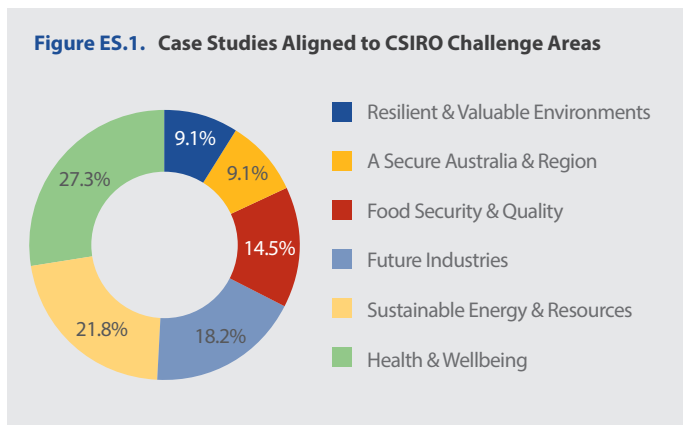
Every 2 years the Commonwealth Scientific and Industrial Research Organisation (CSIRO) assesses the value it delivers to Australia by analysing its impact. This is done with reference to the case studies of CSIRO's research breakthroughs conducted by independent evaluators and analysts. These case studies account for the resources entrusted to CSIRO, and measure the impact which its various programs and initiatives deliver to the nation and to its partners.

The 2020 Value of CSIRO report provides the most up-to-date information about CSIRO's the collective impact. Prepared by the nonprofit research institute, RTI International, this year's report compares the monetised impacts resulting from CSIRO's work compared with the costs of those projects and programs.

We quantified a 7.6 to 1 benefit-to-cost ratio, meaning that every \$1 invested results in about \$7.60 in economic, social, and environmental value. This result is an underestimate; many advances in knowledge, contributions to Australia's human capital, and contributions to conservation and culture are not readily expressed in dollar terms.

## ES.1 CASE STUDY THEMES

CSIRO's impact case studies span CSIRO's Challenge Areas, with most aligning with Health and Wellbeing, Sustainable Energy & Resources, and Future Industries (Exhibit ES.1). The principal form of economic impact realized from CSIRO research was productivity and efficiency gains. CSIRO supported Australian innovators in bringing to market more efficient and effective processes, products, and technologies.



Identified social impacts were more diverse, with the two most recognized primary impacts being improvements in health and wellbeing, and increased resilience. Other commonly identified impacts included improved access to resources, services, and opportunities; increased quality of life; and enhancements in innovation and human capital.

## ES.2 DIMENSIONS OF IMPACT

The 7.6-to-1 return on investment reflects an aggregation of results across a wide portfolio of CSIRO activities, using monetised benefits and costs as a common unit of measure. Certainly, the results are significant, but one must keep in mind that the use of dollar terms as a common denominator underappreciates the nuanced impact CSIRO is generating.

Notable impact narratives from CSIRO's most recent case studies included:

- **Food security and quality**, including ensuring market access for Australian canola and high-pressure processing to improve food shelf-life and quality and to mitigate food waste;
- **Health and wellbeing**, including clinical terminology and patient pathway tools to make public health care more efficient and improve health outcomes;
- **Resilient and valuable environments**, including new technologies for improving maritime operations and offshore environmental management;
- **Sustainable energy and resources**, including more energy-efficient, lower emission minerals processing technologies;
- **Future industries**, including programs that develop entrepreneurs and nurture small companies; and
- **A secure Australia and region**, including technologies for biocontrol to protect Australia's unique environment and technologies to support disaster and emergency situation planning.

## ES.3 SUMMARY RESULTS

Looking across a portfolio of 54 case studies, we found that the net present value of CSIRO's activities and initiatives

was more than \$10 billion (Exhibit ES.2). The benefit-to-cost ratio was 7.6, which means that for every \$1 invested, \$7.60 in value in benefits accrued. These benefits are measured in terms of productivity gains, environmental and social impacts, and other impact metrics.

Many advances in knowledge, contributions to Australia's human capital and contributions to conservation and

culture are not readily expressed in dollar terms. Thus, we consider the 2020 Value of CSIRO return on investment estimate of 7.6:1 to be a conservative, lower-bound estimate.

Overall, the case studies evidence CSIRO's progress in delivering on its mission to solve the greatest challenges through innovative science and technology.

**Exhibit ES.2. Summary Benefit-Cost Analysis Results for CSIRO Activities and Initiatives**

TIME PERIOD	1995 TO 2029
Present Value of Benefits	\$11,613.5 million
Present Value of Costs	\$1,528.9 million
Net Present Value	\$10,084.7 million
Benefit-to-Cost Ratio	7.6

Note: All values are in 2020 dollars terms with a 2020 base year, discounted at a 7% real social discount rate.



# 1. Introduction

CSIRO is Australia's innovation catalyst, investing broadly and holistically across the spectrum of innovation to deliver impact, competitiveness, health and security, and environmental stewardship to the current and future generations of Australians.

Every 2 years CSIRO assesses the value it delivers to the nation by analysing its impact. This is done with reference to the case studies of CSIRO's research breakthroughs conducted by independent evaluators and analysts. These case studies account for the resources entrusted to CSIRO and measure the impact its various programs and initiatives deliver to the nation and its partners.

The 2020 *Value of CSIRO* report provides the most up-to-date information about CSIRO's collective impact. Prepared by the non-profit research institute, RTI International, this year's report compares the monetised impacts resulting from CSIRO's work with the costs of those projects and programs.

We quantified a 7.6 to 1 benefit-to-cost ratio, meaning that every \$1 invested results in about \$7.60 in economic, social, and environmental value. This result is an underestimate: many advances in knowledge, contributions to Australia's human capital, and contributions to conservation and culture are not readily expressed in dollar terms. As such, this report also explores dimensions of impact qualitatively.

## 1.1 BACKGROUND

For more than 100 years, CSIRO has been Australia's mission-led national science agency, collaborating across the innovation system to boost Australia's innovation performance. It is an Australian Government statutory authority within the Industry, Science, Energy, and Resources portfolio, operating under the provisions of the Science and Industry Research Act 1949.

CSIRO's primary objectives are to:

- conduct and encourage the uptake of world-class scientific research,
- mobilise and develop the best talent for the benefit of Australia,
- manage national research infrastructure for the nation, and
- ensure the sustainability of CSIRO.

To achieve these, CSIRO acts intentionally, especially in challenge areas that it believes are of the greatest importance to Australians (Table 1.1). A staff of more than 5,000 experts and professionals in 59 centres collaborate with partners and customers across the country and around the world to serve CSIRO's pursuit of scientific excellence, breakthrough innovation, and global engagement for the national benefit.<sup>1</sup>

**Table 1.1. Challenges Motivating CSIRO Action, Investment, and Collaboration**

CHALLENGE	DESCRIPTION
Food security and quality	Achieving sustainable regional food security and growing Australia's share of premium agrifood markets
Health and wellbeing	Enhancing health for all Australians, through preventative, personalised, biomedical, and digital health services
Resilient and valuable environments	Enhancing the resilience, sustainable use, and value of our environments
Sustainable energy and resources	Building regional energy and resource security and our competitiveness while lowering emissions
Future industries	Creating Australia's future industries and jobs by collaborating to boost innovation performance and STEM skills
A secure Australia and region	Safeguarding Australia from risks such as war, terrorism, pandemics, disasters, and cyber-attacks

Source: CSIRO.

<sup>1</sup> See also CSIRO. 2020. Corporate Plan 2020-21. Canberra, Australia: CSIRO.

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## 1.2 REPORT OBJECTIVES

The purpose of this report is to provide an overall estimate of the return on Australia's investment in CSIRO. As such, CSIRO commissioned economists expert in the analysis and evaluation of innovation programs, research infrastructure, and related services to:

1. review case studies describing the impacts of CSIRO's technology development and innovation programs,
2. advance the strategy and overarching framework for aggregating impacts from economic analyses pursuant to international best practices,
3. synthesise the monetised economic impacts described therein, and
4. compare monetised benefits with monetised costs to estimate Australia's return on investment on CSIRO's portfolio of activities.

CSIRO commissioned RTI International, an independent non-profit research institute, to perform this work. RTI's Centre for Applied Economics and Strategy specialises in economic analysis in the domains of innovation and new technology; environmental and natural resources; food and agriculture; and energy and economic development. Notably, RTI did not conduct the case studies whose results comprise the overall value of CSIRO. This selection was intentional on the part of CSIRO, to ensure that this report was prepared independently and consistent with standards and norms in peer review and scientific excellence.

## 1.3 OVERARCHING PERSPECTIVE ON HOW CSIRO ADDS VALUE FOR THE NATION

As Australia's national science agency, CSIRO plays a foundational and multifaceted role in the economy; in Australia's innovation ecosystem; and in the global research and innovation landscape (Figure 1.1). It book-ends Australian innovation, providing the essential platforms and advice needed by innovators, and then collaborating with those innovators to convert their discoveries and ideas into technologies, services, and best practices that benefit the nation. It also conducts research pursuant to national priorities and directives.

Within this system, CSIRO provides critical elements, including

- major research infrastructure—developing, operating and maintaining world-class laboratories, facilities and research collections that enable science, discovery and innovation;
- subject matter expertise and know-how—sustaining the knowledge base of intellectual and human capital and developing the next generation of innovators and leaders in innovation and science;
- applied research and technology development programs—developing new technologies in collaboration and partnership with Australian innovators;
- accelerator—moving innovators' ideas from discovery to market;
- innovation and education support services—advising stakeholders across the Australian landscape on topics in innovation and science education;
- science communications—promoting science and evidence-based solutions and information to inform the public and nurture the curiosity of the next generation; and
- global ambassador for Australian science—communicating and representing the best of Australian science abroad and facilitating the exchange of ideas between Australia and the rest of the world for mutual benefit.

