Developing a research impact performance management system for The Research Council, Oman

Final Report

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Preface

The Secretary General of The Research Council of Oman, His Excellency Dr Hilal Al-Hinai, commissioned RAND Europe to develop a research impact performance management system to help with the continuous assessment of its sponsored research impact and performance improvement. The project has been conducted in several stages. Together with the How-to Guide, the Final Report is the final deliverable.

The aim of this report is to provide an overview of all the stages of the project from inception to the finalised system. The guiding principles that have steered the development of the system are discussed in detail, and a full overview and discussion is provided of all the data collected during the project. This includes the bibliometric data, the desk research, the ImpactFinder survey and the impact case studies. Headline findings of the data are discussed in the report, and detailed overviews are provided in the Appendices 2-4.

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Abstract

This report sets out our approach and findings in developing a research impact performance management system for The Research Council (TRC), Oman. RAND Europe was asked to design and apply a research impact performance management system that demonstrates and communicates the impact of TRC’s programmes in relation to TRC’s mandate, as outlined in Royal Decree 54/2005 (which established TRC), Royal Decree 30/2010 (which gave TRC administrative and financial independence from civil services system) and in the vision set out in the National Research Strategy.

TRC is the main funding body in Oman and plays an important role in implementing the National Research Strategy. The mission of TRC as outlined in its strategy is ‘to create an innovation ecology that is responsive to local needs and international trends, fosters social harmony, and leads to creativity and excellence.’

Designing and applying the research impact performance management system is different from a full implementation in a dashboard-based system. That would require a full data collection and validation process across all indicators specified in the dashboard, as well as development, testing and implementation of an IT system which would integrate data across TRC. The aim of this project is to build the basic architecture of the research impact performance management system in such a way that it is tailored to the context in Oman and that of TRC, and apply and test the logic within that system by applying some of the data collected through the various phases.
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Summary

This report sets out our approach and findings in developing a research impact performance management system for The Research Council (TRC), Oman. RAND Europe was asked to design and apply a research impact performance management system that demonstrates and communicates the impact of TRC’s programmes in relation to TRC’s mandate, as outlined in Royal Decree 54/2005 (which established TRC), Royal Decree 30/2010 (which gave TRC administrative and financial independence from civil services system) and in the vision set out in the National Research Strategy.

In this report we will discuss the two main components of the project. First, the process by which the research impact performance management system has been established will be described, with the dashboard of impact indicators at the centre. Second, the report will discuss the data collection that forms the second component of the project. Three major methods of data collection have been employed: bibliometrics, the ImpactFinder survey and impact case studies. The methodology underlying these methods will be explained briefly in the report and is further discussed in detail both in the Appendices and in the How-to Guide.

Throughout this Final Report two central concepts will be referred to that require a brief description up front. First, by research impact performance management system we refer to the entire list or dashboard of indicators, as well as the various ways of collecting data to populate the indicators. Second, dashboard refers only to the table of indicators that are used to measure research impact.

The Final Report thereby provides the data to set a baseline against which future progress can be measured, while the How-to Guide complements the Final Report by providing guidance on how the Dashboard can be used today and updated in the future as TRC matures.

Guiding Principles

On the basis of the interviews we conducted during the first visit to Oman and The Research Council in December 2013, we drafted a series of guiding principles (Table 1.1). These guiding principles emphasise the ideas, complexities, and context that need to be taken into account not only when building the research impact performance management system now, but also allowing for further development in the future. To this end, the guiding principles act as the parameters within which we have drafted the system. As the guiding principles were derived from the information collected in the interviews, they serve to ensure that the draft system will fit with the Omani context and will meet the expectations of TRC and the relevant stakeholders.
Table 1.1: Guiding Principles

<table>
<thead>
<tr>
<th>Guiding Principle</th>
<th>The research impact performance management system shall:</th>
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<tr>
<td>1</td>
<td>Align TRC’s goals and objectives with stakeholder expectations of impact on the developing research system in Oman. To achieve this, the dashboard should:</td>
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<td></td>
<td>a) be multi-tiered and easily adaptable as the system develops and further matures in the future</td>
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<td></td>
<td>b) cover the diversity of TRC activities.</td>
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<tr>
<td>2</td>
<td>Be sensitive to the stages of research and innovation development (today) and ensure the sustainable development of the research and innovation system (in the future).</td>
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<tr>
<td>3</td>
<td>Be useful and user-friendly to researchers, policymakers and other stakeholders.</td>
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<tr>
<td>4</td>
<td>Be aligned with the values and objectives of the National Research Strategy.</td>
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<td>5</td>
<td>Maintain transparency with a high level of visibility.</td>
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<tr>
<td>6</td>
<td>Be electronically accessible to TRC and relevant stakeholders.</td>
</tr>
<tr>
<td>7</td>
<td>Make use of available data. Aspire to future applications with newly available data.</td>
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<tr>
<td>8</td>
<td>Consolidate, not fragment, the R&amp;D system and serve as a support mechanism for research and innovation.</td>
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</table>

Dashboard and indicators

The dashboards within the research impact performance management system have been developed at two levels. The first level is designed for use by TRC management and contains aggregate data to reflect how different programmes at TRC perform and contribute to achieving TRC’s Strategic Objectives. We will refer to this as the TRC Top-level dashboard. The second level is a breakdown of the dashboard by TRC programmes. These Programme-level dashboards will provide an overview of the specific inputs, processes, outputs and outcomes of the programmes, and the indicators at the programme level will provide the basis for aggregate indicators at the top-level. The Programme-level dashboards are included in Appendix 5.

Data collection and findings

An important part of this entire project has been the collection of data for a number of research impact indicators. The report provides an overview of the data collection methods applied and highlights the headline findings. Three main methods have been used in this project: bibliometrics, an ImpactFinder survey, and case studies. Each of these methods will be discussed along with the headline findings. Where applicable the indicators from the dashboard that directly draw upon the data discussed will also be mentioned.

Appendices

The appendices to this report contain detailed descriptions and overviews of the material on which the larger report is based. This includes a description of the documents and data reviewed, and an overview of the data collected through the bibliometrics, ImpactFinder survey and the impact case studies. Finally, the appendices will provide the programme-level dashboards.
Acknowledgements

The authors would like to thank His Excellency Dr Hilal Al-Hinai, Secretary General of TRC, for commissioning this study, and Dr Saif Al-Hiddabi and Ms Samia Al-Jahwari of TRC for continued project support.

We would also like to thank Dr Susan Guthrie and Alexandra Pollitt (RAND Europe) for their review of the document and constructive comments in their role providing Quality Assurance on this project. Furthermore, we would like to thank Professor Jonathan Grant (King’s Policy Institute, King’s College London) for his continuous support as Special Advisor to the project.
1. Introduction

1.1. Overview of the project

This report sets out our approach and findings in developing a research impact performance management system for The Research Council (TRC), Oman. RAND Europe was asked to design and apply a research impact performance management system that demonstrates and communicates the impact of TRC’s programmes in relation to TRC’s mandate, as outlined in Royal Decree 54/2005 (which established TRC), Royal Decree 30/2010 (which gave TRC administrative and financial independence from the civil services system) and in the vision set out in the National Research Strategy. Throughout this Final Report two central concepts will be referred to that require a brief description up front. First, by research impact performance management system we refer to the entire list or dashboard of indicators, as well as the various ways of collecting data to populate the indicators. Second, dashboard refers only to the table of indicators that are used to measure research impact.

TRC is the main funding body in Oman and plays an important role in implementing the National Research Strategy. The mission of TRC as outlined in its strategy is ‘to create an innovation ecology that is responsive to local needs and international trends, fosters social harmony, and leads to creativity and excellence.’

Designing and applying the research impact performance management system is different from a full implementation in a dashboard-based system. That would require a full data collection and validation process across all indicators specified in the dashboard, as well as development, testing and implementation of an IT system which would integrate data across TRC. The aim of this project is to build the basic architecture of the research impact performance management system in such a way that it is tailored to the context in Oman and that of TRC, and apply and test the logic within that system by analysing some of the data collected through the various phases. However, these data will not comprehensively cover all data required for the final dashboard, as some are either not available, already held by TRC, or will require additional, new data collection processes to be put in place. This report summarises the work conducted in both designing and applying the research impact performance management system, and provides some baseline indications of where and how TRC is already having an impact on the research and innovation ecosystem in Oman.

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1.2. Developing research impact performance management systems as part of performance monitoring

Performance monitoring can be defined as ‘a continuous process of collecting and analysing data to compare how well a project, program, or policy is being implemented against expected results.’² Performance management systems require managers to have access to information that provides a balanced view of organisational performance without overwhelming managers with data or overburdening their organisation with reporting requirements. Effective performance management systems present a small set of performance measures on a regular and structured basis to strategic decision-makers. These indicators should focus attention on the activities of greatest importance to an organisation and its stakeholders, with minimal data collection burden.

Performance management can be conducted across any range of projects or programmes. In this project, we are applying it to the management of R&D efforts. Specifically, we have developed a way to measure the impact of different types of R&D efforts that TRC is involved in. In the context of R&D and impact, performance management entails looking at the different kinds of benefits and wider academic and non-academic impacts.³ Academic impact includes the impact of the creation of new knowledge and of research on the researchers’ fields, as measured by publications, case studies, peer review and other means. Non-academic impact is about the impact of research on society, education, the economy, culture and more.

Though performance management of R&D is not a new concept, there is a growing interest internationally in methodological approaches to measuring research, and in particular its impact.⁴ Given the vast investments in research, estimated at 0.13 per cent of GDP in Oman in 2011 and an average 2.4 per cent of GDP for all OECD countries in 2012, the interest in research evaluation is not surprising.⁵ Moreover, as R&D is increasingly recognised as vital to sustainable economic prosperity in the Middle

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OECD (2014) Main Science and Technology Indicators: GERD for: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.
Available at: http://stats.oecd.org/Index.aspx?QueryId=33210
East, the topic of performance measurement has recently received substantial attention in the region. The increased interest in research performance management is due to what we call the ‘four As’ of advocacy, accountability, analysis and allocation (see Figure 1.1).

The four As can be understood in the following ways when applied to TRC. First, understanding the impact of R&D can inform the allocation of TRC’s R&D funds at an individual, institutional or system level. Second, it can provide a basis for advocacy, using performance indicators to demonstrate and communicate the benefits of TRC’s activities. Third, it can support analysis, helping TRC answer questions and make decisions based on data. And finally, it can improve accountability, by promoting responsible management informed by measurement of TRC’s results. As seen in the figure above, these purposes can overlap and the data collated from a research impact performance management system could be used for different reasons. The final chapter in the How-to Guide provides a discussion as to how the data collected through the dashboard relates to the A’s.

1.3. Developing an impact performance management system for TRC and in the context of Oman

Developing performance management systems to monitor R&D requires a profound understanding of the context into which the system is being introduced. This context includes organisational, national, regional, cultural, socio-economic, and other considerations which could affect the performance of the system, and how. In order to place the system we developed for TRC in the right context, the broader scientific and economic development of Oman needs to be understood and taken into account. TRC does not operate in a vacuum, and to understand the function of a research impact performance management system for TRC, it is important to situate TRC itself within the science, technology and innovation policy context of Oman.

6 Andersson, T., Djeflat, eds., (2013) *The Real Issues of the Middle East and the Arab Spring: Addressing Research, Innovation and Entrepreneurship*. New York: Springer. See, especially chapters 3, 4, 5 and 6, which are directly related.


1.3.1. Oman 2020 and the National Research Strategy

The Oman Vision 2020 was developed in 1995 with the aim of ensuring economic growth and prosperity for Oman in the future. Sustainable economic growth is envisaged to be the result of economic diversification, which implies the development of sectors other than oil and gas, such as finance and other services. In order to sustain an economy more heavily dependent on knowledge, however, the Vision 2020 also recognises the need to invest in science and technology. Furthermore, through investments in research, education and innovation, national capacity can be built to support the future development of the economy.

The National Research Strategy (NRS), which was part of the Royal Decree (No. 54/2005 and No. 30/2010) by which TRC was founded in 2005 and further shaped in 2010, flows from this ambition to diversify the economy. The objectives of the Strategy were twofold. First, to ‘develop an effective, efficient, flexible and transparent organizational framework and administrative structure for TRC, including the staff and resources required to perform the various tasks and facilitate the operations’. And second, to ‘formulate a Science and Technology Policy that consists of clear strategies and a detailed Road Map for successful implementation’. The Strategy presented both an organisation-wide strategy, as well as sector-specific strategies that were organised around six goals: (1) research capacity; (2) research excellence; (3) knowledge transfer local; (4) knowledge transfer international; (5) value capture; and (6) enabling environment. Later on, when the Strategy was finalised, goals 3 and 4, as well as 5 and 6, merged, so that currently TRC works with four goals (or objectives):

- Building research capacity
- Achieving research excellence
- Developing research networks and knowledge transfer
- Creating an environment that encourages and stimulates research.

1.3.2. TRC and its future development

TRC is the major funding body in Oman. As such, it plays an important part in the delivery of the NRS, and started funding research in 2009. Since then, a total of 114 research project grants (by the end of 2013) have funded a wide variety of research projects at various research institutes in Oman.

TRC is a broad organisation with activities that cover both research and innovation. An organisational chart for TRC is provided in Figure 1.2 below. These programmes follow from TRC’s vision that:

Oman will become a regional hub for innovation, and a leader in producing new ideas, products and services…. Oman will have the largest research capacity in the region.

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9 See TRC web site. As of 27 February 2014: http://home.trc.gov.om
The research programmes contain the two main grant initiatives: the Open Grant Research Program and the Strategic Research Program. Open Research Grants are smaller than Strategic Grants and are awarded in six areas of research (Culture and Basic Sciences; Energy and Industry; Environment and Biological Resources; Education and Human Resources; Health and Social Services; Information and Communication Technology), while Strategic Grants cover fewer projects but are financially larger projects, such as the Road Safety Research Program. Other research programmes are the Research Chair Program, the Research Centers Program, the Adapting towards Sustainable Development Program, and the Faculty Mentored Undergraduate Research Award Program.

Innovation has been an integral part of the mission of TRC from its inception through the Royal Decrees. Within TRC the Innovation Department runs a variety of innovation programmes, among which are four programmes that aim to support innovation (in academia, in the community, in education and in industry), and the Innovation Hub, or I-Hub, which organises activities to foster a culture of innovation and entrepreneurship. Finally, TRC leads the construction of the Innovation Park Muscat (the science park).

Research and innovation within TRC are further supported by programmes in the IT department, the International Cooperation department, and the Administration and Finance department. Together, these programmes serve to help TRC achieve its vision. The research impact performance management system will aim to clarify how different programmes contribute to the Strategic Objectives, and will help to ensure that TRC measures progress towards its vision.
1.4. Underlying conceptual approach

There are a number of key challenges in developing any research impact performance management system, as illustrated in Box A.¹³

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¹² Source: TRC website

Box A: Some common challenges in developing research performance management systems

**Attribution or contribution**: much research is incremental, and most research takes place within a community of researchers across institutions working on similar topics. The challenge is determining the extent to which a particular output or outcome can be attributed to a particular piece of research investment.

**Time lags**: it can take a significant amount of time for research impacts to be realised. The challenge is developing a performance management system that can account for the impacts of research over 10–20 years.

**Data quality**: all performance management systems are necessarily limited by the quality and range of available data. Sources can differ in reliability, validity and accuracy, and this inevitably affects the outcomes and reliability of the evaluation process.

**Unit of assessment**: a further challenge is determining an appropriate organisational unit of assessment(s). For example, should the system assess the performance of the innovation ecosystem, TRC, programmes within TRC or individual funded grants?

**Transaction costs of assessing research impact**: all forms of research performance management are costly and the relative benefits should be considered before any impact system is introduced. However, these benefits are often difficult to monetise.

Two of these will be key in developing a system for TRC and are explored in further detail below. The first is the issue of attribution and contribution. The inevitable relationship between TRC and the wider research and innovation ecosystem that operates in Oman means that the question will arise as to whether the performance of TRC or Oman’s innovation system are being measured. At the heart of this is whether the benefits of research need to be ‘attributed’ to TRC. The second issue is the time between research investment and its subsequent benefits (be those academic or non-academic). This comes into sharp focus for TRC, which is a relatively new entity, having been established in 2005 and having distributed its first grant in 2009.

1.4.1. The need for clarity on attribution or contribution

The challenge of any system that assesses research performance is to ensure that there is a clear and shared understanding of the difference between ‘contribution’ and ‘attribution’. By contribution, we mean understanding how the research has contributed to a set of benefits or impacts. This is in contrast to the extent to which the benefits and impacts can be attributed to any single research effort(s). In this way, when considering attribution, we are referring to the proportional effort made by a research funder to the creation of the outputs. Contribution is reflective of the ability to claim the research outputs, regardless of the relative amount of that contribution. For example, if two research funders were to co-fund a single research project which went on to have a significant monetary impact, we might say that both funders contributed to the impact, and that, assuming equal funding, 50 per cent of the monetary gain could be attributed to each funder.

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The distinction between attribution and contribution is an important one to make, and often the two terms are used interchangeably. Moreover, the way contribution and attribution are, or should be, highlighted in research performance management will vary in importance depending on the purpose of the systems. If the purpose is for advocacy or accountability, then judgements about contribution will be more important than attribution. However, if the purpose is analysis or allocation, the attribution of the research output or outcome to the funder needs to be taken into account in order to be objective and robust (and to mitigate against any so-called double counting). In practice, however, these things are hard to achieve. This is because research is often incremental, collaborative and iterative, so isolating the contribution and attribution of a particular piece of research to a given set of outputs, outcomes and impacts is challenging and will inevitably rely on some form of judgement.

For TRC, the issue needs to be carefully considered, particularly when the impacts of its research are being presented to wider audiences and when expectations are being formed about how much it is able to contribute to the development of the wider research and innovation ecosystem. TRC will certainly play a role in contributing to the development of the system, but should not be expected to be the sole contributor. Equally, the growth of the system will not be solely attributable to TRC, though it may help to catalyse many initiatives and growth along the way. Capturing the difference between attribution and contribution will thus be important to TRC’s overall ability to measure and articulate its research impact.