## 1.4 REPORT ORGANISATION

This report is organised as follows:

- Section 2 describes our approach for measuring the value of CSIRO;
- Section 3 presents the return on investment for CSIRO's portfolio of activities;
- Section 4 contextualises the overall value of CSIRO by characterising contributions along economic, social and environmental dimensions; and
- Section 5 offers important considerations and concluding remarks.

**Figure 1.1. CSIRO's Role in Australia's Innovation System**

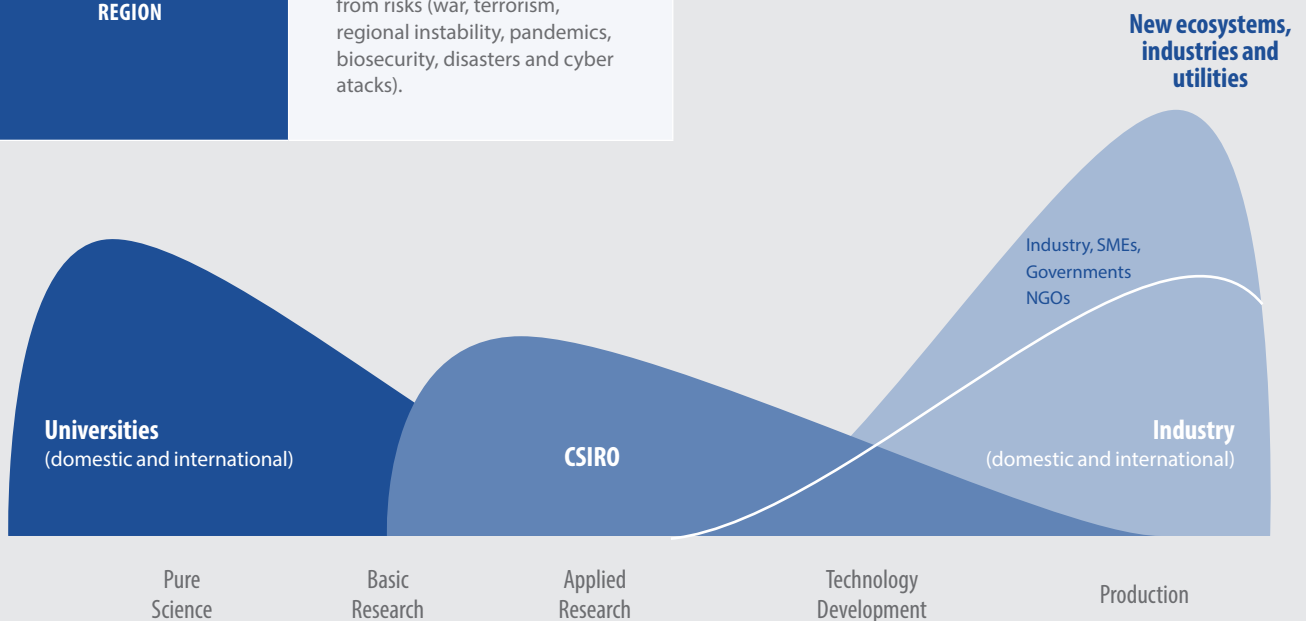
<b>RESILIENT AND VALUABLE ENVIRONMENTS</b>	Enhance the resilience, sustainable use and value of our environments, including by mitigating and adapting the impacts of climate and global change.
<b>FOOD SECURITY AND QUALITY</b>	Achieve sustainable regional food security and grow Australia's share of premium AgriFood markets.
<b>HEALTH AND WELLBEING</b>	Help enhance health for all through preventive, personalised, biomedical and digital health services.
<b>FUTURE INDUSTRIES</b>	Help create Australia's future industries and jobs by collaborating to boost innovation performance and STEM skills.
<b>SUSTAINABLE ENERGY AND RESOURCES</b>	Build regional energy and resource security and our competitiveness while lowering emissions.
<b>A SECURE AUSTRALIA AND REGION</b>	Help safeguard Australia from risks (war, terrorism, regional instability, pandemics, biosecurity, disasters and cyber attacks).

**CSIRO drives ambition, national coherence, scale**  
 Manages Innovation Fund as national steward, bridging gap between science and industry

**CSIRO catalyses network**  
 Manages Challenge Fund to frame, co-create and deliver solutions

**CSIRO delivers critical orchestration skills**  
 Acts as trusted advisor, mega-sites in capital cities, solution architects, deeply collaborative, transdisciplinary teaming, program management

**CSIRO accelerate innovation for national benefit**  
 Solves big challenges, National Commercialiser, creates new ecosystems and utilities, seeds new industries, forges many-many solutions





## 2. Quantifying the Value of CSIRO

We measure the value of CSIRO by comparing the present value of benefits to the present value of costs for technologies and programs delivered by the organisation. In prior years, reports in the *Value of CSIRO* series compared CSIRO's total annual operating expenditures to the present value of benefits for each year of research that generated those benefits, multiplied by two to account for unmonetised benefits. For this year, and going forward, a more straightforward approach was used. Comparing a time series of benefits and costs within a defined time frame that shifts forward with each new report in the series produces an estimate that will become an indicator that reflects, in essence, a moving average of the value CSIRO delivers.

### 2.1 PORTFOLIO OF IMPACT CASE STUDIES

RTI reviewed 63 case studies published between 2010 and 2019. Note that CSIRO's primary evaluation approach is to prepare case studies of research outcomes. Each case study includes a cost-benefit analysis. For simplicity, we refer to each analysis reviewed for this report as a case study.

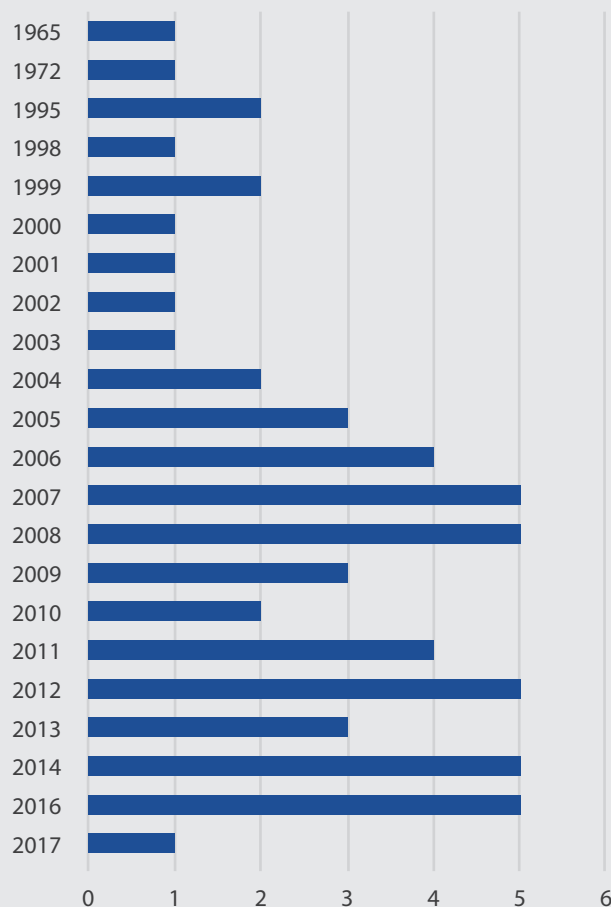
The case studies assess the benefits and costs of CSIRO-funded research initiated between 1964 and 2019, with most of the reports covering research initiated after the year 2000 (see Figure 2.1). Each study was completed by one of five institutions: ACIL Allen Consulting, ACIL Tasman, the Centre for International Economics (CIE), Deloitte Access Economics (DAE), or CSIRO.

Table A.1 in the appendix provides an overview of the case studies reviewed, including title, author, date range covered, whether it was included in the 2017 or 2020 *Value of CSIRO* reports, and information about the nature of the impacts assessed in each study (discussed in greater detail in Section 3).

The case studies include 29 that were included in the 2017 *Value of CSIRO* report as well as 34 case studies

commissioned by CSIRO since the publication of that document.<sup>2</sup> Of these 63 studies, 9 had insufficient benefit or cost data. This meant there was a maximum of 54 studies available to inform our valuation.

**Figure 2.1. Distribution of Reported Start Years for Case Studies of CSIRO Research Outcomes**



Note: There are 58 case studies depicted in this figure.

**Table 2.1. Range of Mean, Minimum, and Maximum Benefits and Costs from Case Studies of CSIRO Research Outcomes**

	MINIMUM (MILLION)	MEAN (MILLION)	MAXIMUM (MILLION)
Benefits	\$0.82	\$604.54	\$8,134.49
Costs	\$0.09	\$46.31	\$469.00

<sup>2</sup> See ACIL Allen Consulting, 2017. The Value of CSIRO – 2017 Update. Available at <https://www.csiro.au/~media/About/Files/CSIRO-Value-Final-Report-2017-PDF.pdf>.

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These 54 case studies presented a broad range of benefits and costs (see Table 2.1). Benefits ranged from about \$800,000 to over \$8 billion, with an average of about \$605 million. Costs ranged from \$90,000 to \$470 million, with an average of about \$46 million.

## 2.2 ANALYSIS OF THE TIME SERIES OF BENEFITS AND COSTS

As an initial step in our synthesis, we reviewed the available data and benefit-cost analysis calculation methods for each case study. We verified the accuracy of the data and methods for each, and standardised methods or made other corrections or adjustments as needed.

We focused on the reported research costs funded directly by CSIRO, and on the estimated benefits attributable to CSIRO. We did not review the underlying assumptions for each case study's valuation approach. The 2017 *Value of CSIRO* report did so for three selected case studies and found those assumptions to have been robust and conservative (ACIL Allen Consulting, 2017).

We brought all dollar values up to date to 2020 terms. When sufficient time series data for benefits and costs were available for a study, we standardised benefit-cost analysis methods by performing inflation and discounting adjustments for each year of data for the case study. We adjusted for inflation (i.e., converted from nominal to real values) using the Australian Consumer Price Index (CPI), estimating the 2020 CPI value based on observations from previous years. We discounted all benefit and cost time series entries to 2020 values using the benchmark 7% real social discount rate specified by CSIRO's impact evaluation guide (CSIRO, 2020). We used 2020 as the base year for both inflation and discounting adjustments, as recommended in the guide. For studies without sufficient benefit or cost data to verify or standardise methods, we updated the originally reported values to 2020 values by carrying out one-time inflation and discounting adjustments.

## 2.3 TIME SERIES ADJUSTMENTS

After reviewing, standardising, and updating the case study data, we built a dataset comprising the time series of benefits and costs for those case studies with time series data. We also identified which values were realised versus projected at the time of publication for each study. The resulting dataset provided a portfolio of benefits and costs from CSIRO activities that can be used to estimate the return on investment over time.

Next, we limited the set of case studies included in the 2020 Value of CSIRO to those covering research initiated in 1995 or later. We removed benefit and cost projections beyond 10 years for each case study to reduce the uncertainty inherent in estimating future benefits and costs. This shortened the benefit and/or cost projections of 23 of the case studies that included projected values for anywhere from 11 to 52 years into the future.

As an illustration, Figure 2.2 shows the years and type (actual versus projected) of benefit and cost data for six case studies included. The figure shows that projected values of either benefits or costs are limited to no more than 10 years, while there is no limit to the number of years of actual (realised) benefit or cost data included.

In reducing the sample to case studies covering research initiated in 1995 or later, we removed one case study that assessed a research project dating back to 1965. This study was removed because it would be unrepresentative to have only one research project informing CSIRO benefit-cost estimates for multiple decades.

The resulting data set included 41 case studies of CSIRO-funded research projects and covers benefits and costs spanning 1995 to 2029.

Going forward, limiting the focus to research initiated within the last 25 years—and with no more than 10 years of projections—will convert the summary metric resulting from the analysis into a moving average that is more comparable between reports in the Value of CSIRO series.

Finally, we aggregated benefits across all case studies and years to generate the present value (PV) of benefits of CSIRO research. We used the same method to generate the PV of costs. We calculated the net present value (NPV) of CSIRO research by subtracting the PV of costs from the PV of benefits and calculated the benefit-cost ratio (BCR) by dividing the PV of benefits by the PV of costs.

## 2.4 METHODOLOGICAL CHANGES FROM PREVIOUS VALUE OF CSIRO REPORTS

The approach used in this report departs from that used in previous reports. The 2017 *Value of CSIRO* report calculated the PV of benefits per year of research and development (R&D) for each study, aggregated those values, and roughly doubled that aggregate value under the assumption that the value of unmonetised CSIRO research is at least as high as the value of the research that has been monetised. This measure was compared with CSIRO's total annual operating

expenditure to estimate a BCR. The 2017 report did not estimate the PV cost of CSIRO research and as such did not report an NPV.

The main limitation to the previous approach is that the estimated costs (i.e., CSIRO’s annual operating budget) do not change drastically over time. In contrast, the aggregated benefits per year of R&D will increase as more studies are reviewed for each bi-annual report. Hence, the calculated BCR largely reflects changes in the number of studies included, rather than changes in the information provided in those studies.

The time series method used in this report more accurately reflects the value of the observed portfolio of CSIRO-funded research. As new studies are added to each bi-annual review, both the benefits and costs of the portfolio will be updated appropriately. This method also focuses on the case studies with the most detailed data records, thereby increasing confidence in the reliability of the results.

**Figure 2.2. Examples of the Benefit and Cost Data Available for Each Study by Year and Type, Actual vs Projected**

		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
Cereal Rust Case Study	Costs	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A															
	Benefits												A	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P	P	P	P	P	P				
LASC Longwall Automation Understanding	Costs						A	A	A	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P	P	P	P	P	P								
	Benefits														A	A	A	A	A	P	P	P	P	P	P	P	P	P	P								
Understanding the value of the Care Assessment Platform / MoTER cardiac rehabilitation program	Costs														A	A	A	A	A	A																	
	Benefits														A	A	A	A	A	A																	
Maintaining access to EU markets for Australian canola	Costs																		A	A	A	A	A	A													
	Benefits																								A	P	P	P	P								
SIEF Impact Case Studies: Distal Footprints	Costs																		A	A	A	A	A	A													
	Benefits																												P	P	P	P	P	P	P	P	
Impact assessment of STEM+ Business: Optotech	Costs																								A	A	A										
	Benefits																												P	P	P	P	P	P	P	P	P

Note: A (Actual or Realised Value), P (Projected Value).

### 3. Economic Analysis Results

We estimate that the benefit-to-cost ratio of CSIRO to be 7.6:1, meaning that for every \$1 invested in CSIRO at least \$7.60 in value is returned to the Australian people. This estimate is a lower-bound because many impacts are not monetised, such as those from contribution to the knowledge base, greater awareness of science and innovation across Australian society, education programs, and the role CSIRO plays in conservation and culture.

*The Value of CSIRO for 2020 is 7.6:1—this means that for every \$1 invested there are at least \$7.60 in benefits.*

#### 3.1 ANALYSIS RESULTS

Table 3.1 provides a detailed account of our synthesis of benefit-cost analysis results for case studies of CSIRO-funded research published since 2010.

The updated PV of benefits and PV of costs for each of the 54 case studies with available data are provided. These data are accompanied by the PV of benefits, PV of costs, NPV and BCR for each of the 41 case studies with time series data starting after 1995 and including up to 10 years of projected values. Recall from Section 2 that it is this set of 41 case studies that ultimately generated the bottom-line value estimate.

We found aggregate benefits of \$32.7 billion for all case studies of CSIRO activities that reported quantified benefits and costs. This is an increase of \$27.3 billion over the

aggregate benefits reported in 2017, reflecting both the increase in the number of studies reviewed and the effect of updating to 2020 values.

As described in Section 2, the value estimates for the restricted sample covering research conducted since 1995 or later and capped at 10 years of projected values provide a more representative estimate of the value of CSIRO research.

We find an NPV of \$10.1 billion and a BCR of 7.6, indicating strong returns. Because different methods were used to generate the BCR of 5:1 in the 2017 report (ACIL Allen Consulting, 2017), our results cannot be directly compared. Though higher in value, the BCR of 7.6 calculated here is still conservative for reasons outlined above.

**Table 3.1. Benefit-Cost Analysis Results from Case Studies Published Since 2010**

CASE STUDY	ALL CASE STUDIES			VALUES FOR 2020 VALUE OF CSIRO				
	ANALYSIS TIME PERIOD	PV BENEFITS	PV COSTS	ANALYSIS TIME PERIOD	PV BENEFITS	PV COSTS	NET PRESENT VALUE	BENEFIT-TO-COST RATIO
		million	million		million	million	million	
Atlantic Salmon Breeding	2005-2025	\$117.5	\$4.7	2005-2025	\$117.5	\$4.7	\$112.7	24.88
Biomarkers for Detection of Colorectal Cancer	2006-2026	\$220.6	\$17.8	2006-2026	\$220.6	\$17.8	\$202.8	12.39
Reservoir Rejuvenation Technology	2008-2031	\$8.0	\$2.0	2008-2026	\$3.5	\$2.0	\$1.4	1.69
Impact Assessment of Remote-I Digital Eye Health System	2013-2028	\$7.4	\$4.7	2013-2028	\$7.4	\$4.7	\$2.7	1.58
Science & Industry Endowment Fund: Plant Yield	2010-2035	\$4,007.0	\$8.7	2010-2023	\$681.4	\$8.7	\$672.7	78.14
Medical Developments International: Pentrox	2014-2029	\$283.8	\$1.0	2014-2023	\$168.0	\$1.0	\$167.0	170.49
Science & Industry Endowment Fund: RAFT for Medical Applications	2011-2035	\$755.1	\$6.8	2011-2026	\$0.0	\$6.8	-\$6.8	0.00