1.4.2. The need to take into account TRC’s ‘start-up’ phase

The time between research investment and wider benefits and impacts on society can be as long as 15–25 years. For example, medical research may take up to 25 years to be implemented in the clinic. Given that TRC started the construction of the R&D ecosystem in 2007, it is important to take into account that ‘start-up’ phase when developing a performance management system. Figure 1.3 below is a notional illustration of the time between research investment and wider socioeconomic impact. The figure illustrates the type of impact and the time it is likely to take for that impact to happen. In the early stages of R&D funding, on the left side of the axis, there will be some direct economic impacts that are associated with investment in broader economic activity. These might be associated with things like new researchers or TRC staff to administer funds being employed. These kinds of effects are referred to as ‘multiplier effects’ by economists. Although the size of these effects is contested, the key message is that R&D funding in and of itself generates economic value. Individuals employed as a result of new TRC funding will spend their income on housing, food and leisure activities which in turn will support the salaries of others.


Moving along the axis in Figure 1.3, some 3–5 years after funding, one would expect to see direct research outputs arising from the research investment, including, for example, research publications and qualifications (e.g. PhDs). These academic impacts are relatively easy to capture and are often an important precursor to achieving wider non-academic impacts. Conceptually, they also provide an inflection point in moving from establishing an innovation ecosystem\textsuperscript{17} to it ‘taking off’. Within 8–12 years of R&D investments, one would anticipate some form of economic spillovers. The term ‘spillover’ is used to describe the idea that some of the economic benefits of research accrue to organisations, regions and countries that did not undertake the initial research. In the context of R&D this would occur, for example, when a company establishes itself near a university to benefit from the local knowledge

\textsuperscript{17} The term ‘innovation ecosystem’ is borrowed from biology and builds on that of an ‘innovation system’ (a term frequently used by innovation economists and policy analysts, see for example Nelson et al. 1993). An ecosystem describes the different components of an environment, and the way these components impact one another to give shape to that environment. When this term is used to refer to innovation ecosystems, it calls our attention to two things. First, the components of an innovation system which can include an array of legal, cultural, social, economic, organisational, political, commercial, scientific, and technological aspects that shape and characterise the system. Second, there are many individual and collective dynamics between these components and each individual component cannot be viewed alone, but must be seen as part of a dynamic whole. See Nelson, R., ed. (1993). \textit{National Innovation Systems: A Comparative Analysis}. New York and Oxford: Oxford University Press.
economy. These benefits might come in the form of informal interactions between academics and the company’s staff, leading to new knowledge for the company, or the proximity of a talent pool of researchers the company can recruit from. However, the proper measurement of economic spillovers in R&D is difficult and requires a comprehensive collection of time series data in order to perform sophisticated econometric analysis.\footnote{18}

The final impacts seen in our figure are the indirect societal ones arising from the research. These could include, for example, improved health outcomes, better educational attainment, and efficient energy production. In health and biomedical research there is a consensus that such impacts take 15–25 years,\footnote{19} although in other sectors this may be lower.\footnote{20}

These time lags need to be taken into account in any assessment of research, but should not be the reason for not trying to assess performance from the beginning of R&D investments. It is important that TRC’s research impact performance management system monitors both academic and non-academic impacts during all stages, from research outputs to wider socioeconomic impact, because: a) there may be ‘early movers’ given that the (assumed) time lags are averages; b) from a management perspective it may be possible to develop ‘early warning’ indicators of potential impact that could then receive some form of special attention; and c) there are potential indirect impacts and spillovers that can occur in the ‘start-up phase’, such as raising international visibility in the global R&D community.

1.4.3. An initial conceptual framework

The TRC research impact performance management system will be designed around a logic model that describes the stages along a ‘pathway’ to impact, as shown in Figure 1.4. The ‘logic model’ is a common evaluation methodology used to assess whether an organisation is taking steps in the near and mid-term to meet its longer-term goals. Logic models aim to consider what inputs and processes are needed now in order to achieve the desired outputs and outcomes, or results, in the future (Figure 1.4 illustrates a generic logic model). A logic model is a way of articulating a causal pathway by which an organisation achieves its aims, and identifies outcomes that can be causally linked back to concrete inputs.

\footnote{18}{The half a dozen or so such studies worldwide suggest that such spillovers could provide a rate of return of around 30 per cent; that is for every $1 invested you would expect a return of $0.3 every year thereafter and, on average, this return occurs 8–12 years after the investment. See Buxton et al. (2008). \textit{Medical Research: What’s It Worth?: Estimating the Economic Benefits from Medical Research in the UK}, London: Wellcome Trust/AMS/MRC.}

\footnote{19}{As reviewed in: Morris et al. (2011). \textit{Op Cit.}}

Figure 1.4: A generic logic model

In TRC’s case, the logic model should be considered as follows. **Inputs** are TRC resources that contribute to the research, such as money invested or number of staff hired to administer the research funds. **Processes** are the activities that are needed to undertake and support the funding of research, such as grant management reporting or monitoring or research activities. **Outputs** are the direct products produced by TRC-funded researchers or direct results of TRC’s activities. These include research publications or new research staff trained. **Outcomes** are the impacts or consequences for society of the research that TRC funded. These kinds of impacts can occur in many different areas, including economic, social, cultural, policy or otherwise. The specific nature of these elements as could be applied to TRC are shown in Figure 1.5 below.

Figure 1.5: A logic model articulating a pathway to impact for TRC

We have used this approach of logic modelling in developing research performance management systems for many organisations, including the English National Institute for Health Research (NIHR)\(^{21}\). In both cases, we developed a framework that had two axes: the horizontal was defined by the logic model; the vertical by an abridged version of organisational objectives, the Balanced Score Card for NIHR.

On the basis of our analysis for this project, we have developed a similar model for the basic structural system for TRC, as shown in Figure 1.6 below. The system and its development are discussed in further detail in Chapter 3. This system allows for a clear understanding of what kinds of inputs, processes, outputs, and outcomes are related to which strategic objectives and what the underlying logic is between

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them. Indeed, there will be overlaps between the objectives and the indicators within the dashboard itself, but the basic architecture should allow TRC to monitor progress towards different objectives in a clear manner.

Figure 1.6: Basic conceptual framework for TRC’s research impact performance management system

1.5. Project methodology

As illustrated in Figure 1.7, the project was conducted across eight interrelated tasks. A detailed description of each task is provided below.

Figure 1.7: Project task description
1.5.1. Task 1: Desk-based document review and data analysis

The aim of this task was to: a) develop our understanding of TRC, its strategy and activities; and b) establish what data and key performance indicators TRC is already collecting about its research and innovation programmes. The desk research involved reading and assessing key documents, and analysing relevant data. We used key documents and data provided to us by TRC, including previous and on-going strategy and evaluation reports of TRC and other relevant material. This task allowed us to develop our knowledge of the Omani research system and the work of TRC, as well as identify specific areas to focus on, explore and investigate in the fieldwork. This helped to ensure the fieldwork was robust and focused.

1.5.2. Task 2: Bibliometric analysis

In parallel to Task 1, we conducted a bibliometric analysis. Bibliometrics is the quantitative analysis of scientific publications and their citation, typically focusing on journal papers in the peer-reviewed literature. It is one of a set of evaluation methodologies – including case study analysis, peer review, economic rate-of-return analysis and surveys – which may be used to help assess research funders and research systems. In addition, bibliometrics allows for the benchmarking of outputs against comparable countries internationally, taking into account the nature and level of development of the research funded through TRC. A range of indicators of research performance can be captured using this approach, such as:

- The number of scientific papers published on an annual basis.
- The number of citations to those papers, controlling for field-specific citation behaviours.
- Patterns of collaboration (domestic, regional and international).
- Relative areas of strengths and weakness (in terms of volume and citations), by subject field including the identification of centres of excellence.

There are limitations to using bibliometrics, which are outlined in Appendix 2. This means that caution is needed when using the results, and the analysis is only intended to inform (not substitute for) wider performance assessment. For this project the bibliometric analysis helped to establish a clear baseline for where TRC is today and where it might look to grow certain areas or continue to invest in others. These results are summarised in Chapter 4.

1.5.3. Task 3: Fieldwork, including key informant interviews and workshops

The purpose of the fieldwork was to contextualise the initial desk research (Task 1) and bibliometrics (Task 2), but also to collect and collate qualitative evidence to inform both the development of the research impact performance management system and the analysis of collated data in Tasks 5 and 6 (ImpactFinder survey and impact case studies). As summarised below in Box B, this task was important, as it allowed us to gain a solid understanding of the Omani innovation ecosystem and the contribution TRC makes to that. Besides, it provided us with technical information to complement the desk-based research.

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of Task 1 and provided an insider’s perspective of Omani research. Interviews with key individuals helped us to map clearly the main issues surrounding TRC and Omani R&D, so that in later stages we have a clear understanding about the primary needs of TRC and Omani research more widely.

**Box B: Nature of data to be collected through fieldwork**

<table>
<thead>
<tr>
<th><strong>Unit of analysis:</strong></th>
<th>we used the fieldwork to make a decision on whether to develop indicators at the programme level, the institutional level or the national level, based on the specific requirements of TRC and its stakeholders.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Administrative burden:</strong></td>
<td>related to issues around the unit of analysis, we ascertained the level of resource available to TRC in gathering data to populate the research impact performance management system. This fed into how we developed the system. Relatedly, we collected evidence on the kinds of data which are already being collected or readily available, and the challenges of data collection.</td>
</tr>
<tr>
<td><strong>Understanding the Omani context:</strong></td>
<td>the fieldwork helped us to ascertain the role of various stakeholders, and to familiarise ourselves with TRC processes. This enabled us to select indicators which are appropriate to assessing the performance of TRC, at all stages of TRC funded research and of the research management process – reflecting the diversity of TRC’s activities. It also allowed us to consider appropriate benchmarks for all data collected.</td>
</tr>
<tr>
<td><strong>Current performance indicators used by TRC:</strong></td>
<td>the fieldwork allowed us to understand how the current performance indicators listed in the National Research Strategy are being used, as well as how sufficient they are in measuring TRC’s activities and impacts. We also sought to understand if and how indicators alternative to those listed in the National Research Strategy are being used, the data they employ and how efficient they are.</td>
</tr>
</tbody>
</table>

We conducted a number of Key Informant Interviews (KII) during the first field visit to Oman from 8 to 12 December 2013. During the week, we spoke with more than 70 people from very diverse institutions and organisations. At TRC the team met with TRC’s management, research programme directors, directors of Innovation programmes, and representatives of other TRC programmes, such as the Virtual Science Library programme. Interviews were also conducted with TRC stakeholders in Oman, including academia, government institutions and industry. Among the governmental bodies visited were the Ministry of Health, the Ministry of Social Development, the Ministry of Agriculture and Fisheries, the Public Authority for Electricity and Water, and the Supreme Council for Planning. In order to speak with representatives from the higher education sector, the team visited Sultan Qaboos University, the University of Nizwa, and met with a representative of the Colleges of Applied Sciences. Finally, the team conducted interviews with representatives from Petroleum Development Oman and Royal Dutch Shell to gather insights from industry.

The interviews from Task 3 generated a substantial amount of qualitative information on a wide range of topics related to TRC and its programmes, and to the research culture and ecosystem in Oman. All interviews followed a ‘semi-structured’ approach to ensure that, on the one hand, we gathered all the relevant information we needed, and on the other hand, left enough room for interviewees to raise and discuss any additional topics they felt were important and relevant to the project. We followed up with some interviewees via email to collect additional information, or simply to obtain the slides they had presented to us in the interviews.
Using an iterative and ‘bottom-up’ (or ‘grounded’) approach to the analysis and synthesis of the data, the team analysed the information to identify common themes and ideas. Information from all the interviews was organised according to these themes to ensure that all relevant data were captured. From the common themes identified we then developed several principles which would guide the drafting of the research impact performance management system.

These guiding principles inform us of the ideas, complexities, and context that will need to be taken into account not only when building the system now, but also allowing for further development in the future. To this end, the guiding principles will act as the parameters within which we have drafted the system. As the guiding principles were derived from the information collected in the interviews, they serve to ensure that the draft system will fit with the Omani context and will meet the expectations of TRC and the relevant stakeholders. By following the guiding principles, we can therefore aim to ‘ground’ truly the research impact performance management system in the right context. The eight guiding principles will be discussed in detail in Chapter 2.

In addition to the interviews conducted in December, we also ran a series of indicator workshops in March 2014. The purpose of the workshops was:

- To share work done to date by RAND on developing a ‘Top-Level’ and programme-specific dashboards for assessing research impact.
- To begin to prioritise the impact-focused indicators within the dashboard based on TRC’s expertise and knowledge.
- To develop knowledge of how to ‘challenge’ indicators for future development.
- To develop further the long-list of indicators for the programme-specific dashboards.
- To build capacity within TRC so that in the future new indicators and dashboards can be developed independently.

Over the course of one week we met with all programmes and departments within TRC and conducted 1-3 hour workshops (depending on the size of the programme). As noted above, the draft dashboard, served as the starting point for further consultation during the workshops with TRC. These workshops were an important step in ensuring the system aligned with the principles and the views of those within TRC who will be using it on a regular basis.

1.5.4. Task 4: Draft research impact performance management system

To formulate a bespoke research impact performance management system for TRC, we used a context-specific approach. The system was developed and populated on the basis of the research conducted in Tasks 1–3 and, as such is tailored towards TRC’s and the wider Omani research environment. The content of the system has been informed by and drawn from the Omani context; informed by local stakeholders, experts and key individuals, and intelligible to those who will work with it.

1.5.5. Task 5: ImpactFinder survey

The application of the research impact performance management system requires us, where possible, to assess the kinds of impacts TRC is currently having. To achieve this, we adopted a multi-method
approach. The bibliometric data collected in Task 2 were the first part of this application. In order to determine some of the impact TRC is already having, we conducted an *ImpactFinder* survey (Task 5) and impact case studies (Task 6).

*ImpactFinder* is an online survey designed to identify the number and nature of research impacts across a range of areas, including: knowledge and skills resources (such as those resulting from collaborations, training of researchers, etc.); technical research infrastructure; national and international visibility; and social, cultural, policy and economic sectors, including new inventions and products. The survey consists of just under 300 individual Yes/No questions that explore a wide variety of benefits and impacts a piece of research may have contributed to. Not all questions are answered by the participant though, as the questions are built in a hierarchical fashion. Secondary and tertiary questions are only revealed if any of the (approximately) 60 primary, ‘top-level’ questions are answered in the affirmative. This structure increases the effectiveness of the tool as it combats one of the key issues with many survey approaches, which is burden on the participants.

The *ImpactFinder* survey tool was originally developed by RAND Europe for the UK Arthritis Research Campaign (now Arthritis Research UK)\(^{23}\) and UK universities.\(^{24}\) It also provides the conceptual underpinning to the UK Medical Research Council E-Val\(^{25}\) system, and subsequent Researchfish.\(^{26}\) In the present study, the survey provided overarching data which fed into the selection of case studies (Task 6).

### 1.5.6. Task 6: Impact case studies

The *ImpactFinder* survey and bibliometric analysis provided macro-level data which will be particularly useful in assessing the impact of Omani research and TRC as a whole. However, in examining the impact of particular programmes or research projects, a micro-level approach is also required, and this was achieved through the development of impact case studies. More specifically, particular research programmes or projects were chosen for further exploration based on the impacts revealed in the *ImpactFinder* survey. Through desk-based research as well as some Key Informant Interviews and TRC input, impact case studies were produced, highlighting the knowledge generated as a result of the research, any further research targeting (indicating previous knowledge is being built upon in a cumulative fashion)

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\(^{24}\) As of 21 October 2013: [http://www.rand.org/rand_europe/research/projects/impactfinder.html](http://www.rand.org/rand_europe/research/projects/impactfinder.html)

\(^{25}\) Medical Research Council (2010). *Outputs, outcomes and impact of MRC Research: Analysis of MRC e-Val Data*. As of 21 October 2013: [http://www.mrc.ac.uk/consumption/groups/public/documents/content/mrc008191.pdf](http://www.mrc.ac.uk/consumption/groups/public/documents/content/mrc008191.pdf)

\(^{26}\) As of 21 October 2013: [https://www.researchfish.com/](https://www.researchfish.com/)
and capacity building, policy or product development as a result of the research, and broader economic and social benefits arising from the research.\(^{27}\)

The case study approach allowed us to develop further the narrative story of the impact case study, in particular understanding what kind of research was conducted and what the pathway was from the research to the eventual impacts. This, in turn, allowed us to understand better what might come next in relation to further impact for the research. Case studies can be a powerful and important tool in understanding and evaluating research impact, because they allow for the nuances and contextual factors affecting research impact. They are useful for both analysis and advocacy, as they allow for an in-depth understanding as to how impacts were achieved through research while simultaneously show-casing the benefits and contributions research can make to society. Given the broad utility of case studies, they should contribute to the final performance management system.

1.5.7. Task 7: Impact conference or workshop

Towards the end of the project, we plan to conduct a series of workshops or a final conference. These will be planned in close collaboration with TRC. The workshops will be conducted internally within TRC to discuss different data collection methods for capturing indicator data in future, while also discussing how to monitor the indicators and introduce new ones as the system changes in future (see discussion on this point in Chapter 2). The ‘impact conference’ will be hosted by TRC with key stakeholders in order to communicate the impact of TRC as captured by the research impact performance management system, and to share insights about research impact assessment more broadly with a wide community.

1.5.8. Task 8: Co-production and learning

Finally, the project has provided the foundation for staff at TRC not only to co-produce the research impact performance management system, but also to learn about how to develop such a system, so that they can oversee, run and, where necessary in future, adapt the system independently once it has been established. The purpose of this is to allow TRC staff to learn from RAND Europe’s experience and expertise in R&D performance management.

1.6. Outline of this report

The main body of this report summarises first the Guiding Principles developed for the research impact performance management system, as these underpin the architecture and the basic framework we recommend TRC should follow when implementing the dashboard in future. We then present the dashboard itself and outline the steps taken to arrive at the dashboard, including how to develop indicators for the dashboard. These steps are important to note now as TRC will need to update the dashboard and indicators in future as the system around them changes. Chapter 4 presents the main

findings from each of the data collection stages: bibliometrics, ImpactFinder survey and the impact case studies. The final chapter provides concluding thoughts and recommendations for TRC as they look to implement this dashboard in the future.

There are also several Annexes to this report which should be referred to throughout. These Annexes provide full details of the data collected throughout the study and cover: a document review of TRC material, the bibliometric analysis, the assessment of impact through the survey and case studies, and an overview of the programme-specific dashboards which feed into the top-level research impact dashboard for TRC.
2. Building the dashboard – Developing Guiding Principles

2.1. The Guiding Principles

On the basis of the interviews we conducted during the first visit to Oman and The Research Council in December 2013, we drafted a series of guiding principles. These guiding principles emphasise the ideas, complexities, and context that will need to be taken into account not only when building the research impact performance management system now, but also allowing for further development in the future. To this end, the guiding principles act as the parameters within which we have drafted the system. As the guiding principles were derived from the information collected in the interviews, they serve to ensure that the draft system will fit with the Omani context and will meet the expectations of TRC and the relevant stakeholders.

Through the analysis of the qualitative information gathered in the interviews, we were able to identify and extract eight guiding principles to steer and inform the drafting of the research impact performance management system. Table 2.1 lists the guiding principles.

Table 2.1: The eight Guiding Principles

<table>
<thead>
<tr>
<th>Guiding Principle</th>
<th>The research impact performance management system shall:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Align TRC’s goals and objectives with stakeholder expectations of impact on the developing research system in Oman. To achieve this, the dashboard should:</td>
</tr>
<tr>
<td></td>
<td>a) be multi-tiered and easily adaptable as the system develops and further matures in the future</td>
</tr>
<tr>
<td></td>
<td>b) cover the diversity of TRC activities.</td>
</tr>
<tr>
<td>2</td>
<td>Be sensitive to the stages of research and innovation development (today) and ensure the sustainable development of the research and innovation system (in the future).</td>
</tr>
<tr>
<td>3</td>
<td>Be useful and user-friendly to researchers, policymakers and other stakeholders.</td>
</tr>
<tr>
<td>4</td>
<td>Be aligned with the values and objectives of the National Research Strategy.</td>
</tr>
<tr>
<td>5</td>
<td>Maintain transparency with a high level of visibility.</td>
</tr>
<tr>
<td>6</td>
<td>Be electronically accessible to TRC and relevant stakeholders.</td>
</tr>
<tr>
<td>7</td>
<td>Make use of available data. Aspire to future applications with newly available data.</td>
</tr>
<tr>
<td>8</td>
<td>Consolidate, not fragment, the R&amp;D system and serve as a support mechanism for research and innovation.</td>
</tr>
</tbody>
</table>
In this chapter the details and data underpinning the principles are discussed in turn. For each principle we describe exactly what it means, what the data were that informed the construction of this principle (in the form of a narrative that summarises data from the interviews), and, where appropriate, how the principle has informed the selection of indicators for the research impact performance management system.

2.1.1. Principle 1: Align TRC’s goals and objectives with stakeholder expectations of TRC’s impact on the developing research system in Oman. To achieve this, the dashboard should: a) be multi-tiered and easily adaptable as the system develops and further matures in the future; and b) cover the diversity of TRC activities

Introduction to the principle

This principle is related to both the form and the content of the dashboard embedded within the research impact performance management system. Form refers to the structure the dashboard will take, that is, what it will look like. Content refers to what will be included in the dashboard (i.e. what the dashboard will aim to measure). From this principle two sub-principles can be formulated: i) create a multi-tiered and easy-to-adapt dashboard; and ii) create a dashboard that covers the diversity of TRC activities and is sensitive to programme and sector differences.

Background analysis on the principle

Create a multi-tiered and easy-to-adapt dashboard

Throughout the interviews, the idea was expressed that the research impact performance management system for TRC should not only capture the actions and impacts of TRC management, but also those of TRC programmes, as these are in place to execute the NRS and achieve TRC’s mission. The first aspect to take into account is therefore that the research impact performance management system should be multi-tiered, consisting of one dashboard developed for TRC management, and other, second-level dashboards developed around the relevant TRC programmes and goals.28 The research impact performance management system would thus span two units of analysis, and this multi-tiered approach draws on three main findings from the interviews:

1. The need for TRC to measure and check that the right processes are in place at management and programme levels to ensure that the activities are sustainable and contribute to the continued development of the research system in Oman.
2. The need to achieve a level of consistency in data collection and reporting that would allow different programmes and lower levels to feed data and information into higher-level dashboards.
3. The need to allow for, and take into account, differences between sectors and programmes. Not all programmes are the same, and different programmes will require different indicators to capture their activities and possible impacts. Through the development of multiple dashboards

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28 This principle, and its implications for the dashboard, is informed by several international studies, such as: El Turabi, A. et al., ‘A novel performance monitoring framework for health research systems; experiences of the National Institute for Health Research’, *Health Research Policy and Systems*, Vol. 9, No. 1, 2011, Article 13.
for the different programmes, the entire research impact performance management system will be flexible enough to be tailored to different contexts, and adaptable to additional programmes that may be developed in the future.

The second aspect relates to the idea that the dashboard should be easy to adapt to different programmes and environments, and should be easy to adopt by other TRC stakeholders. Many stakeholders noted that the TRC research impact performance management system could serve as guidance for the development of their own dashboards. In this way, the TRC research impact performance management system would not only serve the function of measuring its own performance and impact, but it would also facilitate the measurement of performance and impact by others.

Create a dashboard that covers the diversity of TRC activities and is sensitive to programme and sector differences

Context is important in determining what the dashboard should measure. Different programmes will consist of different activities and will produce different outputs and outcomes, and these variations should be taken into account in the dashboard. Nevertheless, despite the fact that the dashboards have been tailored for specific programmes, several statements about what the dashboards should include arose in the interviews, which informed the process of populating the dashboards. A summary of the most frequent statements is provided in the table below.

Table 2.2: Frequent statements on the content of the research impact performance management system

<table>
<thead>
<tr>
<th>Substantive statements on the content of the dashboards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start from TRC’s four Strategic Objectives.</td>
</tr>
<tr>
<td>For each programme, the value it adds to the country should be taken into account.</td>
</tr>
<tr>
<td>Indicators for research and innovation programmes cannot be confined to academic and classic innovation outputs such as publications, patents and spin-offs/start-ups. They should also take other factors, such as administrative burden, public awareness and collaborations into account.</td>
</tr>
<tr>
<td>The content of the dashboards should cover the entire life cycle of projects and programmes from the initial investments and resources up to the final impacts, such as uptake by industry or implementation by government.</td>
</tr>
<tr>
<td>The dashboard should facilitate TRC to build a bridge between research and policy.</td>
</tr>
<tr>
<td>The dashboard should capture TRC’s ability to facilitate research and innovation and to serve as a translator of knowledge.</td>
</tr>
</tbody>
</table>
2.1.2. Principle 2: Be sensitive to the stages of research and innovation development (today) and ensure the sustainable development of the research and innovation system (in the future)

Introduction to the principle

The second principle reflects both the reality of research and innovation in Oman today, as well as development for the future. The research impact performance management system should aim to take both elements into account.

Background analysis on the principle

The first element of this guiding principle states that the system should be sensitive to the stages of development of research and innovation in Oman. This principle follows from repeated observations by various stakeholders that Oman is at an early stage in developing research and innovation capacity, infrastructure and culture. Universities are still largely focused on teaching, whereby faculty are either not accustomed to conducting research, or are constrained in conducting research by various teaching obligations. Furthermore, it was noted that the number of graduate and PhD students is still relatively low, which can make it difficult to staff research projects. Apart from human resource constraints, however, the availability of research infrastructure can also be restricted, given the time delays associated with procurement. Finally, the links with industry are still very limited, and thus the work of universities and innovation programmes does not yet link up with R&D and innovation activities within industry.

It is known from research evidence that (substantial) time lags exist between investments in research and innovation and the subsequent outputs and impacts (see the Inception Report, Section 1.3.2 for further discussion). For example, in medical science the time lag for research to be translated to clinical practice can take up to 25 years. Different stages of development, and the types of impact that can be expected from these different stages, are discussed in Section 1.4.2. In the first few years, outputs will largely be related to direct economic effects (multiplier) and scientific outputs, rather than to long-term impacts on society and the economy.

The second element of the principle is more forward-looking and aims to capture the idea that TRC’s activities should contribute to the sustainable development of the Omani research and innovation system. Central to the long-term sustainability is capacity building, which covers a range of factors across innovation and research, such as graduate students, full-time researchers, research centres, SMEs and start-ups.

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30 Morris et al. (2011). ‘The Answer is 17 years, what is the Question: Understanding time lags in translational research.’ Journal of the Royal Society of Medicine, 104, pp. 510–520.
Operationalising the principle

In order for TRC to contribute to the long-term sustainability of the system, the dashboard should therefore include indicators that not only measure the reality of today, but that also reflect the Strategic Objectives for the future. Although these indicators may initially not show much progress and ‘scores’ might be low, they are important to incorporate in order to keep track of TRC’s progression towards its strategic objectives. One of the most useful ways to capture and structure both the inputs into a system and the planned outcomes and impact is a logic model and, as discussed in Chapter 2, this structure has guided both the Top-level and Programme-level dashboards.

With this in mind, there are three considerations which we took into account in the design of the research impact performance management system:

- **Selecting indicators:** it is important to cover indicators that are relevant today and in the future. Hence, indicators should reflect the current developments of the research and innovation system, but also reflect the future Strategic Objectives towards which TRC is working.

- **Benchmarking:** it is important to set benchmarks realistically, taking into account Oman’s start-up phase, and the differences between research and innovation programmes. In this respect, it might be expedient to set mainly internal benchmarks for Oman over time, rather than benchmarking against international performance.

- **Baseline:** it is important to include a baseline for the reality of today, so that the progress of tomorrow becomes visible.

### 2.1.3. Principle 3: Be useful and user-friendly to researchers, policymakers and other stakeholders

**Introduction to the principle**

To add value to the development of research and innovation in Oman, TRC’s research impact performance management system will have to be useful to researchers, stakeholders (in research and innovation) and policymakers. Usefulness in this respect covers multiple aspects, ranging from administrative burden to knowledge facilitation.

**Background analysis on the principle**

We shall address three main aspects of usefulness which emerged from the interviews. First, it was suggested that TRC could be accommodating to researchers, peer reviewers, and administrators by aiming to simplify administrative processes and reducing administrative burdens. In this way, TRC could

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31 As noted by the FABRIC guidelines, ‘Performance measures should be prioritised on the strategy and objectives of the organisation. Performance measures should aim to measure what the organisation is trying to achieve.’ In: HM Treasury, Cabinet Office, National Audit Office, Audit Commission and Office for National Statistics (2001) Choosing the right FABRIC: A framework for performance information. London: TSO, p. 11

32 It should be recognised, however, that research funders will inevitably impose a certain administrative ‘burden’ in order to ensure and operate competitive peer-review systems.
facilitate researchers in their application to grants for example. Simplified processes would reduce the administrative burden on administrators both within TRC and for stakeholders.

Second, TRC can be useful to a range of different stakeholders by providing an example of a research impact performance management system, and thereby supplying guidelines as to how output and impact might be measured. This aspect links to guiding principle 1 above, and emerges out of the desire by various stakeholders to measure their performance. TRC can be a leader in this sense and provide a model for others to follow.

Third, the usefulness of TRC as a knowledge facilitator was underscored. TRC could keep researchers, universities, industry, and policymakers up to date on research developments in Oman. Specifically, it could provide industry and policymakers with updates on research that may be of direct use to their work. Not only would that improve industrial R&D, innovation and policymaking, but it would also be conducive to the establishment of links between research, innovation, industry and public policy. Important in this respect is also that the indicators chosen fit the needs of the stakeholder, such that they do not spend unnecessary amounts of time and effort on the collection of data which is not essential. 33 We return to this point in guiding principle 7 below.

Operationalising the principle

An implication that follows from this principle for the design of the dashboard is that the dashboard should explicitly adopt indicators to reflect user friendliness and usefulness. A way to incorporate such indicators is to focus on the processes TRC has in place to achieve its outcomes and to capture their effectiveness. Examples in this respect would be the average time that passes between the application for grants and their award and the measure of researcher satisfaction with TRC.

2.1.4. Principle 4: Be aligned with the values and objectives of the National Research Strategy

Introduction to the principle

To make a contribution to the country, TRC has the National Research Strategy (NRS) in place, which in turn specifies four Strategic Objectives:

- Building research capacity
- Achieving research excellence
- Building knowledge transfer and value capture
- Providing an enabling environment for research and innovation. 34

33 Within the FABRIC guidelines it is observed that: ‘At any given level of the organisation there should not be more measures than are necessary to capture the key objectives at that level.’ In: HM Treasury, Cabinet Office, National Audit Office, Audit Commission and Office for National Statistics (2001) Choosing the right FABRIC: A framework for performance information. London: TSO, p. 11. See also: Chaplowe, Scott G. (2008) Monitoring and Evaluation Planning, Washington, DC and Baltimore, MD: American Red Cross and Catholic Relief Services.

To ensure that the dashboard is aligned with the NRS, these Strategic Objectives should guide the development of the dashboard now and in future.

Background analysis on the principle
TRC derives its four Strategic Objectives from the NRS, and these four objectives in turn guide the activities that TRC undertakes in the domains of research and innovation. Some of TRC’s current programmes have been linked in the NRS to specific objectives; the Open Research Grants Program, for example, contributes towards the goal of ‘building research capacity’. For the research impact performance management system to take the values of the country into account as well, it follows the objectives from the NRS.

Operationalising the principle
To account properly for the values and objectives of the NRS, and to include both research and innovation, we have taken a broad perspective on outputs and impacts to cover the many ways in which research and innovation can make a contribution. The indicators measuring outputs and outcomes thus aim to move beyond just the ‘classical indicators’ of research, such as citations and publications, to incorporate the wider impacts that contribute to the achievement of the four goals.

2.1.5. Principle 5: Maintain transparency with a high level of visibility

Introduction to the principle
Transparency, together with efficiency, is one of the core values of TRC. The research impact performance management system should therefore allow and facilitate TRC to maintain transparency with a high level of external visibility.

Background analysis on the principle
Transparency relates to TRC’s ability to show how it has spent its funds and how this has added value to the research system and Omani society (often referred to as accountability). This information should be openly available to the public as well as research stakeholders such as ministries, industries and universities, and the importance of this was stressed in the interviews we undertook. The dashboard could

35 Mentioned by HE Dr Hilal Al-Hinai during the closing meeting of the week of fieldwork on Thursday, 12 December, 2013.
36 In general, performance management and research evaluation can serve several purposes, which can be grouped under four categories: Advocacy, Accountability, Analysis and Allocation. With regard to research evaluation, Guthrie et al. describe these four purposes as follows: advocate: to demonstrate the benefits of supporting research, enhance understanding of research and its processes among policymakers and the public, and make the case for policy and practice change; show accountability: to show that money and other resources have been used efficiently and effectively, and to hold researchers to account; analyse: to understand how and why research is effective and how it can be better supported, feeding into research strategy and decisionmaking by providing a stronger evidence base; allocate: to determine where best to allocate funds in the future, making the best use possible of a limited funding pot’, Guthrie et al. (2013) Measuring Research: A guide to research evaluation frameworks and tools, Cambridge: RAND Europe, p. ix.
facilitate the transparency and accountability of TRC by presenting indicators of its processes alongside the performance of TRC on these indicators. It will show what TRC is doing to achieve its goals, and how it is progressing towards these goals. By sharing the dashboard, TRC could show it is accountable as well as aid other stakeholders in thinking about their own performance management (as noted in the first guiding principle).

Visibility also relates to the public profile of TRC, and how the wider environment perceives it. The interviews revealed that there is often limited interest in research in Oman, and there is little awareness of TRC and its innovation and research activities. In order to create a research and innovation ecology in Oman, an awareness of the importance of research is vital. The dashboard therefore aims to reflect the ambition to achieve a high level of visibility of research in Oman, and an awareness of TRC, initially among its main stakeholders, and in the long term among the public more broadly.

Operationalising the principle

For the dashboard to be transparent we have paid particular attention to process indicators, as these indicators reflect the activities undertaken by TRC to achieve its outputs and outcomes. Process indicators cover a large part of the administrative activities of TRC and can increase visibility by showing exactly what TRC is doing with the funding it receives. In turn, the wider dashboard, which also includes inputs, outputs and outcomes, is conducive to transparency as it makes all of TRC’s activities visible from start to finish.

Furthermore, having clear definitions for all the indicators contributes to the transparency of the dashboard. When indicators are unambiguous they can be interpreted more easily by both TRC and (external) stakeholders, which in turn makes them easier to use by all involved.

Visibility can be captured through indicators that are reflective of the presence of TRC in the media, for example, and the awareness of TRC among policymakers, researchers, the general public and other stakeholders. Indeed, making the dashboard publicly available also helps to increase the visibility of TRC’s activities, outputs and outcomes.

2.1.6. Principle 6: Be electronically accessible to TRC and relevant stakeholders

This is a technical guideline which illustrates the IT dimension of the research impact performance management system. The ambition of TRC is to have an electronic dashboard which allows easy and quick updates on the indicators included in it.

Another dimension of the IT availability of the dashboard is that it, or some of its parts, are electronically accessible to external stakeholders. This would facilitate the transparency and visibility of the dashboard and also allow external stakeholders an insight into how a research impact performance management system is designed.
2.1.7. Principle 7: Make use of available data. Aspire to future applications with newly available data

Introduction to the principle
Data collection is an integral part of performance management, and any system should aim to make use of available data, and simultaneously anticipate applications for data that may become available in the future. As such, the system aims to make the best possible use of available data.

Background analysis on the principle
Underlying the research impact performance management system are indicators for which data need to be collected. A risk with new dashboards is that they can introduce indicators for which data are not collected, thereby increasing the administrative burden for the organisation in collecting these data. Hence, an important guiding principle is to make use of data that are currently available to TRC and to anticipate future applications of the dashboard on the basis of data that will become available. This principle is in line with international recommendations regarding monitoring and evaluation data collection, which state that generally there should be a high level of consistency in the data collected: the same data should be collected throughout the running of a project.

Utilising current data collection practices, however, does not imply that these practices do not require amendments. It emerged from various interviews, particularly with industry, that data collection can be hampered by different understandings about the definition of research and innovation. A means to allow for more data to become available on a shorter term might therefore be to settle on common definitions among stakeholders. The use of the dashboard could facilitate this by stating how certain research and innovation activities might be defined and measured.

Finally, the area of innovation does require the development of new indicators. Whereas indicators for research activities and outputs are better established, indicators for innovation are more complicated because of the more complex and multi-faceted nature of innovation itself. Indeed, there is no consensus in the international literature on how innovation should be measured.