Continued on next page

**Table 3.1. Benefit-Cost Analysis Results from Case Studies Published Since 2010**

CASE STUDY	ALL CASE STUDIES			VALUES FOR 2020 VALUE OF CSIRO				
	ANALYSIS TIME PERIOD	PV BENEFITS	PV COSTS	ANALYSIS TIME PERIOD	PV BENEFITS	PV COSTS	NET PRESENT VALUE	BENEFIT-TO-COST RATIO
		million	million		million	million	million	
BuildingIQ: Opticool	2006-2024	\$101.9	\$1.1	2006-2024	\$101.9	\$1.1	\$100.8	95.30
Science & Industry Endowment Fund: Early Nutrition	2011-2035	\$607.4	\$8.8	2011-2026	\$98.7	\$8.8	\$89.9	11.18
Longwall Automation Steering Committee: Longwall Automation	2001-2024	\$2,400.5	\$58.9	2001-2022	\$2,328.5	\$58.7	\$2,269.8	39.68
Improving Iron Ore Sintering Process Performance	1999-2027	\$2,922.9	\$78.3	1999-2027	\$2,882.2	\$77.8	\$2,804.4	37.03
Science & Industry Endowment Fund: Energy Waste	2011-2035	\$369.5	\$10.3	2011-2026	\$351.2	\$10.3	\$340.8	33.95
Science & Industry Endowment Fund: Synchrotron	2012-2035	\$486.1	\$16.8	2012-2026	\$227.6	\$16.8	\$210.7	13.51
Impact Assessment of STEM+Business: Optotech	2016-2029	\$7.2	\$0.3	2016-2029	\$7.2	\$0.3	\$6.9	27.63
Future Grid Forum & Electricity Network Transformation Roadmap	2012-2050	\$111.6	\$4.4	2012-2026	\$43.4	\$4.4	\$39.0	9.93
Aquaculture Feed (Novacq) & Prawn Breeding	2004-2023	\$1,207.6	\$55.4	2004-2023	\$1,072.7	\$55.4	\$1,017.3	19.37
Maintaining Access to EU Markets for Australian Canola	2011-2021	\$95.3	\$4.6	2011-2021	\$95.3	\$4.6	\$90.7	20.74
Magnetic Resonance Ore Sorter	1999-2027	\$218.5	\$13.3	1999-2027	\$202.2	\$13.3	\$188.9	15.24
Impact Analysis of CSIRO's CAMP – Oventus	2012-2016	\$5.5	\$0.3	2012-2016	\$5.5	\$0.3	\$5.2	\$16.4
Understanding the Value of the Total Wellbeing Diet Online	2013-2030	\$65.4	\$4.1	2013-2028	\$50.3	\$3.6	\$46.7	13.94
Rabbit Biocontrol	2007-2026	\$143.9	\$9.1	2007-2026	\$143.9	\$9.1	\$134.8	15.85
Natural Hazards & Infrastructure Initiative	2009-2027	\$9.3	\$0.7	2009-2027	\$9.3	\$0.7	\$8.6	13.63
Estimating the Impact of the Kick-Start Program	2016-2029	\$1.1	\$0.1	2016-2029	\$1.1	\$0.1	\$1.0	12.41
eReefs	2009-2025	\$137.3	\$13.8	2009-2025	\$137.3	\$13.8	\$123.5	9.94
Impact Assessment of STEM+Business: Aquarius	2017-2029	\$2.6	\$0.3	2017-2029	\$2.6	\$0.3	\$2.2	8.10
Agricultural Flagship: Cotton Varieties	2006-2023	\$962.3	\$126.1	2006-2023	\$911.2	\$126.1	\$785.0	7.22
Dry Slag Granulation	2007-2028	\$89.0	\$12.8	2007-2027	\$71.5	\$12.7	\$58.8	5.63
Botanical Resources Australia	2002-2028	\$13.8	\$2.0	2002-2025	\$11.8	\$2.0	\$9.8	5.85
Impact Assessment of TerriaJS	2014-2028	\$63.8	\$9.5	2014-2028	\$63.8	\$9.5	\$54.3	6.71
Science & Industry Endowment Fund: Distal Footprints	2012-2035	\$31.1	\$6.3	2012-2027	\$18.4	\$6.3	\$12.0	2.89

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**Table 3.1. Benefit-Cost Analysis Results from Case Studies Published Since 2010**

CASE STUDY	ALL CASE STUDIES			VALUES FOR 2020 VALUE OF CSIRO				
	ANALYSIS TIME PERIOD	PV BENEFITS	PV COSTS	ANALYSIS TIME PERIOD	PV BENEFITS	PV COSTS	NET PRESENT VALUE	BENEFIT-TO-COST RATIO
		million	million		million	million	million	
Biosensors for Health & Food: CYBERTONGUE®/CYBERNOSE®	2005-2027	\$62.3	\$13.1	2005-2027	\$62.3	\$13.1	\$49.2	4.75
Understanding the Value of the Care Assessment Platform/ MoTER Cardiac Rehabilitation Program	2008-2017	\$417.0	\$109.1	2008-2017	\$417.0	\$109.1	\$307.9	3.82
Understanding the Value of Vaximiser	2007-2032	\$71.6	\$23.1	2007-2027	\$43.9	\$16.4	\$27.6	2.68
Yield Prophet	1995-2035	\$13.9	\$4.8	1995-2025	\$9.8	\$4.8	\$4.9	2.03
Cereal Rust	1995-2025	\$633.8	\$231.7	1995-2025	\$633.8	\$231.7	\$402.2	2.74
High Pressure Processing	1998-2027	\$322.3	\$143.0	1998-2027	\$322.3	\$143.0	\$179.4	2.25
Bluelink	2003 -2025	\$75.4	\$39.4	2003-2025	\$75.4	\$39.4	\$36.0	1.91
Understanding the Value of the Medical Image Communication Exchange (MICE)	2016-2028	\$0.8	\$0.4	2016-2028	\$0.8	\$0.4	\$0.4	1.86
Pawsey Supercomputing & Efficient Gas Turbines	2014-2050	\$18.9	\$3.0	2014-2028	\$2.6	\$3.0	-\$0.4	0.88
Pawsey Supercomputing & CETO	2014-2050	\$100.5	\$464.2	2014-2028	\$0.0	\$434.7	-\$434.7	0.00
Pawsey Supercomputing & the Murchison Widefield Array	2013-2070	\$13.3	\$67.9	2013-2028	\$5.0	\$51.4	-\$46.4	0.1
Grapevine Breeding	1965-2024	\$481.0	\$57.0	NA	NA	NA	NA	NA
<b>Case Studies without Time Series Data</b>								
Weed Biocontrol	1972-2006	\$2,541.9	\$8.5					
Patient Administration Prediction Tool	2008-2017	\$80.0	\$0.4					
Climate Adaptation Flagship: Climate Ready Crops	2008-2049	\$1,241.3	\$11.5					
Clinical Terminology Tools	2010-2016	\$223.3	\$7.4					
Climate Adaptation Flagship: Coastal Communities	2006-2070	\$496.5	\$24.0					
Understanding the Value & Real-world Impact of the Trustworthy Systems Group's Research & Technology	2009-2028	\$82.4	\$4.5					
Australian Animal Health Laboratory: Foot and Mouth Disease	2008-?	\$8,134.5	\$469.0					
Integrated Water Resource Assessments	2005-?	\$1,837.1	\$244.9					
The UltraBattery	2004-2020	\$94.1	\$13.3					

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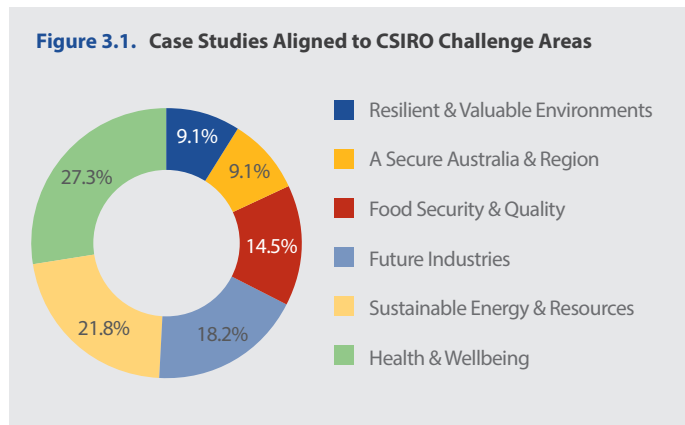
**Table 3.1. Benefit-Cost Analysis Results from Case Studies Published Since 2010**

CASE STUDY	ALL CASE STUDIES			VALUES FOR 2020 VALUE OF CSIRO				
	ANALYSIS TIME PERIOD	PV BENEFITS	PV COSTS	ANALYSIS TIME PERIOD	PV BENEFITS	PV COSTS	NET PRESENT VALUE	BENEFIT-TO-COST RATIO
		million	million		million	million	million	
Social Return on Investment: The Scientists and Mathematicians in Schools Program	2007-2015	\$40.6	\$10.9					
Direct Injection Carbon Engine (DICE)	2007-2050	\$51.2	\$15.8					
Cement Substitutes & Novel Products	2000-?	\$166.3	\$53.2					
BARLEYmax™	?-?	NA	NA					
Sustainable Commercial Fisheries	?-?	NA	NA					
Clinical Terminology Tools	?-?	NA	NA					
AuScope	?-?	NA	NA					
Radio-Astronomy: Square Kilometre Array	?-?	NA	NA					
Understanding the value of Improvy	2014-2017	NA	NA					
RapidAIM Smart Traps	2016-2035	NA	NA					
Impact Analysis of CSIRO's Clayton Advanced Manufacturing Precinct (CAMP)	2012-2032	NA	NA					
IA Quantified Risk Assessment of Complex Systems	2016-2029	NA	NA					
<b>Totals</b>	<b>1965-2070</b>	<b>\$32,652.8</b>	<b>\$2,503.2</b>	<b>1995-2029</b>	<b>\$11,613.5</b>	<b>\$1,528.9</b>	<b>\$10,084.7</b>	<b>7.60</b>

Note: Values for the 2020 report reflect studies covering from 1995 on, with each study capped at 10 years of projected benefits or costs. All values are in 2020 dollars terms with a 2020 base year.

### 3.2 CASE STUDY THEMES

CSIRO’s impact case studies span CSIRO’s Challenge Areas, with most aligning with Health and Wellbeing, Sustainable Energy & Resources, and Future Industries (Figure 3.1). The principal form of economic impact realized from CSIRO research was productivity and efficiency gains (Figure 3.2). CSIRO supported Australian innovators in bringing to market more efficient and effective processes, products, and technologies.