Operationalising the principle
In the selection of indicators, one of the main criteria for inclusion will be data availability, both today and in the future. The dashboard aims to make as much use as possible of available data, or data which

39 The Phase II report contains a discussion of this issue and how it relates to the construction of the Dashboard.
will be available in the future. Care has been taken in introducing indicators for which no data are currently collected.

In the case of Oman, indicators on innovation have been selected which enable Oman to compare itself to other jurisdictions, but also to measure its own unique progress based on its policy initiatives and natural development of its economy.

2.1.8. Principle 8: Consolidate, rather than fragment, the R&D system and serve as a support mechanism for research and innovation

Introduction to the principle
TRC aims to stimulate and support the entire R&D system in Oman, which includes both research and innovation. A risk in policy development and performance management often exists in the creation of silos whereby research and innovation are separated. The aim of the dashboard is to overcome such silos and to consolidate the wider ecosystem. This can be achieved by showing the links between research and innovation, and by highlighting how both contribute to fulfilling TRC’s goals.

Background analysis on the principle
TRC aims to achieve its objectives through a range of research and innovation programmes. As was noted in the 2012 Annual Report, ‘our mission, vision and objectives recognise the contribution of research to society, the key role of innovation and the benefits that flow from that research and innovation.’ This diversity of TRC’s activities implies that a holistic research impact performance management system is required to capture and consolidate, rather than fragment, the activities of TRC, and, by extension, the R&D system as a whole. As TRC is not the only body in Oman to fund research and innovation activities, it is also important to understand the areas TRC does and does not have influence over. The dashboard should therefore strike a balance between being holistic and recognising the inevitable limitations to the influence that TRC is able to exert.

Nevertheless, through a research impact performance management system that takes both research and innovation into account, TRC can play a guiding role in showing how the R&D and innovation ecology is holistic, rather than fragmented. In several interviews, for example with industry, it emerged that the lines that traditionally ‘divide’ research and innovation may not actually be clear. It is often difficult to establish where research ends and innovation begins, given the interconnected nature of the two. Several interviewees therefore suggested that the dashboard should aim to integrate, and not divide, research and innovation, so that the interconnections between the two are clarified, without, however, missing the unique contributions that research and innovation make individually.

This implies that the various outcomes and impacts that different research and innovation activities produce should be recognised and taken into account in order to reflect the entirety of TRC’s activities. Especially important in this respect are the outputs generated by innovation and R&D activities (for example, a new industrial application) which cannot be captured by the conventional research output

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40 TRC Annual Report 2012
indicators (such as papers and patents). As TRC-funded activities could also contribute to such outputs, these have been captured in the dashboard. This issue links in to the exploration of new indicators mentioned in the previous section.

Operationalising the principle

The first implication for the design of the dashboard is that it should aim to move beyond conventional indicators of research and innovation, to capture the wider contributions made by both.

Another way to ensure that the research and innovation activities are not separated is by integrating them into one dashboard that is structured by Strategic Objectives rather than by programmes or by research versus innovation activities. Both research and innovation can in this way be seen to contribute to all the Strategic Objectives, as indicators dependent on research and innovation activities might both be incorporated under the same Strategic Objective.
In this chapter we outline the steps involved in the construction of the final research impact performance management system. The dashboards within the research impact performance management system have been developed at two levels. The first level is designed for use by TRC management and contains aggregate data to reflect how different programmes at TRC perform and contribute to achieving TRC’s Strategic Objectives. We will refer to this as the TRC Top-level dashboard. The second level is a breakdown of the dashboard by TRC programmes. These Programme-level dashboards will provide an overview of the specific inputs, processes, outputs and outcomes of the programmes, and the indicators at the programme level will provide the basis for aggregate indicators at the top level. The Programme-level dashboards are included in Appendix 5.

This chapter is structured in such a way that the building blocks that underlie the research impact performance management system as a whole are clearly visible. Thus, apart from presenting the dashboard, this chapter also aims to illustrate the steps that have been taken to construct them.

3.1. Step 1 – The logic model

As described above, ‘the “logic model” is a common evaluation methodology used to assess whether an organisation is taking steps in the near and mid-term to meet its longer-term goals.’ Logic models therefore aim to identify what inputs and processes are needed now in order to achieve the desired outputs and outcomes, or results, in the future (Figure 3.1 illustrates a generic logic model).

Figure 3.1: A logic model, articulating a pathway to impact

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In the case of TRC, the logic model could be populated as follows:

- **Outcomes** are the impacts or consequences for society of TRC-funded research and innovation. These kinds of impacts can occur in many different areas, including economic, social, cultural, policy or otherwise.
- **Outputs** are the direct products produced by TRC’s various research and innovation programmes that aim to achieve the outcomes.
- **Processes** are the activities undertaken to produce the outputs, and concern the funding of research and innovation, such as grant management or monitoring of research activities.
- **Inputs**, finally, are TRC resources that contribute to research and innovation, such as money invested or number of staff hired to administer the research funds.

### 3.2. Step 2 – Incorporating the Strategic Objectives

The second step in the construction of the research impact performance management system is to start to populate the logic model. The Top-level dashboard is organised according to the four Strategic Objectives of the NRS which are central to TRC’s mission and vision. The four Strategic Objectives are:

- **Building research capacity**
- **Achieving research excellence**
- **Building knowledge transfer and value capture**
- **Providing an enabling environment for research and innovation.**

These four Strategic Objectives, together with the logic model, form the basic architecture of the TRC Top-level dashboard (see Figure 3.2). Combined, the Strategic Objectives and the Inputs, Processes, Outputs and Outcomes of the logic model cover both the objectives which TRC tries to achieve, and specify the actions that need to be taken to achieve these objectives.

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42 TRC, Strategic Objectives. As of 27 February 2014:
3.2.1. Specification of the Strategic Objectives

The Strategic Objectives reflect the diversity and breadth of TRC’s vision and thereby capture a wide range of activities. In order for the dashboard to reflect precisely what the inputs, processes, outputs and outcomes are for each Strategic Objective, it is necessary to highlight up front what activities are captured by each Strategic Objective. In turn, these descriptions will clarify why indicators have been assigned to particular positions.

Below, we specify for each Strategic Objective what the activities are that are captured and measured by the indicators for that objective. These descriptions are based on the National Research Strategy, the document and data review, and the interviews conducted during the fieldwork.

Building research capacity

The first objective, ‘building research capacity’, reflects the activities undertaken by TRC that aim to strengthen Oman’s capacity to conduct research. Research capacity in the dashboard will largely relate to the building of human capital. Infrastructure will be covered under the fourth Strategic Objective. The indicators for this objective should therefore reflect all of the activities undertaken by TRC that contribute to the building of human capital (such as delivering PhDs). Other aspects of conducting research, such as generating publications, are not covered by this objective, but will be captured by the second objective, ‘achieving research excellence’.
Achieving research excellence

Complementing the first objective, the second objective, ‘achieving research excellence’, captures the actual research activities conducted by researchers in Oman, and aims to measure their quality and development. This objective is therefore wholly about the activity of conducting research which results in, for example, publications and conference presentations. Any further activities related to wider impacts on, or spillovers from research into, policymaking or innovation will be captured by the following two Strategic Objectives.

Building knowledge transfer and value capture

This objective is focused on facilitating knowledge exchange both between academia and industry and various sectors within industry, in order to find the most effective solutions to Oman’s problems. The innovation programmes are particularly important to this objective, given their focus on networks and collaboration with industry, although their effects will also be realised and measured elsewhere. This objective will also aim to capture the wider benefits of collaborations and knowledge spillovers, including economic, policy and health impacts.

Providing an enabling environment for research and innovation

This objective aims to capture how far the funding, research infrastructure, policy environment, research and innovation culture, and TRC priorities enable research and innovation in Oman. It looks beyond the capacity of researchers to the wider environment, which is measured in a number of ways, including the amount of funding available for research and innovation, quality and amount of equipment, researcher satisfaction, and awareness of and interest in research in the general population.

3.3. Step 3 – Incorporating the National Research Strategy

The NRS already lists a range of performance indicators for each of the Strategic Objectives. As was observed in the Inception Report, however, several of these performance indicators are specified at a national level, and TRC is not the only player who can influence their development. Therefore, even though TRC contributes to the development of these indicators (such as ‘number of researchers per million inhabitants’), it cannot solely be held accountable for them. Nonetheless, these national performance indicators reflect national goals and outline what is important for the research system as a whole to attain. In order not to lose sight of these long-term goals, the Top-level dashboard incorporates the performance indicators from the NRS in a separate column on the far right called ‘NRS Outcome’. It is placed here to indicate that, while these are important goals to work towards, TRC is not the only player that aims to achieve them. The NRS Outcome column could in fact be used by various organisations and institutions in Oman that, together with TRC, aim to achieve these goals (see Figure 3.3).

The inclusion of these NRS indicators draws direct attention to the complexities of contribution and attribution in the funding of research and innovation. The issue was also explored in the Inception Report, but it is helpful to revisit it. It is well known that much research is incremental, and takes place within a community of researchers across institutions working on similar topics. As was noted in the Inception Report:
The challenge of any system that assesses research performance is to ensure that there is a clear and shared understanding of the difference between ‘contribution’ and ‘attribution’. By contribution we mean understanding how the research has contributed to a set of benefits or impacts. This is opposed to the extent to which the benefits and impacts can be attributed to any single research effort(s). In this way, when considering attribution, we are referring to the proportional effort made by a research funder to the creation of the outputs. Contribution is reflective of the ability to claim the research outputs, regardless of the relative amount of that contribution.43

In the construction of the dashboard, we therefore separate the outcomes over which TRC has substantial influence (TRC Outcomes) from the outcomes over which TRC has much less influence (NRS Outcomes). Attribution and contribution, in turn, can be established with much more certainty in the case of the former than in the case of the latter. The inclusion of the NRS outcomes, nevertheless, ensures that the overall goals for Oman are linked to those over which TRC has more direct control.

Figure 3.3: Different players contributing to the NRS targets

3.4. Step 4 – Populating the Top-level dashboard

Following the guiding principles, Figure 3.4 and Table 3.1 present the TRC Top-level dashboard for use by TRC Management. The indicators that populate the Top-level of the dashboard in Table 3.1 are generally of two types. The first are indicators that aggregate ‘lower-level’ data collected at a programme level and present TRC management with the overall value. Examples are indicators for research funding and numbers of publications. The second are indicators that are unique to the Top-level and contain data that can only be gathered at this level. Examples are indicators that reflect TRC as a whole such as public awareness and specific bibliometric indicators such as citations. Generally speaking, any performance-

monitoring dashboard should not contain too many indicators, as this then lowers the ability of managers to keep oversight of their programmes effectively. The indicators in the Top-level dashboard were selected, reviewed and finalised in several stages which we will discuss in turn.

Figure 3.4: Draft of the TRC Top-level dashboard

3.4.1. Stage 1: A long-list of indicators was drafted before the workshops

As summarised in the Phase II report, the long-list contained 45 indicators divided over the 16 cells of the dashboard. These 45 indicators served as input to the workshops conducted in March 2014. The long-list was drafted on the basis of RAND’s knowledge of research impact indicators as well as on the interviews conducted in December 2013.

3.4.2. Stage 2: Running the workshops – Mapping by TRC staff

Ten workshops were conducted in March 2014 with over 50 TRC staff from the Research and Innovation departments, as well as with several other TRC departments such as International Relations and Media. The aim of the workshops was to distinguish indicators of central importance from indicators

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of marginal importance, and to provide TRC with the opportunity to suggest new indicators. In order to rank the indicators, TRC staff were asked in each workshop to map the indicators on a matrix with two axes (Figure 3.5).

**Figure 3.5: Indicator matrix**

![Indicator matrix diagram]

The first axis ran from marginal to central importance, and allowed participants to distinguish the indicators they deemed central to the measurement of TRC’s goals from those deemed marginal. The second axis allowed participants to indicate if the data required for the indicators were easy to collect or difficult to collect. As a result of this mapping, each indicator therefore was assigned to one out of four quadrants on the map by TRC staff, the quadrants being:

- **EC**: Easy to collect and Central importance
- **DC**: Difficult to collect and Central importance
- **EM**: Easy to collect and Marginal importance
- **DM**: Difficult to collect and Marginal importance

As discussed in the Phase II report, indicators in the first two quadrants are of most interest, as they are of central importance. During the workshops, 32 suggestions were also made for new indicators, thus extending the long-list of indicators to 77. The detailed mapping results and new indicators generated by the TRC staff in the workshops have been listed in the Appendix to the Phase II Report.

3.4.3. **Stage 3: Team scoring of all 77 indicators**

The next step in the process was to reduce the long-list of 77 indicators to a shortlist of indicators that will constitute the final dashboard. In order to create the shortlist, the project team conducted an internal round of scoring to select indicators that cover the breadth of the Strategic Objectives and all stages of the logic model. The team based their scores on several considerations:
3.4.4. Stage 4: Shortlist

On the basis of both the mapping scores from the TRC workshops and the team scores, a new shortlist of indicators was then created by excluding indicators that did not meet the minimum requirements. The steps for exclusion from the original long-list of 45 indicators were:

1. The indicator was not deemed to be of central importance by TRC staff
2. An average score equal to or higher than 2.0
3. None or only one score of 1.0 (i.e. deemed of central importance by only one person or no one)
4. It duplicated another indicator.

The long-list of the 45 original indicators, their scores and their inclusion or exclusion have been listed in the Appendix to the Phase II Report.

The steps for exclusion from the list of 32 new indicators generated during the TRC workshops were:

1. An average score equal to or higher than 2.0.
2. None or only one score of 1.0 (i.e. deemed of central importance by only one person or no one).
3. It duplicated an original indicator.
4. It was irrelevant to the Top-level dashboard given to the eight Guiding Principles (see Phase II report).

The list of 32 new indicators, their scores and their inclusion or exclusion have been listed in the Appendix to the Phase II Report.

3.4.5. Stage 5: Phased introduction of the final dashboard

Through the exclusion of eight indicators from the initial long-list, and the inclusion of seven newly suggested indicators from the TRC workshops, the final dashboard contains 44 indicators. If indicators have been rephrased during the workshops, the new phrasing is used. Several indicators have also moved
Developing a research impact performance management system

Strategic Objective or within the sections of the logic model based on input received from TRC staff during the workshops.

Given the time it takes for certain impacts to materialise and become visible (as discussed in Section 1.4.2), it is not useful for the TRC to aim, at this stage, to collect data for all indicators. For some indicators data may not yet be available, while for others it may be too early to collect relevant data. However, this does not mean that these indicators should be forgotten or not included in the dashboard. We therefore suggest that certain indicators need to be phased in in the future. These indicators are predominantly outcome indicators, and have been highlighted in grey in the final dashboard below (see Table 3.1). In practice, this means that today, data will only need to be collected for 35 indicators, which ensures that the dashboard is manageable.

In parallel to the adoption of new indicators, TRC can retire certain other indicators in the future. As TRC matures, some indicators will not be as relevant in the future as they are today, and can be phased out. To determine the (continued) relevance of indicators, TRC itself can run workshops similar to the ones discussed here and conducted in March 2014. By continuously assessing and evaluating the importance of indicators, TRC can therefore keep the Dashboard manageable in the future.

3.4.6. Stage 6: Quality assurance

Finally, to ensure that the process of selection was conducted in accordance with RAND quality standards, the entire process has been reviewed by Dr Susan Guthrie.
Table 3.1: Final Top-level dashboard

<table>
<thead>
<tr>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>NRS outcome</th>
</tr>
</thead>
</table>
| **Building research capacity** | Number of TRC-supported research and innovation activities (aggregate of Innovation programs) | Number of students enrolled in undergraduate or graduate research programmes supported by TRC or number of students funded by TRC enrolled in undergraduate or graduate research programmes (or % change) (numbers by training stage) | Number of TRC-funded MSc/PhD students completing their course (or % change) | Number of PhD Programmes  
Number of researchers per million inhabitants  
Number of graduate students as a % of total student body | Number of TRC-supported undergraduates going on to enrol in a graduate/PhD research programme (or % change)  
Number of Omani-educated researchers becoming Principal Investigators (or Co-PIs) on TRC projects (or % change)  
Number of TRC-funded graduate/PhD students who continue to work in research (or % change)  
Number of Omani-educated researchers becoming Principal Investigators (or Co-PIs) on TRC projects (or % change) | Number of graduate students in S&T as a % of total graduate student body |
| Achieving research excellence | Total number of applications to TRC (across all programmes) (or % change) | Proportion of applications for research grants that were funded (or % change)  
Number (or %) of applications deemed of high quality by peer review (or % change) (qualitative and quantitative component) | Number of TRC-supported publications (or % change)  
Number of national/international research collaborations (or % change)  
Cited papers (or % change) (including highly cited papers)  
Number of nationally/internationally collaborated publications  
Field-weighted citation impact of TRC-supported publications  
Number of awards  
Critical mass achievement in specific fields (e.g. bibliometric indicator Relative Intensity Index (RII)) | Number of researchers in strategic areas  
Number of strategic research centres  
Number of publications in scientific journals per million inhabitants  
Number of citations per paper  
Number of patents per million inhabitants  
% of R&D spending on strategic grants |  


<table>
<thead>
<tr>
<th>Building knowledge transfer and value capture</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>NRS outcome</th>
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</thead>
<tbody>
<tr>
<td>Number of national and international companies at Innovation Park</td>
<td>Number of research grants awarded to public and private bodies (non-universities) (or % change)</td>
<td>Number of TRC grants collaborating with/or funded by industry and other research stakeholders (or % change)</td>
<td>Number of research-based interventions to address practical problems faced in Omani society achieved through TRC-funded research</td>
<td>Number of collaborative research projects between public &amp; private sector</td>
<td></td>
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<tr>
<td>Number of TRC staff dedicated to networking activities (aggregate of programmes)</td>
<td>Elapsed time for delivery of equipment/consumables/infrastructure</td>
<td>Number of companies working with TRC-funded R&amp;D (or % change)</td>
<td>Number of TRC-funded grants that have had a social impact, a policy impact, an economic impact. Measurement options: - Annual ImpactFinder survey</td>
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</tr>
<tr>
<td>Number of venture capital initiatives supported</td>
<td>Number of TRC-funded staff or researchers participating in knowledge transfer activities such as workshops or awareness-raising activities (or % change) (aggregate of programmes)</td>
<td>Strength of ties (or increased linkages) with industry/policy and other stakeholders (national/ international). (E.g. a network map of TRC-established connections / collaborations with industry/policy/ other stakeholders, updated yearly)</td>
<td>Number of collaborative research projects internationally</td>
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</tr>
<tr>
<td>Amount of seed funding provided for incubation activities</td>
<td></td>
<td></td>
<td>Number of spin-offs/SMEs created as a result of TRC-funded projects/activities (or % change)</td>
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<td>Number of patents resulting from TRC-funded research and innovation activities</td>
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<td>Efficiency tech-transfer: aggregate indicator of the timeliness of, for example obtaining patents, and generating spin-offs</td>
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<td>Number of collaborative research projects internationally</td>
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<td>Number of high-technology/ knowledge-based enterprises formed per year</td>
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<td>Number of collaborative research projects internationally</td>
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### Providing an enabling environment for research and innovation

<table>
<thead>
<tr>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>NRS outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total amount of TRC funding available. Possible breakdowns: (1) Percentage of research funding spent on technical infrastructure (2) Funding available for dissemination activities (aggregate of programmes) No. of FTE researchers supported by TRC (or % change)</td>
<td>% of total cost of TRC funding spent on research and innovation administration Change (%) in researcher satisfaction with the grant application process (collected through survey) Average time from application to award of research or innovation grant Average time from grant award to the availability of funds to the recipient (university or other institution)</td>
<td>Participation/attendance numbers at TRC-organised activities/events: - Open days - Science Cafes - Seminars/Lectures - School visits - Website visits - Downloads Share (%) of total amount of TRC funding available actually disbursed (two ways of counting: actually spent and funding committed)</td>
<td>Improved public awareness of TRC-funded research and innovation (e.g. media mentions, re-tweets) Satisfaction with TRC as a whole (collected through survey) - questions could concern: - efficiency - effectiveness - administrative burden - usefulness of TRC funding to fill research needs (constraints of funding) Levels of additional research funding from external sources provided to TRC</td>
<td>% GDP spent on R&amp;D % total R&amp;D spending by private sector % total R&amp;D spending on S&amp;T Number of international researchers in Oman as a % of total researchers Ease of doing research (surveys)</td>
</tr>
</tbody>
</table>
4. Data collection and headline findings

An important part of this project has been the collection of data for a number of research impact indicators. This chapter provides an overview of the data collection methods applied and highlights the headline findings. Three main methods have been used in this project: bibliometrics, an ImpactFinder survey, and case studies. Each of these methods will be discussed along with the headline findings. Where applicable, we will also mention the indicators from the dashboard that directly draw upon the data discussed. The data presented here establish a baseline against which future developments and progress can be measured.

4.1. Bibliometric analysis

4.1.1. Introduction to bibliometrics

Bibliometrics employs quantitative analysis to measure patterns of scientific publication and citation, typically focusing on journal papers. It is one of a set of evaluation methodologies – including case study analysis, peer review, economic rate-of-return analyses, and surveys and consultations (among others) – that may be used to help assess the academic impact of research. Bibliometric approaches offer important advantages over other research evaluation methods. They can be used to generate useful quantitative indicators of productivity, academic impact, mobility and collaboration. As the sophistication of analytical tools for bibliometrics improves, they are being used to develop more general indicators of ‘quality’ and even ‘excellence’. These analyses are supported by a range of indicators of varying complexity which have been developed over recent years. Robust bibliometric analysis requires a clear understanding of the strengths and limitations of each of these measures, and sensitivity to the contexts in which they are used.

Primarily, bibliometrics is based on the assumption that new research papers will cite other research papers that are perceived as useful for informing new research. In this regard, a citation is viewed as a measure of the ‘utility’ and ‘visibility’ of a piece of research. Furthermore, if a researcher or a piece of research has more utility as shown via a larger number of citations, it is assumed that the research is of

46 Ismail S., Nason E., Marjanovic S., Grant J. (2009) Bibliometrics as a tool for supporting prospective R&D decision-making in the health sciences: Strengths, weaknesses and options for future development, Santa Monica, Calif.: RAND
higher quality. Therefore, a citation is perceived as a proxy for research quality and a measure for research achievement and excellence.

We undertook a preliminary bibliometric analysis of Oman’s research output with three aims:

- To provide the project team with an overview of research activity in Oman (as proxied by research publications).
- To test the feasibility of including some bibliometric indicators in the research impact performance management system (mainly as an ‘output’ indicator in measuring ‘research excellence’; but bibliometrics can also capture other information such as scientific mobility).
- To provide TRC with comparable and temporal benchmark data.

There are however, several limitations to bibliometrics. The first limitation refers to the analysis and interpretation of citations. While citations can be interpreted as a reflection of quality, they cannot, without the proper context, be taken as a direct measure of quality. A second and more general limitation of bibliometric analysis relates to different publication practices in academic fields. Bibliometrics is based on published articles and only covers a marginal amount of books and book chapters, which may be important research outputs in some fields (such as the social sciences and humanities). Such publications may therefore be overlooked by a bibliometric analysis. In the interpretation of bibliometric results it is therefore important to be aware of the possible bias. Finally, bibliometric databases need time to be updated and therefore generally bibliometric analyses do not include the most recent papers.

4.1.2. Headline bibliometric findings

The Centre for Science and Technology Studies (CWTS) was contracted by RAND Europe to provide the bibliometric analysis for this project. CWTS maintains a bibliometric database of all scientific publications for the period 1980 to the present based on the Thomson Reuters Web of Science database. As the bibliometric analysis was conducted in 2013, the last year for which full citation data were available is 2012, which means that, in terms of identifying publications, we look up to 2011 to allow for at least one year of citations to accrue.

The first thing the bibliometric analysis reveals is the total research output in Oman for each year from 1980 to 2011 (Figure 4.1). The research output includes articles, letters and reviews published in indexed scientific journals, which, in the case of Oman, has been rising steadily since the early-1990s to just under 500 publications in 2011. Of the publications indexed in Web of Science and produced in Oman over

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47 For a detailed discussion of the strengths and weaknesses of bibliometrics as a research evaluation method, see Ismail S., Nason E., Marjanovic S., Grant J. (2009) Bibliometrics as a tool for supporting prospective R&D decision-making in the health sciences: Strengths, weaknesses and options for future development, Santa Monica, Calif.: RAND.

48 In the database, letters are given a weight of 0.25; thus, four letters are the equivalent of an article or review.
Developing a research impact performance management system

This period, 16 acknowledged The Research Council as a funder. Other publications that acknowledge The Research Council can be found using, for example, Google Scholar, but these may not appear in Web of Science if they have not been published in indexed journals. Furthermore, TRC may have funded papers which have not been acknowledged. It is therefore important for TRC to ensure that funding is acknowledged on papers produced through TRC funded research.

Linked indicator: Number of TRC-supported publications (or % change)
On the basis of acknowledgments in publications, it can be established which articles, letters or reviews published in Oman were supported by TRC. These publications would form a subsection of the total research output of Oman.

Figure 4.1: Number of publications in Oman per year, 1980-2011

The second important finding from the bibliometric analysis relates to the number of citations to articles, letters and reviews. The number of citations which publications receive differs considerably by discipline, however, and in order to make sensible comparisons between disciplines and countries, it is important to

49 Other publications that acknowledge The Research Council can be found using, for example, Google Scholar, but these may not appear in Web of Science if they have not been published in indexed journals.
‘normalise’ the number of citations (see Appendix 2 for full explanation). Through the process of normalisation of citations, a score of 1 for a publication or for a set of publications implies that the publication or set of publications has received a number of citations that is equal to the world average for publications of the same age in that discipline. A score above 1 indicates a higher number of citations than the world average, and a score below 1 the opposite. In this way, publications within very different disciplines, such as anthropology and medicine, become comparable, as in each a score of 1 implies that the article received a number of citations equal to the world average for papers of the same age in that discipline.

Using two normalised citation scores, the Mean Normalised Citation Score (MNCS) and the Mean Normalised Journal Score (MNJS), the citations to Oman’s publications can be compared over time and across countries (see the Appendix 2 for further explanation). The analysis shows that for the MNCS the number of citations to publications from Oman is comparable to the regional average, being higher than Saudi Arabia, but slightly lower than Qatar. Having a score below 1, however, means that all countries receive fewer citations than the world average. The MNJS, which indicates the visibility of the journals that Omani researchers are publishing in, shows that Omani research is generally published in journals which tend to receive fewer publications than the world average. As the MNJS is higher than the MNCS, it could indicate that in the future the MNCS might increase.

### Linked indicator: Cited papers (or % change)

Receiving citations in publications is an important indicator of their utility. Through a bibliometric analysis TRC can track the number of Omani publications which have received citations. Furthermore, on the basis of the indicator mentioned above (Number of TRC-supported publications (or % change)), it can track the number of TRC-supported publications which have received citations.

### Linked Indicator: Field-weighted citation impact of TRC-supported publications (including highly cited papers)

This indicator complements the former indicator and specifies not just the number of publications that have been cited, but also indicates how many citations publications, or a set of publications, have received in comparison to their field. Field-weighted citations are obtained through the normalisation of the actual (or raw) number of citations (see the Appendix 2 for a full explanation). In the bibliometric analysis for TRC, two measures of field-weighted citation impact that are calculated by CWTS were included: the Mean Normalised Citation Score (MNCS) which measures the citations received by publications and the Mean Normalised Journal Score (MNJS) which measures the visibility of the journals published in. These measures provide a substantial input for this indicator. Furthermore, in the future the MNCS and MNJS can also be calculated for the subset of TRC-supported publications.

As the research system matures in Oman, it is likely that the visibility of publications will further improve and receive increasingly more citations. At that point, it could be useful to track how many of the cited publications qualify as ‘highly cited papers’. Highly cited papers are papers that receive substantially more citations than other publications in that field, and can therefore be considered to be particularly important publications. While cut-off values differ, highly cited papers are usually understood to constitute the publications that belong to the top 10 per cent of all publications in the same field and year.
Apart from country comparisons, the normalisation of citations also allows for the comparison between different research fields to understand, for example, in which fields publications receive numbers of citations above the world average. The fields are based on the Thomson Reuters Journal Subject Classification system which contains 249 fields. Only fields for which the MNCS is greater than 1.0 (i.e. those in which papers originating in Oman are cited more often than the world average for the field) and for which there are at least 20 publications are included. The results of this analysis are shown in Table 4.1, and reveal that based on the publications, Oman’s research strength can be found in several natural sciences: polymer science; geology; atomic, molecular and chemical physics; mechanical engineering; and industrial engineering.

**Linked indicator: Critical mass achievement in specific fields (e.g. bibliometric indicator Relative Intensity Index (RII))**

For strategic purposes it can be of interest to gain an understanding of the fields in which Omani research has established a substantial body of research, i.e. critical mass. Although there is no fixed definition of the number of publications that defines when a critical mass has been achieved, we can suggest 20 papers in a particular field to start with. As the research system matures, this number can nevertheless be increased to keep up with the development of research. Knowing which fields perform well can provide policymakers with evidence on the basis of which future strategic decisions, for example on the allocation of funding, can be made.
Combined with a field-weighted measure of citations, the analysis of fields that have achieved a critical mass can allow for the further identification of ‘top performing fields’ in Oman (see Table 4.1). These fields have not only reached a critical mass (i.e. a minimum of 20 publications), but also have an MNCS (i.e. citation impact) above the world average (>1). The identification of top performing fields can provide TRC with information and data on the basis of which to build the research strategy for Oman.

Finally, as the number of publications in Oman will increase in the future, TRC can consider the inclusion of a more technical bibliometric measure of critical mass and specialisation in the bibliometric analysis. A candidate for such a measure is the Relative Intensity Index (RII), which has been used in the study of mental health research and which ‘indicates the relative proportion of publications of a given country by mental health research area or document type relative to the proportion of the world in the same domain or document type. An RII value above 1 means that an observed group of researchers publishes more in the domain than would be expected, while an index value below 1 indicates the opposite.’\textsuperscript{50} As this index can also be applied to other fields, it can allow for the identification of fields in which Oman is particularly specialised.

### Table 4.1: Top performing fields in Oman

<table>
<thead>
<tr>
<th>Research field</th>
<th>Number of publications</th>
<th>MNCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLYMER SCIENCE</td>
<td>25</td>
<td>1.83</td>
</tr>
<tr>
<td>GEOLOGY</td>
<td>46</td>
<td>1.68</td>
</tr>
<tr>
<td>PHYSICS, ATOMIC, MOLECULAR &amp; CHEMICAL</td>
<td>29</td>
<td>1.46</td>
</tr>
<tr>
<td>ENGINEERING, MECHANICAL</td>
<td>73</td>
<td>1.45</td>
</tr>
<tr>
<td>ENGINEERING, INDUSTRIAL</td>
<td>34</td>
<td>1.41</td>
</tr>
<tr>
<td>GENETICS &amp; HEREDITY</td>
<td>73</td>
<td>1.32</td>
</tr>
<tr>
<td>AUTOMATION &amp; CONTROL SYSTEMS</td>
<td>35</td>
<td>1.30</td>
</tr>
<tr>
<td>GEOSCIENCES, MULTIDISCIPLINARY</td>
<td>193</td>
<td>1.24</td>
</tr>
<tr>
<td>ENGINEERING, PETROLEUM</td>
<td>119</td>
<td>1.22</td>
</tr>
<tr>
<td>OCEANOGRAPHY</td>
<td>41</td>
<td>1.22</td>
</tr>
<tr>
<td>TOXICOLOGY</td>
<td>31</td>
<td>1.17</td>
</tr>
<tr>
<td>OPERATIONS RESEARCH &amp; MANAGEMENT SCIENCE</td>
<td>45</td>
<td>1.16</td>
</tr>
<tr>
<td>PALEONTOLOGY</td>
<td>32</td>
<td>1.10</td>
</tr>
<tr>
<td>FOOD SCIENCE &amp; TECHNOLOGY</td>
<td>150</td>
<td>1.09</td>
</tr>
<tr>
<td>INSTRUMENTS &amp; INSTRUMENTATION</td>
<td>37</td>
<td>1.09</td>
</tr>
<tr>
<td>CHEMISTRY, APPLIED</td>
<td>56</td>
<td>1.07</td>
</tr>
<tr>
<td>COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE</td>
<td>32</td>
<td>1.05</td>
</tr>
<tr>
<td>BIOTECHNOLOGY &amp; APPLIED MICROBIOLOGY</td>
<td>45</td>
<td>1.05</td>
</tr>
<tr>
<td>NUTRITION &amp; DIETETICS</td>
<td>23</td>
<td>1.03</td>
</tr>
<tr>
<td>AGRICULTURE, DAIRY &amp; ANIMAL SCIENCE</td>
<td>55</td>
<td>1.02</td>
</tr>
<tr>
<td>VETERINARY SCIENCES</td>
<td>55</td>
<td>1.02</td>
</tr>
</tbody>
</table>

Developing a research impact performance management system

Through an examination of the authors listed in research publications and their affiliations, the bibliometric analysis can also reveal differences between papers produced with and without collaborations. It is known that nowadays research is increasingly conducted in teams and that collaborations on research publications, especially international collaborations, are associated with higher levels of citations. The bibliometric analysis shows that this is also the case for publications from Oman. Publications produced through national collaborations (for example, between researchers of Sultan Qaboos University and the University of Nizwa) on average have a slightly higher citation score (MNCS) than publications produced without a collaboration. Publications produced through international collaborations, however, have the highest citation score on average, which is in line with broader research findings on publications and citations (Figure 4.3).

Linked indicator: Number of nationally/internationally collaborated publications

On the basis of the author affiliations listed in publications it can be established if the publication was the result of a collaboration and if so, what the collaboration consisted of in terms of institutions and countries involved. The number of publications with a collaboration can show the frequency with which researchers in Oman build collaborations to conduct research, and if these collaborations involve international partners. Figure 4.4 below provides an overview of collaboration for the publications from 1980 to 2011.

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Finally, the analysis of authors and their affiliations also provides an insight into the networks of research collaboration that exist within Oman, and between Oman and other countries. Together with the number of publications per institution, a first network map can be constructed which provides an overview of the publishing culture in Oman (Figure 4.5). The first network map shows that the Sultan Qaboos University (SQU) is the largest producer of research output in Oman (indicated by the size of the circle) and is also the main institution for collaborations, as most links run from SQU to other institutions. Given that a large share of Oman’s publications comes from SQU, and given its central position in terms of collaborations, it appears that at the moment the research publishing culture in Oman is mainly structured around SQU.
A similar network map can be constructed for the collaborations that Oman has with other countries as listed in the publications included in the bibliometric analysis (Figure 4.6). In the map, the proximity of countries to Oman indicates the frequency of collaborations. Researchers from countries in close proximity to Oman collaborate more often with Omani-based researchers than those in countries further away. Perhaps not surprisingly, the countries with the closest proximity are countries which have well-established research infrastructures, such as the US, France, Germany and Japan.
4.2. ImpactFinder survey analysis

4.2.1. Introduction to the survey tool

ImpactFinder is an online survey designed to identify the number and nature of research impacts across a range of areas, including: knowledge resources (such as those resulting from collaborations, training of researchers, etc.); technical research infrastructure; national and international visibility; social, cultural and policy sectors; and the economy, including new inventions and products. It consists of just under 300 individual Yes/No questions that explore a wide variety of benefits and impacts to which a piece of research may have contributed. Not all questions need to be answered by the participant though, as the questions are built in a hierarchical fashion. Secondary and tertiary questions are only revealed if any of the (approximately) 50 primary, ‘top-level’ questions are answered in the affirmative. This structure increases the effectiveness of the tool as it combats one of the key issues with many survey approaches, which is the burden on the participants. ImpactFinder is a tool which was originally developed by RAND Europe for the UK Arthritis Research Campaign (now Arthritis Research UK)\(^{52}\) and UK universities.\(^{53}\) It also provides the conceptual underpinning to the UK Medical Research Council Researchfish system.\(^{54,55}\)

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53 As of 28 February 2014: http://www.rand.org/randeurope/research/projects/impactfinder.html

54 Medical Research Council (2010) Outputs, outcomes and impact of MRC Research: Analysis of MRC e-Val Data. As of 28 February 2014:
The survey provided overarching data which fed into the selection of case studies (Task 6) as well as the performance management system more broadly.