Identified social impacts were more diverse, with the two most recognized primary impacts being improvements in health and wellbeing, and increased resilience (Figure 3.3). Other commonly identified impacts included improved access to resources, services, and opportunities; increased quality of life; and enhancements in innovation and human capital.

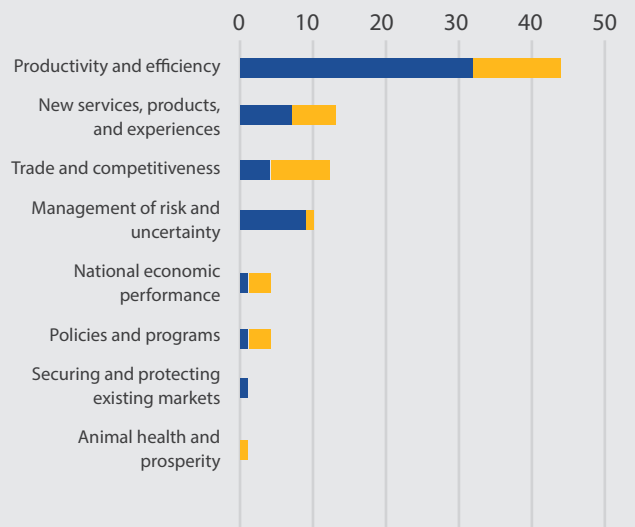
More than 35 of the case studies addressed environmental, resource management, and ecosystem health issues (Figure 3.4). The three most common environmental impacts identified were improvements in ecosystem health and integrity, energy generation and consumption, and aquatic environments.

Section 4 will explore the various dimensions of impact in greater depth.

### 3.3 KEY TAKEAWAYS

We conservatively estimate an NPV of \$10.1 billion and a BCR of 7.6 for CSIRO research initiated since 1995. The benefits and costs of this research were originally estimated in 41 case studies published since 2010, with each study restricted to projecting values forward no more than 10 years into the future. Even these conservative estimates suggest strong positive returns for the citizens of Australia. Additional case studies assessing the benefits and costs of CSIRO research outcomes will provide an even deeper understanding of the social value of CSIRO.

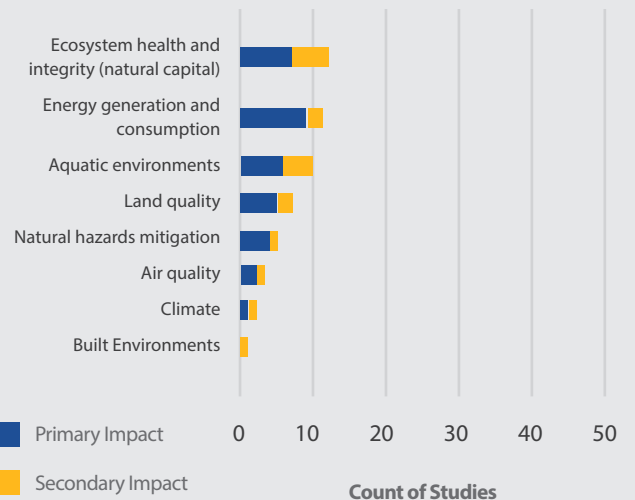
**Figure 3.2. Distribution of Reported Start Years for Case Studies of CSIRO Research Outcomes**



**Figure 3.3. Social Impact Dimensions**



**Figure 3.4. Environmental Impact Dimensions**





## 4. Dimensions of Impact

The 7.6-to-1 return on investment presented in the preceding chapter aggregates results across a wide portfolio of CSIRO activities, using monetised benefits and costs as a common unit of measure. The results are significant, but the use of dollar terms as a common denominator can underappreciate the nuanced impact CSIRO is having.

As such, this chapter explores CSIRO's impact along dimensions aligned to CSIRO's six challenge areas:

- Food security and quality
- Health and wellbeing
- Resilient and valuable environments
- Sustainable energy and resources
- Future industries
- As secure Australia and region

The focus herein is on value delivered in terms of economic, social, and environmental dimensions through science and innovation, talent mobilisation and development, and research infrastructure. For each challenge area, we present excerpts from case studies completed in the last 3 years by CSIRO's Performance, Planning and Impact team, ACIL Allen Consulting, and The Centre for International Economics.<sup>3</sup>

### 4.1 FOOD SECURITY AND QUALITY

Food security and quality focuses on CSIRO's work to achieve sustainable food security and grow Australia's share of premium agrifood markets.

#### Advanced Processing Technologies for Food Safety

Consumer demand for high quality products with natural and fresh appearance, flavour, texture, taste, and nutritional value has been growing over the last decade. Product safety is imperative, and natural products without additives such as preservatives are desirable (CSIRO, 2018a).

To satisfy these demands of 'fresh like' food products, without compromising the safety of the products and at the same time improve shelf life, high pressure processing (HPP) has become an established technology in the food industry.

Rooted in early support from a Victorian Government Strategic Technology Infrastructure grant, CSIRO's HPP research has led to new technologies, supported and

incubated companies, and lead to adoption of HPP by Australian food producers. Rigorous testing shows that HPP increased shelf-life fivefold with minimal adverse effects on quality, taste, and nutrition.

#### Securing Export Market Access for Australia's Canola

Australia's grain production is valuable not only for food production, but also for renewable fuels. Biodiesel is a renewable fuel made from canola. Australia's canola crop generates substantial export revenue for growers, while also providing a fundamental feedstock for biodiesel producers.

The European Union is the most important market for Australian canola, accounting for more than 70% of exports (about 1.7 million tonnes/year). An EU directive tightened greenhouse gas emissions targets throughout the biodiesel supply chain, including in feedstock production in exporting countries. The policy directive injected uncertainty into the market about whether emissions from different countries' grain production were low enough (CSIRO, 2019a).

CSIRO, the Australian Oilseeds Federation, and the Australian Export Grains Innovation Centre rapidly mobilised to conduct a full life-cycle assessment of the greenhouse gas emissions profile of Australian canola production. The analysis showed that the emissions profile of Australian canola was sufficiently low that grain traders could purchase it with confidence. Australian trade officials in Brussels liaised with EU officials to have the results accepted prior to finalisation of the EU rule, thus ensuring no disruptions to Australia's market access.

### 4.2 HEALTH AND WELLBEING

Health and wellbeing covers CSIRO's work to enhance health for all Australians through preventative, personalised, biomedical, and digital health services. Many of the case studies of CSIRO's research and technologies over the last 3 years addressed the organisation's efforts to improve health outcomes.

#### Improving health care through clinical terminology tools

Australia faces challenges in health information exchange between individual health practitioners, health care provider organisations, and state/territory health departments (CSIRO, 2017a). Patient data are often captured in disparate electronic systems, in different formats,

<sup>3</sup> All case studies excerpted herein are available on CSIRO's website at <https://www.csiro.au>.

and described using different clinical terminologies or 'languages.' This makes it difficult for computers to process and combine the information.

The National e-Health Transition Authority (NEHTA, 2004-2016) and now the Australian Digital Health Agency (ADHA, 2016-ongoing) were established to tackle this challenge by designing the information standards for electronic health information to be shared securely. A key requirement was to develop standard clinical terminology to describe the care and treatment of patients, to allow full interoperability between electronic health systems.

CSIRO research supports the goal of health data interoperability (and, more broadly the Australia's National Digital Health Strategy) by developing innovative tools and technologies for use in electronic health and medical records systems.

CSIRO informatics researchers have created solutions and tools that underpin the continued development of clinical terminology its implementation for use in Australia. This work allows improvements in the use, interoperability, and effectiveness of patient data captured in electronic medical records. This makes health care delivery more efficient for both patients and providers. Economic analysis estimates that benefits outweigh costs 30 to 1. This work is essential for providing the best-possible care for patients.

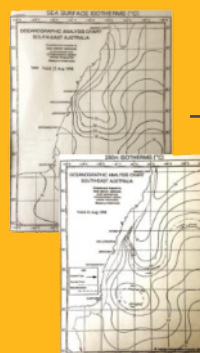
### Improving patient outcomes through patient-pathway planning technologies

Access to reliable public health care is a key foundation of Australia's social and economic wellbeing. Increasing demands on staff and resources in public hospitals is resulting in critically overcrowded emergency departments. Delays can cause patients' conditions to deteriorate and can increase patient mortality by up to 30%. To improve patient outcomes, strategies involving a whole-of-hospital response are required to improve the flow of patients through hospitals and alleviate congestion.

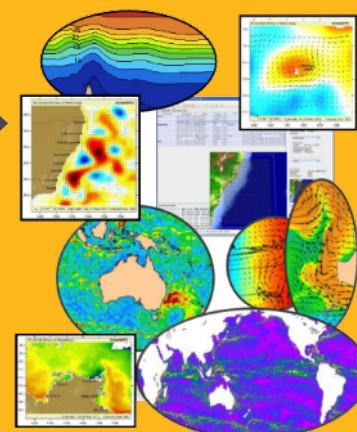
One solution to improving patient flow and resource management is forecasting demand. The Patient Admission and Prediction Tool (PAPT) was developed through deep collaboration between the Australian eHealth Research Centre (a joint venture between CSIRO eHealth and Queensland Health), which is supported by Griffith University, and the Queensland University of Technology.