For this study, we contacted all current and past TRC-funded researchers and asked them to complete the survey. This included researchers from the following TRC programmes:

- Open Research Grant Program: the principal investigators for completed and ongoing grants
- Strategic Research Grant Program: the principal investigators for completed and ongoing grants
- Research Chair Program: the past and present chair-holders of the programme
- Innovation programmes in industry, education and academia
- Adapting towards Sustainable Development Research Program: the principal investigators for completed and ongoing grants.

The response rates for each discipline are presented in the table below.

<table>
<thead>
<tr>
<th>Table 4.2: Number and percentage of responses to the survey</th>
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<tr>
<td></td>
</tr>
<tr>
<td>Number of responses</td>
</tr>
<tr>
<td>Percentage across all respondents</td>
</tr>
<tr>
<td>Response rate relative to size of field (TRC funding portfolio)</td>
</tr>
</tbody>
</table>

4.2.2. Headline ImpactFinder survey findings

The ImpactFinder survey asked a wide range of questions about the impact emanating from TRC-funded research to date – from impacts on research capacity building to the production of products and processes and the generation of IP. This section presents the headline findings for each area of the survey. The full survey results are presented in Appendix 3, which provides a detailed break-down of the impacts TRC has

http://www.mrc.ac.uk/consumption/groups/public/documents/content/mrc008191.pdf

55 As of 28 February 2014:

https://www.researchfish.com/
had in each area by field. Please refer to Appendix 3 for more detailed information (including numerical break-downs) of the impacts presented here.

When interpreting the findings from the survey there are a few limitations to be aware of. Firstly, all of the survey data are self-reported. Therefore all findings are based on the answers PIs gave about the impact of their research and have not been validated. In exploring these impacts further through the case studies, it became apparent that some of the reported impacts were anticipated to happen in the future and have not happened to date. Therefore, we cannot be certain that all of the reported impacts in the survey have taken place. Moreover, there was only one survey respondent from the humanities discipline, and therefore the results for the humanities should be interpreted with caution and should not be compared to the other disciplines in the survey.

Each section presents an impact array. This is a visual representation of reported impacts across the fields. The dark red shading indicates that a ‘yes’ response was given for one of the questions (or that an option was selected from a multiple choice list, indicating an impact); the light pink shading indicates that a ‘no’ response was given; the grey shading indicates that a ‘don’t know’ response was given – i.e. respondents did not know whether a particular impact had occurred or not; and no shading means that the question was not answered. This may have been because they were questions which required an initial ‘yes’ response to appear in the survey, or because they were options in a multiple choice list that were not selected. It should also be noted that each impact array presents the research projects according to the start date of their grant. The oldest projects are at the top of each discipline section, working down towards the newest. Therefore we might expect to see more impacts at the top of each discipline section in each of the impact arrays.
Creating human capital in research and a research culture

Figure 4.7: Impact array for each field in the area of building human research capacity

It is clear from the large amounts of dark red shading on the impact array that Oman is building in-country research capacity. It is primarily achieving this through a high number of Omani nationals participating in the research, the training of Omani residents and, to a lesser extent, the inclusion of junior researchers in research. The survey also found that there is a significant number of additional research staff moving to Oman to support a research project in engineering and natural sciences, which may be indicative of growing awareness of TRC and the research system in Oman internationally, as well as the quality and credibility of research undertaken in Oman.

A high proportion of respondents also reported that their TRC-funded research made a significant contribution to the career advancement of the research team. There was a relatively even rate of responses across all fields – ranging from 90% to 100% of respondents reporting this impact.

The survey also found that Omani research is largely collaborative. Engineering and natural sciences had the largest total number of collaborations (with 52 collaborations inside Oman and 58 collaborations outside Oman), followed by social sciences (39 collaborations inside Oman and 27 collaborations outside Oman) and agricultural and medical sciences (19 collaborations inside Oman and 25 collaborations outside Oman). Humanities did not report any collaborations (although again, these data are only representative of one respondent). However, it should be noted that a minority of respondents reported a
large number of collaborations. In all fields reporting collaborations, those with universities were the most common (accounting for 62.9 per cent in agricultural and medical sciences, 58.1 per cent in engineering and natural sciences and 60 per cent in social sciences). This finding is in line with the bibliometric analysis which found that over half of the publication output of TRC-funded research is a result of collaborative activity (see Figure 4.4).

When asked if there were benefits for their organisation as a result of collaboration, 66.7 per cent of respondents in the agricultural and medical sciences reported there were, followed by 61.3 per cent of respondents in engineering and natural sciences and 50 per cent of respondents in social sciences. Fewer respondents reported benefits for the collaborating organisation across the fields comparatively. Again this finding is broadly in line with the bibliometric analysis which found that the Mean Normalised Citation Score was higher for collaborative research (see Figure 4.3) – suggesting that collaborations make researchers and institutions more visible.

Creating a research infrastructure

Figure 4.8: Impact array for each field in the area of technical capacity building
Developing a research impact performance management system

The impact array shows that relatively few impacts were reported in this area. It should be noted that the alternate shading in the array between agricultural and medical sciences and engineering and natural sciences on the one hand and social sciences and humanities on the other hand reflects that different sets of questions were asked to these two groups.

However, despite a large number of impacts in this area, a large proportion of respondents across all fields reported that they have produced a database or collection of research material from their TRC-funded research, although reported usage of these resources was low. Interestingly, fewer respondents reported the development of a new technology or methodology than a new database, although reportage of use was much higher. Across all of the disciplines, respondents reported that universities use these resources the most.

We also asked respondents if they had produced a database or technique not previously accessible in Oman as a result of their TRC-funded research. Respondents from the agricultural and medical sciences field reported the production of such material the most (61.9 per cent) followed by respondents from engineering and natural sciences (48.4 per cent) and the social sciences (40 per cent). Universities were reported as the main user of this material across all fields, followed by public sector research organisations for engineering and natural sciences (23 per cent) and public sector agencies for all other fields (excluding humanities).

A high proportion of respondents reported that their research led to new laboratory equipment or infrastructure being introduced into Oman in both the agricultural and medical sciences (85.7 per cent) and the engineering and natural sciences (83.9 per cent). However, a far higher proportion of respondents from the engineering and natural sciences field had had a laboratory built from scratch (67.7 per cent) compared with respondents from the agricultural and medical sciences (33.3 per cent). Given that both of these fields require large specialised equipment in order to conduct research, it is perhaps unsurprising they have had an impact on research infrastructure. Indeed, the percentage of respondents who reported the production of highly specialised equipment or material was significantly higher than those who reported the production of basic equipment or material.

Respondents also reported fairly high usage rates of both the new laboratories and the new equipment (for example 42.9 per cent of agricultural and medical sciences respondents and 48.4 per cent of engineering and natural sciences respondents reported that the new equipment emanating from their research is used by universities). In terms of the laboratory use, other TRC-funded research groups were the primary users in both fields.
National and international visibility

**Figure 4.9: Impact array for each field in the area of international visibility and dissemination**

The impact array shows that a large percentage of respondents reported the use of a variety of dissemination techniques for their research. Overall, 57.5 per cent of respondents indicated that they had made their TRC-funded research accessible to the public outside of the academic community. The spread of this response was relatively similar across fields. A range of outputs were identified in all fields. Articles published in open-source journals were the most popular research outlets, with other popular outlets including articles in a general circulation population and online research resources. Further analysis of this in the future might explore where researchers are publishing and how this is contributing to sharing TRC-funded research. In particular, it would be worth assessing the extent of the use of social media, open-access, online-based journals and other outlets available to researchers – possibly through novel scientometric tools such as altmetrics.\(^{56}\)

A significant proportion of engineering and natural sciences and social sciences respondents also reported presenting their findings of TRC-funded research to the public – 64.5 per cent and 65 per cent

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respectively, and 38.1 per cent of agricultural and medical sciences respondents also reported communicating their research to the public. The primary ways in which research had been presented to the public were through online publications and press releases.

Creating knowledge-based societies

**Figure 4.10: Impact array for each field in the area of creating a knowledge-based society**

<table>
<thead>
<tr>
<th>Field</th>
<th>Benefits for education and learning</th>
<th>Benefits for business &amp; professional practices</th>
<th>Benefits for public policy and public services</th>
<th>Cultural benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural and Medical</td>
<td>.................................</td>
<td>...............................................</td>
<td>...............................................</td>
<td></td>
</tr>
<tr>
<td>Engineering and Natural</td>
<td>.................................</td>
<td>...............................................</td>
<td>...............................................</td>
<td></td>
</tr>
<tr>
<td>Social Sciences</td>
<td>.................................</td>
<td>...............................................</td>
<td>...............................................</td>
<td></td>
</tr>
<tr>
<td>Humanities</td>
<td>.................................</td>
<td>...............................................</td>
<td>...............................................</td>
<td></td>
</tr>
</tbody>
</table>

The impact array shows that compared to other types of impacts, there are relatively few impacts in this area across the disciplines. However, the social sciences field has reported a number of impacts in relation to benefits for business and professional practices and benefits for public policy. Engineering and natural sciences and the social sciences also have a number of impacts in relation to benefits for education and learning.

**Benefits for education and learning**

A number of researchers from all fields excluding the humanities have contributed to teaching activities at school, university and professional practice levels. Respondents in the social sciences discipline were active influencers of teaching activities at school and professional practice levels, with 40 per cent of respondents in that discipline reporting impacts on teaching in these areas. The primary ways in which social science respondents reported they had influenced teaching activities at the school level were presentations to students in Oman and contributions to school curriculum content. The primary ways in which social science respondents reported influencing teaching activities at a professional practice level were through contributing to ongoing professional development course content, contributing to online research tools/resources and providing mentoring or consultancy to practitioners. 30 per cent of social sciences respondents also reported an influence on teaching activities in further or higher education.

In addition, 32.3 per cent of engineering and natural sciences respondents reported an impact on influencing teaching activities in further or higher education. The primary ways in which respondents had achieved this were through involving undergraduates in the research and informing a live presentation for
students. Respondents in this discipline also reported impacts on school students (12.9 per cent) and practitioners (19.4 per cent).

Relatively few respondents reported influencing teaching activities in the agricultural and medical sciences, although 14.3 per cent did note an impact on the training of professional practitioners and 9.5 per cent reported an impact on teaching activities in further or higher education.

**Benefits for business or professional practice**

Very few respondents have reported influence in this area, although 45 per cent of respondents in the social sciences discipline reported an influence on organisations’ regulations, policies and procedures. Respondents reported they achieved this in a diverse number of ways, including through the use of their research in training or helping improve the skills of practitioners (20 per cent), improving the accessibility and use of business services by clientele (15 per cent), improving the effectiveness of business practice in meeting its objectives or serving its clientele (15 per cent) and improving the environmental or conservation of natural resources by helping to change business activities or procedures (15 per cent).

An impact on professional practice through improving the social welfare of employees or clients in an organisation was also reported by 14.3 per cent of agricultural and medical sciences respondents, 12.9 per cent of engineering and natural sciences respondents and 20 per cent of social sciences respondents. Across all disciplines, the primary way in which this was achieved was through introducing more culturally appropriate procedures or practices (10.9 per cent) followed by changes to policies and practices for corporate social responsibility or ethical standards (6.8 per cent).

**Benefits for public policy and public services**

Respondents from the social sciences discipline reported the highest number of impacts in the area of public policy and public services. This is likely to be due to the fact that informing the policy process is often the intended end-point of research activities in this discipline. The humanities respondent did not report any impacts on policy from their research, although again these data are only representative of one respondent.

Some 50 per cent of social sciences respondents reported identifying policy issues, while 45 per cent reported both communicating their research to policymakers and informing the policymaking process through their research. Respondents reported it was primarily government institutions and other organisations in Oman who had used or considered their research. The primary way in which research had impacted on the policymaking process in the social sciences was through influencing the writing of policy guidelines (15%).

Interestingly, for the engineering and natural sciences discipline, fewer respondents had identified policy issues than had communicated their research to policymakers. It may be that communication to policymakers had not taken place with a particular policy change or recommendation in mind. Respondents in this discipline reported that the primary means of reporting the findings of their research to policymakers was written research papers or oral briefings for His Majesty Sultan Qaboos (9.7 per cent).
Finally, the agricultural and medical sciences had a particularly low number of respondents who had communicated their research to policymakers (9.5 per cent) compared with the number that identified policy issues (23.8 per cent) and those who had informed policymaking (19 per cent). When asked whether their contributions led to any changes in the policy process, one respondent noted that their research improved the knowledge base for policy development, although no other answers were given. This is likely to be related to the fact that a change in the policy process represents a long-term impact and therefore there may have not been enough time for this impact to come into fruition. It may be beneficial to monitor projects which have the potential to impact on the policy process in the future, in order that this impact is captured over time.

Given that most TRC-funded research is relatively recent, it is not surprising that there have not been large impacts in the policymaking process, as there is usually a time delay in this process.
Creating knowledge-based economies and generating IP and patents

**Figure 4.11: Impact array for each field in the area of building a knowledge-based economy**

The impact array shows many respondents indicated impacts in relation to generating additional revenue and economic activity, although very few respondents reported that they had created a new business or that their research resulted in an existing business or company moving to Oman. A number of social sciences respondents and the humanities respondent also reported they had contributed to the development of sustainable, ethical or other alternative economic activities. Some 76.7 per cent of respondents reported that their TRC-funded research has generated additional revenue and economic activity. The primary way in which economic activity was generated for both the agricultural and medical
Developing a research impact performance management system

sciences, and engineering and natural sciences was through generating revenue for the university and community by attracting students (47.6 per cent and 41.9 per cent respectively), although it should be noted that this option was not given to the other disciplines. It should also be noted that the attraction of students also contributes to building research capacity in Oman as well as the creation of a research culture.

The humanities respondent noted two ways in which their research had generated economic activity: through contributing to the creative economy and contributing to employment in the public, private and not-for-profit sectors. In terms of social sciences, the main ways in which respondents reported the generation of economic revenue was through attracting capital investment and through generating revenue for not-for-profit organisations. The social sciences, like the humanities, is not a field which is traditionally linked with economic benefits. The fact that respondents have reported economic impacts in these fields is encouraging and may be worth TRC exploring further in the future (through case studies for example).

A significant proportion of respondents in the agricultural and medical sciences field noted the likelihood of impacts in this area in the future including the protection of research through patents or IP (52.4 per cent), the development of a complex intervention to improve patient health or care (52.4 per cent), the development or trialling of a therapeutic pharmaceutical product (33.3 per cent) and the development or trialling of a diagnostic test (38.1 per cent). Respondents in the field of engineering and natural sciences also reported a number of impacts in this area which are likely to happen in the future, including the protection of research through patents or IP (54.8 per cent), the commercial development of a product or process (61.3 per cent) and the development of a product or process which could have wide impacts on society (64.5 per cent). Respondents from the social sciences also cited the protection of research through patents or IP as a likely future impact (40 per cent) along with the production of a new product for the marketplace (40 per cent). Given that a significant proportion of respondents have predicted the occurrence of future impacts it may be beneficial to monitor projects over time in order to capture these impacts if and when they do occur and to gain and understanding of how accurately impact has been predicted.

The humanities did not report any impacts in this area, either which have already occurred or which are likely to occur in the future. This is not surprising, as humanities research is unlikely to have impacts in these areas, and these data are only representative of one respondent.

4.2.3. Cross-cutting observations

Table 4.3 below shows the percentage of respondents who answered positively in each of the ImpactFinder categories, and serves as a numerical representation of the responses in the TRC impact array. In agricultural and medical sciences, and engineering and natural sciences responses are concentrated on the left-hand side of the array, with the larger average responses occurring in these categories. However, a large proportion of respondents answered positively in the section on creating a knowledge-based economy, and these impacts primarily related to generating additional revenue and economic activity. Every respondent in the social sciences discipline answered positively at least once in all of the impact areas apart from generating inventions, products and IP – although, as explained above, a number of
respondents in this field did suggest that these impacts are likely to arise in the future. It is difficult to interpret the humanities data given that they are only representative of one respondent – and therefore all answers are either 100% or 0%.

A far smaller percentage of respondents answered positively to the section on generating inventions, products and IP than the rest of the impact areas across all of the disciplines. This is to be expected given that these are long-term impacts and the majority of TRC-funded projects are relatively recent and these types of impact are not expected to occur as a result of every research project.

Table 4.3: Percentage of respondents who answered ‘yes’ in each section of the survey

<table>
<thead>
<tr>
<th>Section</th>
<th>Agricultural and medical sciences</th>
<th>Engineering and natural sciences</th>
<th>Social sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating human capital</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Technical capacity building</td>
<td>100%</td>
<td>96.8%</td>
<td>100%</td>
</tr>
<tr>
<td>National and international visibility</td>
<td>76.2%</td>
<td>96.8%</td>
<td>100%</td>
</tr>
<tr>
<td>Creating a knowledge-based society</td>
<td>42.9%</td>
<td>67.7%</td>
<td>100%</td>
</tr>
<tr>
<td>Creating a knowledge-based economy</td>
<td>76.2%</td>
<td>80.6%</td>
<td>100%</td>
</tr>
<tr>
<td>Generating inventions, products and IP</td>
<td>14.3%</td>
<td>58.1%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Linked indicator: Applying ImpactFinder data to the dashboard

The ImpactFinder survey is a useful way of comprehensively measuring the impact of TRC research in a wide range of areas across the disciplines it supports. It can help to inform strategy – for example, if very few TRC-funded researchers are communicating their research to policymakers or other relevant stakeholders, there may be a role for TRC to play in supporting them to do this. The ImpactFinder survey can also be used to collect data required for the indicators in the research impact performance management system. One example of this is the indicator ‘the number of grants which have had a social, policy or economic impact’. These data can be gathered by counting the number of respondents who answered positively at least once in these sections of the survey. The data from the ImpactFinder survey we undertook for this indicator are presented in Table 4.4 below.

Table 4.4: Number of TRC grants with a social, policy or economic impact

<table>
<thead>
<tr>
<th></th>
<th>Social impact</th>
<th>Policy impact</th>
<th>Economic impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of TRC grants</td>
<td>41</td>
<td>29</td>
<td>65</td>
</tr>
</tbody>
</table>
4.3. Impact case study analysis

4.3.1. Introduction to the case studies

The ImpactFinder survey and results from the bibliometric analysis provide the macro-level data which have been particularly useful in assessing the impact of Omani research and TRC as a whole. However, in examining the impact of particular programmes or research projects, a micro-level approach is required, and this has been achieved through the development of impact case studies. Particular research programmes or projects were chosen for further exploration based on the impacts revealed in the ImpactFinder survey. A total of three case studies were conducted.

The case study approach is used internationally and it allows us to develop further the narrative story of the impacts which arise from research. In particular, the case studies allow for a more nuanced understanding of what kind of research was conducted and what the pathway was from the research to the eventual impacts. This, in turn, allows us to understand better what might come next in relation to further impact for the research. Case studies can be a powerful and important tool in understanding and evaluating research impact, because they allow for the nuances and contextual factors affecting research impact to be explored. They can be useful for both the analysis of ‘what worked’ in supporting a particular research process, and for advocacy and further promotion of TRC. As such, the case studies contribute to the overall research impact performance management system of TRC.

4.3.2. Headline findings from the case studies

The impact case studies reveal in great detail the diversity of impacts achieved through TRC-funded research for a selection of cases identified through the ImpactFinder survey. Case studies, as mentioned above are a particularly good method to understand precisely how impacts were created through research (the aspect of Analysis). Furthermore, given the level of detail obtained through case studies, they are a useful resource for the advocacy of research (the aspect of Advocacy). The headline findings below provide a first glance of some of these impacts that have been generated through TRC funded research.

As TRC is a relatively young research funder, some of the impacts are still at an early stage, yet show the potential for wider impact as the projects develop. Other impacts, however, as diverse as technical capacity and social impact, have already been achieved and are clearly visible in the case studies.

In total, three case studies were conducted which covered a variety of impacts. On the basis of the data from the ImpactFinder survey one case of economic impact was selected, one case of technical capacity building impact, and one case of social impact. For each case we will provide a brief summary to highlight the major impact. Additional details on the impacts and on the research underpinning the impacts can be found in Appendix 4.

Economic Impact

The research team at Dhofar University under the leadership of Dr Wazwaz developed a Solar Beam Station (SBS) and an Automated Weather Station (AWS). The SBS consists of a large parabolic dish collector which has a surface able to absorb all radiations in the solar range and convert them into heat. The SBS can be used for a wide range of applications which require heat energy such as the sterilisation of...
water (or any liquid) and the sterilisation of medical equipment, the production of electricity using a
sterling engine, the desalination of sea water, the production of thermal chemical reactions and the
production of biofuel. This project used the SBS to sterilise water, and created a solar steriliser for this
purpose.

The project showed a high potential for economic impact. The solar sterilisation system is not currently
being used to provide clean drinking water to residents in Dhofar. However, Dr Aref noted that there are
a high number of springs in the region, which would facilitate the use of the system to pump clean water
to homes. If this system was introduced, it could have an impact on employment given that it could take
up to five employees to operate the system on each spring. In addition, this equipment is now available
for use at Dhofar University, and it is hoped that chemical engineering students will use the SBS and the
AWS for their research projects, which Dr. Aref anticipates will attract more students to the university –
thereby generating revenue. Given that a number of impacts are anticipated to happen in the future, it
will be important to monitor these impacts and ensure the impact of this work can be properly evidenced.

Technical capacity building impact

The second case study focuses on research conducted at the University of Nizwa under the leadership of
Professor Ahmed Al-Harrasi and Dr Javid Hussain on Omani frankincense (Boswellia sacra). Frankincense
is an ancient and highly valued product native to Oman. In many of the societies to which
frankincense is native, it has been used for therapeutic and medicinal purposes. More recent academic
research on frankincense has been conducted on the Indian and Ethiopian species, yet the specific
properties of the Omani frankincense remained unexplored. These studies provided clear indications of
the medicinal properties of frankincense and triggered Prof. Al-Harrasi to explore the exact chemical
nature of the Omani frankincense and to link possible compounds derived to medical treatment.

With regard to the technical impacts, three main areas of impact emerged as a result of the research
undertaken: the development of a new distillation method; the acquisition of a Nuclear Magnetic
Resonance (NMR) Spectrometer; and the development of a database. First, the traditional technique to
extract oils from organic materials such as frankincense is hydro-distillation. This technique can however
be assisted with the use of microwaves. For the extraction of oils from frankincense this combined
technique has been explored and compared to traditional hydro-distillation. Second, the acquisition of the
NMR by the University of Nizwa helped to improve greatly the accuracy of the analysis of frankincense.
Third, the research conducted has allowed for the construction of a database of ‘spectra’ of the
frankincense studied. The different spectra indicate the presence and type of compound within certain
materials and thereby serve as a kind of library.

Social impact

The third case study focuses on research conducted at Sultan Qaboos University under the leadership of
Professor Mohamed Essa. The research conducted focused on the effect that fruits native to Oman, such
as pomegranate, figs and dates, might have on several cognitive diseases, such as Alzheimer’s disease.
Through the study of the effect of these fruits on human primary brain cell cultures, on mice, and
recently on humans, the potential of the fruits to slow down the degenerative processes of Alzheimer’s have been established.

The social impacts that resulted from this work are of three different kinds. First, through the research projects the Ageing and Dementia Research Group was able to contribute to the establishment of the Alzheimer Society Oman which in 2013 was officially approved by the Ministry of Social Development. The launch in 2013 preceded a ‘Remember’ walkathon which was repeated in 2014 and aims to generate awareness of Alzheimer’s disease in Oman. Second, these initiatives to raise awareness among the public are complemented by a second scientific symposium to be organised in October 2014. Finally, through the project, a substantial amount of training and capacity building was achieved. The project first led to the establishment of the Ageing and Dementia Research Group and has also allowed for the training of volunteers in research methods, usually bachelor’s students seeking a job, to enable them to take up a research position.
5. Conclusion and recommendations

This report has covered the two main components of this project in detail. First, it has described the process by which the research impact performance management system has been established, with the dashboard of impact indicators at the centre. Together with the How-to Guide, it is hoped that the description provided in this report of the steps taken to establish the research impact performance management system will enable TRC to update and improve the system and the dashboard as TRC matures. The steps outlined in this report have all been explained to TRC, and through the visits of the research team to Oman, TRC staff have been closely involved in the development of the dashboard. On the basis of this element of capacity building, TRC can update the dashboard in the future.

The second component of the project has been the application of the system through comprehensive data collection. Three major methods of data collection have been employed: bibliometrics, the ImpactFinder survey and impact case studies. The methodology underlying these methods has been explained briefly in the report and is further discussed in detail both in the Appendices 2-4 and in the How-to Guide. TRC can continue to collect these different types of data in the future using the guidance provided in the How-to Guide. Thereby TRC can ensure that the dashboard is updated with sufficient frequency.

This Final Report brings these two components together by linking a selection of impact indicators to methods of data collection, and highlighting headline findings emerging from the analysis of the data. The report thereby provides an overview of the process by which the research impact performance management system has been established, as well as of the data and findings actually underlying these indicators. Through this first round of data collection for these selected impact indicators, a baseline has been set against which TRC can start to measure progress in the future.

Going forward, TRC can undertake three main actions in relation to the dashboard. TRC can update the indicators to ensure the data are reflective of the most recent developments. Second, TRC can monitor the utility and relevance of indicators and decide either to phase new indicators in, or phase existing indicators out. And third, TRC can start to think about setting goals for indicators to measure how they are progressing against their targets.

In the end, and as explained in the How-to Guide, the dashboard can assist TRC with the design and formulation of an evidence-based strategy, which in turn will help to ensure that research and innovation in Oman will be of high quality and will serve the Strategic Objectives set by TRC following the National Research Strategy.


Ismail S., Nason E., Marjanovic S., Grant J. (2009) Bibliometrics as a tool for supporting prospective R&D decision-making in the health sciences: Strengths, weaknesses and options for future development, Santa Monica, Calif.: RAND
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Morris, et al. (2011). ‘The Answer is 17 years, what is the Question: Understanding time lags in translational research.’ Journal of the Royal Society of Medicine, 104, 510-520

Medical Research Council (2010). Outputs, outcomes and impact of MRC Research: Analysis of MRC e-Val Data. As of 21 October 2013: http://www.mrc.ac.uk/consumption/groups/public/documents/content/mrc008191.pdf


OECD (2014) Main Science and Technology Indicators. Available at: http://stats.oecd.org/Index.aspx?QueryId=33210


6. Appendix 1: Overview of TRC programmes

6.1. Documents reviewed

In the table we summarise the documents which were provided to us by TRC at the start of the project in September 2013, and reviewed to develop the additional information about the programmes. In reviewing the documents we aimed to summarise their main purpose and how they could contribute to wider thinking on developing and applying a performance management system. Given the key importance of the National Research Strategy we provide a more detailed summary below.

Based on the documents provided by TRC and the information available online, we have mapped the core activities of TRC into four main areas: (1) Research Programs; (2) Innovation Programs; (3) Finance, Admin and IT Support; and (4) Awareness and Knowledge Transfer. As the aim of our study will be to construct a research impact performance measurement system, we will here focus on the Research and Innovation Programs only.

Research Programs are the largest of the areas and contain the two grant initiatives run by TRC: the Open Grant Research Program and the Strategic Research Program. Open Research Grants are smaller than Strategic Grants and are awarded in six areas of research (see above), while Strategic Grants cover fewer but financially larger projects, such as the Road Safety Research Program. Other programmes falling under the area of Research Programs are the Research Chair Program, the Research Centers Program, the Adapting towards Sustainable Development Program, and the Faculty Mentored Undergraduate Research Award Program.

Innovation Programs are similarly quite diverse and range from assistance programmes to the Innovation Park Muscat. Innovation has been an integral part of the mission of TRC from its inception through the Royal Decrees. Within TRC, the Innovation Department runs a variety of innovation programmes, most notably four programmes that aim to support innovation (in academia, the community, education and industry), and the I-Hub which organises activities to foster a culture of innovation and entrepreneurship. Finally, TRC is strongly involved in the construction of the Innovation Park Muscat (the science park) where new facilities for research and innovation are being established.
### Table 6.1: Summary of documents reviewed

<table>
<thead>
<tr>
<th>Title</th>
<th>Year Published</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Research Strategy</td>
<td>Not published</td>
<td>Foundation report in which TRC’s strategy is described (see Section 4.1).</td>
</tr>
<tr>
<td>TRC Annual Report 2011</td>
<td>2012</td>
<td>Summarises the activities of TRC over 2011 (e.g. Strategic and Open Research Programs), and outlines future plans such as the construction of the Science, Research and Innovation Park.</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td>• no update or mention of the performance indicators.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no indication that the Grants (open and strategic) are being evaluated.</td>
</tr>
<tr>
<td>TRC Self-Appraisal Report</td>
<td>2011 or 2012</td>
<td>Contains an overview of the major activities that have been funded by TRC, such as the National Research Strategy and the Road Safety Research Program.</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td>• the forms per activity contain sections for ‘Outcomes’ consisting of ‘Main results’, ‘Deviations from plan’, ‘Unexpected benefits’, and for Hurdles consisting of ‘Reasons for deviation from plan’, ‘How were the hurdles addressed’ and ‘Planned measures to address outstanding issues’. These sections are, however, rarely filled out in detail.</td>
</tr>
<tr>
<td>TRC Annual Report 2012</td>
<td>2013</td>
<td>Summarises the activities of TRC over 2011 (e.g. Strategic and Open Research Programs), and outlines future plans such as the construction of the Innovation Park Muscat.</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td>• no update or mention of the performance indicators.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no indication that the Grants (open and strategic) are being evaluated, but it is noted that this should be done.</td>
</tr>
<tr>
<td>TRC’s Research Council (2005–2012)</td>
<td>2012</td>
<td>Provides an overview of the activities undertaken by TRC up until 2012. It lists such activities as the funding of research, the Innovation Park Muscat, and the efforts made by TRC to reach out to ('building relationships'): The Public Sector, Higher Education &amp; Industry, International Collaboration and the public.</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td>• no update or mention of the performance indicators.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no measures in place to evaluate outcomes or impacts, yet the need is recognised.</td>
</tr>
<tr>
<td>TRC’s N/A</td>
<td>N/A</td>
<td>Provides an update on the National Research Strategy by listing the activities TRC has undertaken.</td>
</tr>
</tbody>
</table>

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57 ‘TRC acknowledges the need to broaden the scope of scientific research evaluation, that is, not only evaluating the outcomes of research for the scientific community, but also the impact of research on society. Projects of this kind are: America’s Star Metrics (Science and Technology for America’s Reinvestment: Measuring the Effects of Research on Innovation, Competitiveness and Science) and the European Union’s SIAMPI (Social Impact Assessment Methods for research and funding instruments through the study of Productive Interactions between science and society).’ From: ‘The Research Council (2005-2012)’, page 7.
6.2. Data reviewed

In addition to the documents provided by TRC, the project team also reviewed TRC data from TRESS (The Research Electronic Submission System), complemented by additional data from the Annual Reports, the report ‘TRC’s Contribution’ and bespoke data requests provided by TRC.

TRESS contains data on Open and Strategic Grant applications and lists the total number of proposals received per Open Grant area and per Strategic Grant area, as well as the number of proposals that have been approved. Dividing the number of successful proposals by the total number of proposals received gives us the success rate of proposals per area, per Grant type, per year, and overall.

Figure 6.1 provides the success rates of applications to TRC for all research grants between 2009 and 2013. The first point of note is that the success rates are high compared to other research funders. Overall, between 2009 and 2103 TRC funded 50 per cent of the total number of proposals received in comparison to, for example, the US National Science Foundation (21 per cent in 2006), the UK Research Councils (ranging from 20 per cent to 69 per cent in 2011–2012, depending on the area) or the Qatar National Research Fund (20 per cent in 2013). TRC has noted that the high success rate for the initial cycles of the Open Research Grants stems from the aim to generate momentum in research among local research institutions during the start-up phase.\(^{59}\)

\(^{58}\) For 2011–2012: 34 per cent for the Arts and Humanities Research Council; 30 per cent for the Biotechnology and Biological Sciences Research Council; 41 per cent for the Engineering and Physical Sciences Research Council; 26 per cent for the Medical Research Council; 21 per cent for the Natural Environment Research Council; 69 per cent for the Science and Technology Facilities Council; around 20 per cent for the Economic and Social Research Council.

\(^{59}\) Communication from TRC, 24 October 2013.
The high success rates can imply, among other things, two situations:

- Demand is low, i.e. there are not many applications, and in order for any research to be conducted, most proposals are accepted and funded. In this situation it is likely, however, that lower-quality work will be funded.
- Most applications received are of a high standard, and thus, many applications are approved and funded.

Conversely, if success rates were low this can imply, among other things, two further situations:

- Very few applications reach sufficient quality standards, and thus, few applications are successful.
- Demand is high, that is there are too many applications and, given limited funding opportunities, only the very best are successful and receive funding.

The question of what qualifies as a ‘fundable’ proposal obviously plays a significant role. If the standards for fundable research are high, then the success rate will be low in an environment of low- to medium-quality proposals. Similarly, and depending on the available resources, high standards can also lead to a high success rate when proposals are generally of a high quality. The diversity of interpretations and situations illustrates that it is important to understand the dynamics underlying success rates, including the latent demand for research funding and the quality of research that TRC funds.
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Table 6.2 contains further break-downs of success rates for Open Grants for the different areas from 2009 up to 2013. Fewer Strategic Grants have been proposed, and of the 21 proposals between 2009 and 2013, ten, or 48 per cent, were successful.

Table 6.2: Success rates for TRC’s Open Grants by subject area, 2009–2013

<table>
<thead>
<tr>
<th>Proposed</th>
<th>Approved</th>
<th>Success Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Technology and Communication</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Culture, Humanities and Basic Sciences</td>
<td>27</td>
<td>11</td>
</tr>
<tr>
<td>Energy and Industry</td>
<td>45</td>
<td>26</td>
</tr>
<tr>
<td>Health and Social Services</td>
<td>52</td>
<td>26</td>
</tr>
<tr>
<td>Biological and Environmental Resources</td>
<td>44</td>
<td>21</td>
</tr>
<tr>
<td>Education and Human Resources</td>
<td>32</td>
<td>18</td>
</tr>
</tbody>
</table>

Each funding cycle TRC has, with the exception of 2010/11, resulted in an expenditure on Open Grants adding up to around 1.5 million OR (3.9 million US$) (Table 6.3). The average amount of funding per approved project has, however, increased to an average of 175,000 OR for the first cycle of 2013. The largest share of funding through open grants goes to Energy and Industry, Biological and Environmental Resources, and Health and Social Services.

Table 6.3: Total expenditure per proposal cycle

<table>
<thead>
<tr>
<th>Year</th>
<th>Approved</th>
<th>Total in OR</th>
<th>Average in OR</th>
<th>Total in US $</th>
<th>Average in US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>17</td>
<td>1,195,482</td>
<td>70,322</td>
<td>3,104,987</td>
<td>182,646</td>
</tr>
<tr>
<td>2010/1</td>
<td>11</td>
<td>826,765</td>
<td>75,160</td>
<td>2,147,330</td>
<td>195,211</td>
</tr>
<tr>
<td>2010/2</td>
<td>14</td>
<td>1,536,818</td>
<td>109,772</td>
<td>3,991,528</td>
<td>285,109</td>
</tr>
<tr>
<td>2011/1</td>
<td>13</td>
<td>1,352,918</td>
<td>104,070</td>
<td>3,513,890</td>
<td>270,299</td>
</tr>
<tr>
<td>2011/2</td>
<td>13</td>
<td>1,503,087</td>
<td>115,622</td>
<td>3,903,919</td>
<td>300,301</td>
</tr>
<tr>
<td>2012/1</td>
<td>13</td>
<td>1,635,950</td>
<td>125,842</td>
<td>4,249,000</td>
<td>326,846</td>
</tr>
<tr>
<td>2012/2</td>
<td>11</td>
<td>1,368,844</td>
<td>124,440</td>
<td>3,555,254</td>
<td>323,204</td>
</tr>
<tr>
<td>2013/1</td>
<td>10</td>
<td>1,759,413</td>
<td>175,941</td>
<td>4,569,667</td>
<td>456,966</td>
</tr>
</tbody>
</table>

Without further data, the differences in total amounts of funding per area cannot directly be seen as reflective of research quality, as some areas of research, such as energy and industry, and social research, may be more expensive than others. A trend of increased funding within a particular area may signal an increase in quality, as TRC has apparently been willing to fund more expensive projects (given the rise in
average funding per approved proposal). Conversely, it could just be the case that this area is deemed a high priority and is therefore allocated more funding.\textsuperscript{60} These are dynamics we would explore in interviews, as they will also inform how projects will be evaluated. Fewer research projects at a greater average cost may require different performance and evaluation measures than a higher number of research projects at a lower average cost.