PAPT predicts emergency department patient arrivals, their medical urgency and requirement for specialty treatment, admissions, and likely discharge times. It provides a predictive picture of patient movement through the hospital,

### Pre-Bluelink



### Post-Bluelink



## OceanMAPS

The OceanMAPS system incorporates observations from the Global Ocean Observing System – including satellite data, a global network of autonomous floats (Argo), a global network of moorings and in situ observations. It is one of a small number of similar systems for forecasting ocean conditions in operation around the world. Other systems that are analogous to OceanMAPS include those in the USA, UK, and France. OceanMAPS is used to forecast ocean eddies, with a resolution of between 10 and 50 km. The Bureau of Meteorology has successfully used the system to provide 7-day ocean forecasts every day since it became operational.

OceanMAPS also provides predictions for ocean properties that are used to inform TESS, the Navy's Tactical Environmental Support System, which in turn is used to predict acoustic properties of the ocean.

BRAN (Bluelink ReANalysis) uses OceanMAPS to reproduce the ocean circulation over the past 20+ years. Output from BRAN underpins a broad range of research within CSIRO, at BoM, at universities, and within industry. Industry uses BRAN data for the purposes of strategic planning and approvals (for example, the oil and gas exploration sector).

Source: ACIL Allen, 2016.

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enabling hospitals to improve resource allocation efficiency, reduce waiting times, and increase timely access to emergency care. Total benefits to Australia in terms of improved health outcomes and efficiency could be as high as \$160 million per year (CSIRO, 2017b).

### 4.3 RESILIENT AND VALUABLE ENVIRONMENTS

Resilient and valuable environments refer to CSIRO's work to enhance the resilience, sustainable use, and value of Australia's environments.

#### Improving ocean forecasting for maritime and naval operations

Better understanding and forecasting of ocean conditions and behaviour is essential to all manner of offshore operations. Better information and forecasts allows maritime and naval operations to proceed with greater confidence (ACIL Allen, 2016).

CSIRO, the Royal Australian Navy, and the Bureau of Meteorology funded the Bluelink project to develop a suite of tools that permits modelling of ocean currents and behaviour. The suite of tools developed delivers vastly improved information to users, informs blue-water ship operations, and allows stakeholders in the public and private sectors manage offshore operations more efficiently and effectively.

Benefits to-date have included tracking the oil slick from the Montara oil well accident, reductions to vessel fuel combustion through better understanding of currents, and improvements to beach safety. Thus, impacts from improved ocean forecasting span the spectrum from economic, to environmental and social, to public safety.

### 4.4 SUSTAINABLE ENERGY AND RESOURCES

Sustainable energy and resources refers to CSIRO's work to build regional energy and resource security and competitiveness while lowering emissions.

#### Improving iron ore sintering process performance

Increased worldwide demand for iron ore has led to the depletion of high-grade reserves in Australia. Iron ore is an important and widely used component in steel production, and most ore is prepared for use in blast furnaces by the process of sintering. In order to meet continued global demand for steel, iron ore of lower purity has been increasingly used in the production of sinter.

CSIRO has undertaken both applied and fundamental research to evaluate the current challenges facing Australian iron ore producers, developing strategies to bring new products into the market. Researchers developed strategies for using lower grade ores, while maintaining sinter quality. Production methods were not only more efficient, but also resulted in lower carbon dioxide emissions (CSIRO, 2018b).

#### Using advanced imaging technologies for ore sorting

Mineral deposits vary widely in their concentration of valuable mineral, which means large volumes of a deposit have grade that is well below average. It is often difficult to preferentially mine or even identify low-grade ore during the mining process as such the low grade and valuable ore must be processed together.

Traditional ore sorting technologies require significant feed preparation, have limited throughput capacities (<200t/hr), have high capital requirement and operating costs, and operate at low efficiencies. There are no bulk ore sorting technologies currently on market capable of meeting the needs of mining sites with high throughput facilities (CSIRO, 2018c).

As written above, the world's high-grade mineral ore deposits are depleted and larger, lower-grade deposits are mined to meet global demand. Low-grade deposits contain a larger portion of unwanted materials, resulting in increased processing cost, energy and water usage and increased tailings. There is therefore growing interest in technologies that enable extraction of what were previously uneconomical deposits. Water intensity of mining activities in a context of water scarcity, and the environmental and health implications of comminution dust and mine tailings are existing challenges. There is therefore also an interest in safer, cleaner, and less wasteful extraction and production to ensure community well-being and environmental resilience. Improving sustainable and economic mineral processing requires technological innovation.

CSIRO led the development of an advanced imaging system that leverages magnetic resonance for on-line sensing of mineral grade and sorting of large volumes of material. The system overcomes longstanding impediments to high-tonnage ore sorting, and of rapid on-line quantitative detection of bulk materials in actual mining applications.

The technology is being commercialised via NextOre, a new company owned by CSIRO, RFC Ambrian, and Worley.

## 4.5 FUTURE INDUSTRIES

Future industries refers to CSIRO's work to create Australia's future industries and jobs by collaborating to boost innovation performance and STEM (science, technology, engineering, and mathematics) skills.

### Supporting innovation and commercialisation for small and medium sized businesses with SME Connect

In a 2019 case study, The Centre for International Economics conducted an in-depth review of the Science and Industry Fund's (SIEF) STEM+Business Program. Managed by CSIRO's SME Connect, the program provides (capped) dollar matched funding to encourage small to medium sized enterprises to engage with early career researchers to accelerate innovation and commercialisation of ideas, and to build a network of researchers with commercial experience (CIE, 2019a). Every dollar of SIEF funding is paired \$1.13 in SME funding and \$0.85 in funding by research organisations.

Research funding has been directed to 32 projects spread across various sectors. As of the case study's writing, two projects were trialling their technology and are close to the commercialisation stage.

- Aquarius Technologies delivered a real-time phosphonate monitoring system of corrosion inhibitors for water industries; CIE notes the technology was novel and likely would not have emerged the STEM+Business Program; and
- OptoTech, in partnership with RMIT University, designed a hard disk substrate detection system after being approached by one of the world's largest manufacturers of hard disks. In addition to lowering manufacturing costs of hard disk drives, the project presents an opportunity for OptoTech to be recognised as a provider of solutions to the challenges facing the international semiconductor industry.

The CIE also found that, beyond technology acceleration and innovation benefits, program participants noted that their projects were faster to complete, and academics gained greater awareness of the realities of industry requirements and the significance of identifying practical solutions to industry problems.

### Nurturing start-ups and small businesses with the Kick-Start Program

CSIRO's Kick-Start Program supports start-ups and small businesses in Australia to develop, refine and enhance their innovations by facilitating collaboration between the

## CSIRO's Kick-Start Program

CSIRO's Kick-Start Program provides innovative Australian start-ups and small businesses access to funding support and CSIRO's research expertise and capability to:

- research into a new idea with commercial potential
- development of a novel or improved product or process, and
- test a novel product or material developed by the company.

The Program provides dollar matched funding (up to \$50 000) to undertake research activities with the CSIRO. Research expertise is delivered by CSIRO business units and/or facilities.

While there are a number of funding grants and research opportunities targeted at SMEs, the Kick-Start Program targets high-potential start-ups and SMEs that do not meet the turnover eligibility thresholds for other existing programs.

with an annual turnover and operating expenditure of less than \$1.5 million in the current and each of the two previous financial years, or businesses that have been a registered company for less than three years). Businesses must be registered for GST and have an Australian Company Number (ACN).

Source: CIE, 2019b.

business and CSIRO's research staff, and dollar matching funding to conduct research with CSIRO, using CSIRO's facilities (CIE, 2019b). The Kick-Start Program supports the Australian Government's broader objectives of supporting innovative businesses by providing access to facilities and expertise not available elsewhere.

The CIE noted the following benefits in evaluation of the program:

- **Demonstrating proof-of-concept** — Kick-Start has provided firms with an affordable and meaningful way to conduct a feasibility study, which is a necessary first step before approaching research organisations.
- **Enabling experimental approaches** — CSIRO researchers have encouraged recipients to experiment with different approaches and enabled an iterative research process, unlike alternative (commercial) partners that are more focused on immediate commercial translation and returns.
- **Providing access to CSIRO facilities and staff expertise** — the Kick-Start Program has provided recipients

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with access to CSIRO's research equipment (often otherwise unavailable), and expertise in operating the equipment.

- **Boosting industry–research collaboration** — recipients have valued the industry research collaboration enabled by the Program, which brings them in step with collaborative approaches internationally.
- **Creating positive reputation effects for CSIRO** — the commercial success of businesses participating in a Kick-Start project brings positive exposure and publicity to CSIRO research teams working with the business.
- **Furthering Australian Government's objectives of supporting innovation in Australia.**
- **Providing access to global markets** — working with the CSIRO has provided opportunities for Australian businesses to access international markets with increased legitimacy (with CSIRO "branding" on their product or concept), and providing new connections through networking opportunities.

## 4.6 A SECURE AUSTRALIA AND REGION

A secure Australia and region refers to CSIRO's efforts to meet the challenges of safeguarding Australia from risks such as war, terrorism, pandemics, disasters, and cyberattacks.

### Innovating technologies for disaster and emergency situation planning

Natural and man-made disasters constitute a major threat to the economy, environment, and communities in Australia and globally (CSIRO, 2019b). CSIRO's research aims at improving situational awareness and building decision support for strategic, tactical, and real-time planning and post-recovery efforts. These decisions involve multiple complex infrastructures, multiple agencies, and multiple stakeholders and focus on building environmental and societal resilience.

The CSIRO Data61 Natural Hazards and Infrastructure (D61-NHI) group are driving a nationwide all-hazards planning and adaptation initiative which brings together researchers, emergency services, government, and the community to deliver innovative digital solutions to build a more resilient and sustainable society.

The D61-NHI has developed several relevant technologies, including:

- flexible bushfire modelling tools (e.g., Spark, Amicus),
- an integrated shallow water-based framework (Swift) for the study of floods,
- an intelligent system for integrated evacuation planning,
- a general-purpose geospatial analytics infrastructure (Geostack) for digital tools, and
- Emergency Situation Awareness (ESA) platform, CSIRO's award-winning technology that analyses Twitter streams to deliver awareness information to crisis coordinators and the general public.

### Addressing the threats invasive alien species present to Australia's unique environment

The impacts of invasive alien plants are a top threat to Australian biodiversity and ecosystem services (CSIRO, 2017c). Invasive plants cause significant economic damage on agriculture, as well as extensive environmental and social impacts by degrading natural landscapes, waterways, and coastal areas.

Since the 1930s, CSIRO's research has led to the introduction of 126 different agent species for biological control of 34 weeds in Australia. More recently, CSIRO has led the development and application of risk assessment and sector-specific frameworks to prioritise invasive plant species as targets for biological control, thereby guiding investment by a range of stakeholders.

CSIRO has demonstrated that carefully selected and risk assessed biocontrol agents can reduce invasive plant populations with no adverse effects on native wildlife and plants, livestock and crops, or human health.

## 5. Concluding Remarks

The Science and Industry Act 1949 (SIR Act) created CSIRO to engage in scientific research and innovation to further Australia's national interest. Beyond research performance, the organisation was charged with the uptake of evidence and innovative ideas, mobilising and training talent, and serving national interests by managing and making available research infrastructure and facilities (Figure 5.1). The case studies reviewed in the report evidence CSIRO's delivery on this charge.

A recurring theme was how many of CSIRO's activities deliver on multiple objectives in the SIR Act. For example, High-Pressure Processing to improve food shelf-life touches not only on the value of research, but also the promotion of evidence-based practices, training, and making scientific facilities available. The technology also mitigates food waste, which leads to environmental benefits. STEM+Business and Kick-Start Program case studies describe CSIRO's role in the national innovation ecosystem, helping to support Australia's entrepreneurs. The Clinical Terminology and Patient Pathway Prediction Tool case studies document the broader social value of CSIRO's work, noting specifically how these technologies improve health care delivery and health outcomes for all Australians.

CSIRO is currently delivering a 7.6 to 1 benefit-to-cost ratio. This means that for every \$1 invested, about \$7.60 in economic, social, and environmental value resulted from CSIRO's activities.

We analysed the case studies conducted by CSIRO's independent consultants and evaluators, relying on their reports, data, and analyses to inform our benefit-cost analysis synthesis. These case studies account for the resources entrusted to CSIRO and measure the impact various programs and initiatives deliver to the nation and its partners. Note also that many of the programs featured in CSIRO's case studies for the first time in the past 2 years have their origins in research that began many years before. This underscores the temporal nature of research as an investment for long-term economic gain.

Many advances in knowledge, contributions to Australia's human capital and contributions to conservation and culture are not readily expressed in dollar terms. Thus, we consider the 2020 Value of CSIRO return on investment estimate of 7.6:1 to be a conservative, lower-bound estimate.

Overall, the case studies evidence CSIRO's progress in delivering on its mission to solve the greatest challenges through innovative science and technology.

**For every \$1 invested in CSIRO's research and innovation programs, \$7.60 in benefit accrues to the Australian people.**

**Figure 5.1. DCSIRO's functions, per the Science and Industry Act of 1949**

### **The functions of the Organisation are:**

- a. to carry out scientific research for any of the following purposes:
  - i. assisting Australian industry;
  - ii. furthering the interests of the Australian community;
  - iii. contributing to the achievement of Australian national objectives or the performance of the national and international responsibilities of the Commonwealth;
  - iv. any other purpose determined by the Minister;
- b. to encourage or facilitate the application or utilisation of the results of such research;
- c. to encourage or facilitate the application or utilisation of the results of any other scientific research;
- d. to carry out services, and make available facilities, in relation to science;
- e. to act as a means of liaison between Australia and other countries in matters connected with scientific research;
- f. to train, and to assist in the training of, research workers in the field of science and to co-operate with tertiary-education institutions in relation to education in that field;
- g. to establish and award fellowships and studentships for research, and to make grants in aid of research, for a purposed referred to in paragraph (a);
- h. to recognise associations of persons engaged in industry for the purpose of carrying out industrial scientific research and to co-operate with, and make grants to, such associations;
- i. to collect, interpret and disseminate information relating to scientific and technical matters; and
- j. to publish scientific and technical reports, periodicals, and papers.

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# References

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# Appendix A: Review of Impact Case Studies

**Table A.1. High Level Summary of Included Case Studies**

STUDY NAME	PUBLICATION YEAR	AUTHOR	USED FOR 2020 ESTIMATES	IN 2017 VALUE OF CSIRO REPORT	SECTOR	PRIMARY CSIRO CHALLENGE AREA	PRIMARY ECONOMIC IMPACT	PRIMARY ENVIRONMENTAL IMPACT	PRIMARY SOCIAL IMPACT
Estimating the Impact of the Kick-Start Program	2019	CIE <sup>3</sup>	✓	✗	Services	Future Industries	Management of Risk & Uncertainty	NA	Innovation & Human Capital <sup>4</sup>
Impact Analysis of CSIRO's CAMP – Oventus	2019	CIE	✓	✗	Manufacturing	Health & Wellbeing	New Services, Products, Experiences & Market Niches	NA	Health & Wellbeing
Impact Assessment of STEM+Business: Aquarius	2019	CIE	✓	✗	Services	Future Industries	New Services, Products, Experiences & Market Niches	NA	Innovation & Human Capital
Impact Assessment of STEM+Business: Optotech	2019	CIE	✓	✗	Services	Future Industries	New Services, Products, Experiences & Market Niches	NA	Innovation & Human Capital
Impact Assessment of TerriaJS	2019	CIE	✓	✗	Other	Future Industries	Productivity & Efficiency	NA	Access to Resources, Services & Opportunities
Pawsey Supercomputing & CETO	2019	CIE	✓	✗	Astronomy	Future Industries	Productivity & Efficiency	Energy Generation & Consumption	Access to Resources, Services & Opportunities
Pawsey Supercomputing & Efficient Gas Turbines	2019	CIE	✓	✗	Astronomy	Future Industries	Productivity & Efficiency	Energy Generation & Consumption	Access to Resources, Services & Opportunities
Pawsey Supercomputing & the Murchison Widefield Array	2019	CIE	✓	✗	Astronomy	Future Industries	Productivity & Efficiency	Energy Generation & Consumption	Access to Resources, Services & Opportunities
Impact Assessment of Remote-I Digital Eye Health System	2018	CIE	✓	✗	Health	Health & Wellbeing	Productivity & Efficiency	NA	Health & Wellbeing
Understanding the Value of the Care Assessment Platform/ MoTER Cardiac Rehabilitation Program	2017	CIE	✓	✗	Health	Health & Wellbeing	Productivity & Efficiency	NA	Health & Wellbeing
Understanding the Value of the Total Wellbeing Diet Online	2017	CIE	✓	✗	Health	Health & Wellbeing	Management of Risk & Uncertainty	NA	Quality of Life <sup>5</sup>
Understanding the Value of Vaximiser	2017	CIE	✓	✗	Health	Health & Wellbeing	New Services, Products, Experiences & Market Niches	NA	Quality of Life
Maintaining Access to EU Markets for Australian Canola	2019	CSIRO <sup>6</sup>	✓	✗	Agriculture	Food Security & Quality	Securing & Protecting Existing Markets	Energy Generation & Consumption	Access to Resources, Services & Opportunities
Natural Hazards & Infrastructure Initiative	2019	CSIRO	✓	✗	Environment	A Secure Australia & Region	Management of Risk & Uncertainty	Natural Hazards Mitigation	Health & Wellbeing
Understanding the Value & Real-world Impact of the Trustworthy Systems Group's Research & Technology	2019	CSIRO	✓	✗	Other	A Secure Australia & Region	Productivity & Efficiency	NA	Security <sup>7</sup>
Dry Slag Granulation	2018	CSIRO	✓	✗	Minerals and mining	Sustainable Energy & resources	Productivity & Efficiency	Air Quality	Safety

<sup>3</sup> Center for International Economics.

<sup>4</sup> Full text: 'Innovation & Human Capital (Creativity & Invention)'.  
<sup>5</sup> Full text: 'Quality of Life (Material Security & Livelihoods)'.  
<sup>6</sup> Commonwealth Scientific and Industrial Research Organisation.  
<sup>7</sup> Full text: 'Security (e.g., Cyber, Biological, Civil & Military)'.



# Appendix A: Review of Impact Case Studies continued

**Table A.1. High Level Summary of Included Case Studies**

STUDY NAME	PUBLICATION YEAR	AUTHOR	USED FOR 2020 ESTIMATES	IN 2017 VALUE OF CSIRO REPORT	SECTOR	PRIMARY CSIRO CHALLENGE AREA	PRIMARY ECONOMIC IMPACT	PRIMARY ENVIRONMENTAL IMPACT	PRIMARY SOCIAL IMPACT
Dry Slag Granulation	2018	CSIRO	✓	✗	Minerals and mining	Sustainable Energy & resources	Productivity & Efficiency	Air Quality	Safety
High Pressure Processing	2018	CSIRO	✓	✗	Agriculture	Food Security & Quality	Trade & Competitiveness	Energy Generation & Consumption	Resilience
Improving Iron Ore Sintering Process Performance	2018	CSIRO	✓	✗	Minerals and Mining	Sustainable Energy & resources	Trade & Competitiveness	Climate	Access to Resources, Services & Opportunities
Magnetic Resonance Ore Sorter	2018	CSIRO	✓	✗	Minerals and Mining	Sustainable Energy & resources	Productivity & Efficiency	Energy Generation & Consumption	Quality of Life
Understanding the Value of the Medical Image Communication Exchange (MICE)	2018	CSIRO	✓	✗	Health	Health & Wellbeing	Productivity & Efficiency	NA	Quality of Life
Biomarkers for Detection of Colorectal Cancer	2017	CSIRO	✓	✗	Health	Health & Wellbeing	Productivity & Efficiency	NA	Health & Wellbeing
Biosensors for Health & Food: CYBERTONGUE®/ CYBERNOSE®	2017	CSIRO	✓	✗	Health	Health & Wellbeing	Productivity & Efficiency	NA	Access to Resources, Services & Opportunities
Clinical Terminology Tools	2017	CSIRO	✓	✗	Health	Health & Wellbeing	New Services, Products, Experiences & Market Niches	NA	Health & Wellbeing
Direct Injection Carbon Engine (DICE)	2017	CSIRO	✓	✗	Energy	Sustainable Energy & resources	Productivity & Efficiency	Energy Generation & Consumption	Security
Future Grid Forum & Electricity Network Transformation Roadmap	2017	CSIRO	✓	✗	Energy	Sustainable Energy & resources	Productivity & Efficiency	Air Quality	Resilience
Patient Administration Prediction Tool	2017	CSIRO	✓	✗	Health	Health & Wellbeing	Productivity & Efficiency	NA	Health & Wellbeing
Rabbit Biocontrol	2017	CSIRO	✓	✗	Biosecurity	A Secure Australia & Region	Management of Risk & Uncertainty	Ecosystem Health & Integrity <sup>8</sup>	Resilience
Reservoir Rejuvenation Technology	2017	CSIRO	✓	✗	Energy	Sustainable Energy & resources	Productivity & Efficiency	Aquatic Environments	Resilience
Weed Biocontrol	2017	CSIRO	✓	✗	Biosecurity	A Secure Australia & Region	Productivity & Efficiency	Ecosystem Health & Integrity	Resilience
Social Return on Investment: The Scientists and Mathematicians in Schools Program	2015	CSIRO	✓	✗	NA	NA	NA	NA	NA
Aquaculture Feed (Novacq) & Prawn Breeding	2016	ACIL Allen <sup>9</sup>	✓	✓	Agriculture	Food Security & Quality	Productivity & Efficiency	Aquatic Environments	Access to Resources, Services & Opportunities
Bluelink	2016	ACIL Allen	✓	✓	Environment	Resilient & Valuable Environments	Productivity & Efficiency	Aquatic Environments	Health & Wellbeing
Botanical Resources Australia	2016	ACIL Allen	✓	✓	Agriculture	Sustainable Energy & resources	Productivity & Efficiency	Ecosystem Health & Integrity	Health & Wellbeing
BuildingIQ: Opticool	2016	ACIL Allen	✓	✓	Energy	Sustainable Energy & resources	Productivity & Efficiency	Energy Generation & Consumption	NA
eReefs	2016	ACIL Allen	✓	✓	Environment	Resilient & Valuable Environments	Policies & Programs	Natural Hazards Mitigation	Resilience

<sup>8</sup> Full text: 'Ecosystem Health & Integrity (Natural Capital)'.  
<sup>9</sup> ACIL Allen Consulting.

# Appendix A: Review of Impact Case Studies continued

**Table A.1. High Level Summary of Included Case Studies**

STUDY NAME	PUBLICATION YEAR	AUTHOR	USED FOR 2020 ESTIMATES	IN 2017 VALUE OF CSIRO REPORT	SECTOR	PRIMARY CSIRO CHALLENGE AREA	PRIMARY ECONOMIC IMPACT	PRIMARY ENVIRONMENTAL IMPACT	PRIMARY SOCIAL IMPACT
Medical Developments International: Pentrox	2016	ACIL Allen	✓	✓	Health	Health & Wellbeing	New Services, Products, Experiences & Market Niches	NA	Health & Wellbeing
Science & Industry Endowment Fund: Distal Footprints	2016	ACIL Allen	✓	✓	Minerals and Mining	Sustainable Energy & resources	Productivity & Efficiency	Ecosystem Health & Integrity	Innovation & Human Capital
Science & Industry Endowment Fund: Early nutrition	2016	ACIL Allen	✓	✓	Health	Health & Wellbeing	Productivity & Efficiency	Air Quality	Health & Wellbeing
Science & Industry Endowment Fund: Energy waste	2016	ACIL Allen	✓	✓	Manufacturing	Sustainable Energy & resources	National economic performance	Energy Generation & Consumption	Health & Wellbeing
Science & Industry Endowment Fund: Plant yield	2016	ACIL Allen	✓	✓	Agriculture	Food Security & Quality	Productivity & Efficiency	Land Quality	Resilience
Science & Industry Endowment Fund: RAFT for medical applications	2016	ACIL Allen	✓	✓	Manufacturing	Sustainable Energy & resources	Trade & Competitiveness	NA	Health & Wellbeing
Science & Industry Endowment Fund: Synchrotron	2016	ACIL Allen	✓	✓	Minerals and Mining	Future Industries	Productivity & Efficiency	NA	Health & Wellbeing
Agricultural Flagship: Cotton Varieties	2014	ACIL Allen	✓	✓	Agriculture	Sustainable Energy & resources	Productivity & Efficiency	Land Quality	Quality of Life
Australian Animal Health Laboratory: Foot and Mouth Disease	2014	ACIL Allen	✓	✓	Health	Health & Wellbeing	Trade & Competitiveness	Ecosystem Health & Integrity	Health & Wellbeing
Integrated Water Resource Assessments	2014	ACIL Allen	✓	✓	Biosecurity	A Secure Australia & Region	Productivity & Efficiency	Ecosystem Health & Integrity	Resilience
Longwall Automation Steering Committee: Longwall Automation	2014	ACIL Allen	✓	✓	Energy	Future Industries	New Services, Products, Experiences & Market Niches	Land Quality	Safety
The UltraBattery	2011	ACIL Tasman	✓	✓	NA	NA	NA	NA	NA
Cement Substitutes & Novel Products	2010	ACIL Tasman	✓	✓	NA	NA	NA	NA	NA
Climate Adaptation Flagship: Climate Ready Crops	2010	ACIL Tasman	✓	✓	Environment	Resilient & Valuable Environments	Management of Risk & Uncertainty	Natural Hazards Mitigation	Resilience
Climate Adaptation Flagship: Coastal Communities	2010	ACIL Tasman	✓	✓	Environment	Resilient & Valuable Environments	Management of Risk & Uncertainty	Natural Hazards Mitigation	Resilience
Atlantic Salmon Breeding	2016	CSIRO	✓	✓	Agriculture	Food Security & Quality	Productivity & Efficiency	Aquatic Environments	Resilience
Cereal Rust	2016	CSIRO	✓	✓	Agriculture	Food Security & Quality	Productivity & Efficiency	Aquatic Environments	Resilience
Grapevine Breeding	2016	CSIRO	✓	✓	Agriculture	Food Security & Quality	Productivity & Efficiency	Land Quality	Resilience
Yield Prophet	2016	CSIRO	✓	✓	Agriculture	Food Security & Quality	Productivity & Efficiency	Land Quality	Resilience
Radio-Astronomy: Square Kilometre Array	2010	ACIL Tasman	✗	✓	NA	NA	NA	NA	NA
AuScope	ND	DAE <sup>10</sup>	✗	✓	NA	NA	NA	NA	NA
Clinical Terminology Tools	2017	DAE	✗	✓	Health	Health & Wellbeing	Productivity & Efficiency	NA	Health & Wellbeing

9 ACIL Allen Consulting.

10 Deloitte Access Economics.

## Appendix A: Review of Impact Case Studies continued

**Table A.1. High Level Summary of Included Case Studies**

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BARLEYmax™	2014	DAE	✗	✓	NA	NA	NA	NA	NA
Sustainable Commercial Fisheries	2014	DAE	✗	✓	NA	NA	NA	NA	NA
Impact Analysis of CSIRO's Clayton Advanced Manufacturing Precinct (CAMP)	2019	CIE	✗	✗	Manufacturing	Health & Wellbeing	New Services, Products, Experiences & Market Niches	NA	Health & Wellbeing
IA Quantified Risk Assessment of Complex Systems	2019	CIE	✗	✗	Biosecurity	Future Industries	Management of Risk & Uncertainty	Ecosystem Health & Integrity	Social Cohesion <sup>11</sup>
RapidAIM Smart Traps	2017	CIE	✗	✗	Biosecurity	A Secure Australia & Region	Management of Risk & Uncertainty	Ecosystem Health & Integrity	Resilience
Understanding the value of Impromy	2017	CIE	✗	✗	Health	Health & Wellbeing	Management of Risk & Uncertainty	NA	Health & Wellbeing

<sup>11</sup> Full text: 'Social Cohesion (Social Inclusion, Social Capital & Social Mobility)'

# The Value of CSIRO

## The Broader Impact of CSIRO's Portfolio of Activities

**2020 Update**

**RTI Project Number 0217323**

**February 2021**

### **About RTI**

RTI International is an independent, nonprofit research institute dedicated to improving the human condition. Our partners and clients rely on us to answer questions that demand an objective and multi-disciplinary approach—one that integrates expertise across the social and laboratory sciences, engineering, and international development. We believe in the promise of science, and we are inspired every day to deliver on that promise for the good of people and communities around the world.

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