Through TRESS, TRC has a system in place to collect descriptive data on Open and Strategic Grants, by which trends in the development of funding become visible. It readily provides an overview of which projects are funded in what area. However, the data remain very descriptive and do not yet provide a sufficient basis for any performance evaluation. In order to construct a performance management system, the data from TRESS will need to be linked up to other indicators, for example, data on users' satisfaction with the administrative procedures. Given the use researchers already make of TRESS through their grant applications, it appears it could be used as a way to collect further data throughout the running of funded projects and towards the end of projects, including, for example, questions from the \textit{ImpactFinder} survey. In this way the existing infrastructure could be expanded without the need to develop new systems.

\textbf{6.3. Current evaluation practices}

The Strategic Goals listed in the National Research Strategy were accompanied by a set of Performance Indicators in order to indicate the extent of the work required to meet the goals (called ‘Strategic Gaps’) and to monitor the progress towards these goals (see Table 6.4). The actual level for each indicator is listed under 2007, the goal under 2020, while the column ‘Gap’ indicates the size of the Strategic Gap as estimated by TRC in the National Research Strategy.

\textsuperscript{60} As inflation stood at around 3 to 4 per cent in Oman in 2010 and 2011, it also seems to explain some, but probably not all, of the increase in spending.
The Performance Indicators listed above were also incorporated, although not updated, in the report ‘TRC’s Contribution’, yet they do not appear in other reports. Any updates on the Indicators are from data provided to us by TRC or from UNESCO. Perhaps a reason why the Performance Indicators have not been updated regularly and included in TRC publications is because they can be difficult to obtain or measure accurately. As the indicators do not reappear in any recent documentation, there is also no indication that they are actually used to inform decisionmaking, and thus it is not clear what their function is in relation to TRC. The Performance Indicators, of course, have been linked to the Strategic Goals set out by TRC in the National Research Strategy, yet it remains unclear if the indicators are used on a regular basis to measure any progress towards the Strategic Goals. Furthermore, most indicators are high level, in the sense that they cover the entire country rather than any specific activities or processes undertaken by TRC. The indicators thereby do not seem to be directly related to Research and Innovation Programs run by TRC, and will most likely not be sufficient as a performance measurement framework for TRC.

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Apart from Strategic Goals, the National Research Strategy also outlined an ‘Implementation Plan’ which consisted of twelve programmes that TRC aimed to implement in order to achieve the goals. Nearly all programmes had an evaluation component to them. However, in the National Research Strategy it was not clear how monitoring and evaluation practices would be implemented. The majority of these programmes are currently being run by TRC, yet from the documents alone it is impossible to determine if, how, and to what extent performance and evaluation data are collected for these programmes, and how they might inform future policy decisions.

62 The 12 programmes are: Technology Foresight, Grants, Research Chairs, Research Centers, Researcher Directory, Researcher Training, Conferences, Researcher Mobility, Publication Corp., Knowledge Brokers, Commercialization Fund and Science Parks.
7. Appendix 2: Bibliometric analysis

7.1. Methods

The Centre for Science and Technology Studies (CWTS) was contracted by RAND Europe to provide the bibliometric analysis for this project. CWTS is an interdisciplinary research institute housed within the Faculty of Social Sciences of Leiden University, the Netherlands. CWTS specialises in advanced quantitative analysis of science and technology performance and the cognitive and organisational structure of science and technology. CWTS maintains a bibliometric database of all scientific publications (including health and biomedical research) for the period 1981 to the present generated by the Thomson ISI Web of Science database. The database allows for the analysis of the growth of scientific publications, the patterns of collaboration and numerous other measurements of scientific performance. This dataset is based on the journals and serials of the Science Citation Index and associated citation indices (CI): the Science Citation Index (SCI), the Social Science Citation Index (SSCI), and the Arts & Humanities Citation Index (A&HCI), extended with six so-called specialty Citation Indices (Chemistry, Materials Science, Biotechnology, Biochemistry & Biophysics, and Neuroscience).

As is the norm in bibliometric analysis, all publications published from 1980 that were classified as original articles, letters or reviews with an Omani address and that were indexed on CWTS’s database were identified (the letters were given a weight of 0.25, i.e. four letters are equivalent to one article or review). As the bibliometric analysis was conducted in 2013, the last year for which full citation data were available is 2012, which means that, in terms of identifying publications, we look up to 2011 to allow for at least one year of citations to accrue.

As with other methods of research evaluation, there are several limitations to bibliometrics, and we will highlight the most prominent ones. The first limitation refers to the analysis and interpretation of citations. While citations can be interpreted as a reflection of quality, they cannot, without the proper

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63 As of 21 October 2013: http://www.cwts.nl/
64 For a detailed discussion of the strengths and weaknesses of bibliometrics as a research evaluation method, see Ismail S., Nason E., Marjanovic S., Grant J. (2009) Bibliometrics as a tool for supporting prospective R&D decision-making in the health sciences: Strengths, weaknesses and options for future development, Santa Monica, Calif.: RAND.
context, be taken as a direct measure of quality. Other explanations may exist for why publications have either high or low numbers of citations, even in the case of normalised citation scores, which take differences by academic fields into account. A second and more general limitation of bibliometric analysis relates to different publication practices in academic fields. Bibliometrics is based on published articles and only covers a marginal amount of books and book chapters, which may be important research outputs in some fields (such as the social sciences and humanities). Such publications may therefore be overlooked by a bibliometric analysis. In the interpretation of bibliometric results it is therefore important to be aware of the possible bias. Finally, bibliometric databases need time to be updated and therefore generally bibliometric analyses do not include the most recent papers.

The only real way to overcome these difficulties is, on the one hand, to use multiple bibliometric indicators rather than just one, and on the other hand, to use multiple research evaluation methods in parallel to bibliometrics to examine the various ways in which research can have an impact.

7.1.1. Indicators used

A number of variables were used in the production of this report to highlight the research profile of Oman. A description of these variables is outlined in Table 7.1. A more in-depth discussion of the meaning and use of some of these indicators is also offered in this section.

7.1.2. Normalisation approaches

The normalisation of bibliometric indicators allows for the direct comparisons between different fields, times and countries. The MNCS (mean normalised citation score) was used to make comparisons in the citation performance between countries, fields and years. Different fields have different citations characteristics. This is because some fields take longer to gain citations or gain fewer citations in total (e.g. Humanities) than others (e.g. Medicine). The MNCS corrects for the differences in citation characteristics between publications from different fields, from different years and between different document types (i.e. articles, reviews, letters and editorial). The fields are defined using Thomson Reuters’ Journal Subject Classification (JSC) system that clusters similar journals into fields based on expert opinion and citation linkages. In total there are 249 such fields. The MNCS is normalised to the world average of citations gained, which means it can be interpreted as showing how well the performance of the research is relative to a world average. If the number is 1.0, this can be described as equal to the world average. If the number is below 1.0, then it is described as below the world average, and if it is above, then it is described as above the world average. For example, an MNCS of 1.2 can be described as achieving a level of citations that is 20 per cent above the world average. Conversely, an MNCS of 0.7 is described as performing at 30 per cent below the world average.

65 Publications in multidisciplinary journals such as Nature, Proceedings of the National Academy of Sciences, and Science were individually allocated, if it was possible, to subject fields on the basis of their references. The reassignment was done proportionally to the number of references pointing to a subject category. It is important to highlight that the impact indicators are calculated based on this assignment.
In general, publishing in high-impact journals is seen as an indication of the quality of the work, due to the higher impact journals generally having stricter quality criteria and more rigorous peer-review systems than low-impact journals. In order to reflect this, the other indicator used in this report, the MNJS (mean normalised journal score), provides a more sophisticated measure of the impact of a journal than other, more commonly used journal measures, such as the Journal Impact Factor (JIF). Unlike the JIF, the MNJS describes the impact of the articles published within the journal that has been corrected for differences in citation characteristics between scientific fields. This allows us to make direct comparisons between fields. As with the MNCS described above, the MNJS value can be interpreted similarly by taking 1.0 as indicative of the world average. Scores less than 1.0 are therefore described as below the world average, with scores above 1.0 being above the world average.

Table 7.1: Description of the variables employed in the analysis of Oman’s research output

<table>
<thead>
<tr>
<th>Name</th>
<th>Measurement capabilities</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of publications</td>
<td>Research output</td>
<td>Number of individual publications produced.</td>
</tr>
<tr>
<td>Number of citations</td>
<td>Utility (raw)</td>
<td>Citations between source articles and other articles.</td>
</tr>
<tr>
<td>Mean normalised citation score (MNCS)</td>
<td>Utility (normalised)</td>
<td>The average number of citations per article in a field relative to the world average (self-citations not included).</td>
</tr>
<tr>
<td>Mean normalised journal score (MNJS)</td>
<td>Visibility (normalised)</td>
<td>The average number of citations received in a journal in a field, relative to the world average (self-citations not included).</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Visibility through collaboration</td>
<td>Articles with only one institutional affiliation from Oman (no collaboration), articles with national collaboration (with more than one institutional affiliation but only within Oman), and international collaboration (articles with at least one author with an address outside Oman).</td>
</tr>
</tbody>
</table>

7.2. Initial bibliometric assessment impact of Omani research publications

Findings are presented below in five sections, covering: the total scientific publication output of Oman; the visibility of Oman’s scientific output; Oman’s strength in different research fields; an analysis of research collaboration; and maps to represent research collaborations. Comparisons are drawn across time and between Oman and neighbouring regional countries such as Jordan, Kuwait, Qatar, Saudi Arabia and the United Arab Emirates.

7.2.1. Total research output, 1980–2011

Data on the total publications output of Oman are illustrated in Figure 7.1. Total research output in Oman between 1980 and 2011 was just under 5,000, with a steady increase following 1987, accelerating from 2008 onwards. In 2011 there were just under 500 research papers published. Figure 7.2 shows the
output for selected benchmark countries. Note in this figure that Saudi Arabia is on the secondary axis, as it has a significantly larger output than the other countries. Over the period of analysis (1980–2011) Oman’s comparative position has remained relatively stable, i.e. lying between UAE and Qatar, but in recent years the Qatar output has begun to grow and is now roughly the same as Oman’s.

**Figure 7.1: Total research output in Oman, 1980 to 2011**
7.2.2. Funder acknowledgements and TRC-funded publications

The analysis of the funder acknowledgements in publications from Oman from 1980 until 2011 revealed that 1,551 publications included funder acknowledgements. Funder acknowledgements on papers are however not fully accurate, and may contain for example simple salary acknowledgments rather than grants. As with the other bibliometric indicators, care therefore needs to be taken in the interpretation of the data. Furthermore, it is important for TRC to ensure that grantees accurately acknowledge the grants they have received from TRC.

The most frequently acknowledged institutions from Oman are the Sultan Qaboos University (247 acknowledgements), Sanofi Aventis (39 acknowledgements) and Petroleum Development Oman (25 acknowledgements); The Research Council was acknowledged as a funder in 16 publications. As this is a small number, no further analyses were conducted on these 16 publications (such as MNCS or MNJS), since this would not provide much information. Other publications that acknowledge The Research Council can be found using, for example, Google Scholar, but these may not appear in Web of Science if they have not been published in indexed journals.

7.2.3. The citation visibility of Omani research

As described above, the MNCS and MNJS are indicators of the utility and visibility of research output. The trends in these indicators over time for Oman as a whole are shown in Figure 7.3. We have focused this analysis on the period 1990–2011 in order to deal with the small number of papers published annually prior to this period. There is no discernible pattern to note in Figure 7.3 apart from the fact that the total utility and visibility of Omani research publications is below the world average at 0.8.
Figure 7.4 shows that when Oman is compared to Saudi Arabia, which has a yearly output ten times the size of Oman, the citation visibility is higher in Oman as reflected in the MNSC and MNJS. However, when compared to Qatar, which has a relatively similar output volume, the MNCS is lower, though the MNJS is the same. As discussed below, this difference may be explained through higher rates of international collaboration in Qatar.
7.2.4. Bibliometric assessment of research strengths and weaknesses

Bibliometrics also allows us to assess research performance in different fields, and identify particular strengths and weaknesses. The fields are based on the 249 Thomson Reuters’ Journal Subject Classification system. Table 7.2 shows Oman’s volume of output and MNCS in different scientific fields. Only fields for which the MNCS is greater than 1.0 (i.e. those in which papers originating in Oman are cited more often than the world average for the field) and for which there are at least 20 publications are included. In other words, Table 7.2 provides a bibliometric assessment of Oman’s research strengths. Notable, perhaps, are the three fields with critical mass (i.e. with more than 100 publications) which are performing above world average, although cut-off values are arbitrary. These are: multidisciplinary geosciences, petroleum engineering, and food science and technology.
Table 7.2: Top performing fields of research in Oman with a MNCS greater than the world average in which more than 20 papers were published, 1980–2011

<table>
<thead>
<tr>
<th>Research Field</th>
<th>Number of publications</th>
<th>MNCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLYMER SCIENCE</td>
<td>25</td>
<td>1.83</td>
</tr>
<tr>
<td>GEOLOGY</td>
<td>46</td>
<td>1.68</td>
</tr>
<tr>
<td>PHYSICS, ATOMIC, MOLECULAR &amp; CHEMICAL</td>
<td>29</td>
<td>1.46</td>
</tr>
<tr>
<td>ENGINEERING, MECHANICAL</td>
<td>73</td>
<td>1.45</td>
</tr>
<tr>
<td>ENGINEERING, INDUSTRIAL</td>
<td>34</td>
<td>1.41</td>
</tr>
<tr>
<td>GENETICS &amp; HEREDITY</td>
<td>73</td>
<td>1.32</td>
</tr>
<tr>
<td>AUTOMATION &amp; CONTROL SYSTEMS</td>
<td>35</td>
<td>1.30</td>
</tr>
<tr>
<td>GEOSCIENCES, MULTIDISCIPLINARY</td>
<td>193</td>
<td>1.24</td>
</tr>
<tr>
<td>ENGINEERING, PETROLEUM</td>
<td>119</td>
<td>1.22</td>
</tr>
<tr>
<td>OCEANOGRAPHY</td>
<td>41</td>
<td>1.22</td>
</tr>
<tr>
<td>TOXICOLOGY</td>
<td>31</td>
<td>1.17</td>
</tr>
<tr>
<td>OPERATIONS RESEARCH &amp; MANAGEMENT SCIENCE</td>
<td>45</td>
<td>1.16</td>
</tr>
<tr>
<td>PALEONTOLOGY</td>
<td>32</td>
<td>1.10</td>
</tr>
<tr>
<td>FOOD SCIENCE &amp; TECHNOLOGY</td>
<td>150</td>
<td>1.09</td>
</tr>
<tr>
<td>INSTRUMENTS &amp; INSTRUMENTATION</td>
<td>37</td>
<td>1.09</td>
</tr>
<tr>
<td>CHEMISTRY, APPLIED</td>
<td>56</td>
<td>1.07</td>
</tr>
<tr>
<td>COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE</td>
<td>32</td>
<td>1.05</td>
</tr>
<tr>
<td>BIOTECHNOLOGY &amp; APPLIED MICROBIOLOGY</td>
<td>45</td>
<td>1.05</td>
</tr>
<tr>
<td>NUTRITION &amp; DIETETICS</td>
<td>23</td>
<td>1.03</td>
</tr>
<tr>
<td>AGRICULTURE, DAIRY &amp; ANIMAL SCIENCE</td>
<td>55</td>
<td>1.02</td>
</tr>
<tr>
<td>VETERINARY SCIENCES</td>
<td>55</td>
<td>1.02</td>
</tr>
</tbody>
</table>

7.2.5. The effect of collaboration

Collaboration among different research groups, either within the same country or internationally, is becoming an increasingly prominent feature of scientific research. For relatively small research systems, such as those in Oman, collaborating internationally provides an opportunity to derive benefits from wider expertise, and to raise the profile of their country’s own research and researchers. This is illustrated in Figure 7.5. The MNCS is higher (0.82) for papers with an international collaborator than those with no collaboration (0.51) or a national collaborator (0.53).
7.2.6. Mapping the research output network

The analysis of authors and their affiliations also allows an insight into the networks of research collaboration that exist within Oman and between Oman and other countries. For each publication, it is known who the authors are, what their affiliations are, and what the countries are in which they are based. Using this information at an aggregate level, CWTS can generate a mapping of research institutions in Oman.

Together with the number of publications per institution, a first network map can be constructed which provides an overview of the publishing culture in Oman (Figure 7.7, Figure 7.8, Figure 7.9). The map conveys the following information:

- The institutions involved in research in Oman
The volume of research output by institution (the size of the circle)
The number of collaborations between institutions (thickness of the connecting lines).

The network maps show that for the last 25 years the Sultan Qaboos University (SQU) has been the largest producer of research output in Oman (size of the circle) and is also the main institution for collaborations, as most links run from SQU to other institutions. The number of collaborations has quite clearly increased, especially when the map over the 2006-2011 period is compared to the 1980-2000 map, which is considerably less dense. The institutions, however, do not change position as their position has been fixed on the basis of the entire dataset from 1980 to 2011.

The increased number of connecting lines, and their increased thickness, shows visually that the network of research in Oman is expanding, and collaborations are becoming more common. Nonetheless, given that a large share of Oman’s publications continues to come from SQU, and given its central position in terms of collaborations, it appears that at the moment the research publishing culture in Oman remains structured around SQU.
Figure 7.7: Network map of institutional collaboration in Oman, 1980-2000
Figure 7.8: Network map of institutional collaboration in Oman, 2000-2005
Figure 7.9: Network map of institutional collaboration in Oman, 2006-2011
An interesting finding which is illustrated in Figure 7.10, Figure 7.11 and Figure 7.12 is that the vast majority of collaborations are international, which means collaborations between a researcher at a research institution in Oman and a researcher at an institution outside Oman. On the basis of this information, a further set of network maps can be constructed which shows the countries with which Oman collaborates on research according to the indexed publications for the period from 1980 to 2011. In the map, the proximity in the figure of countries to Oman indicates the frequency of collaborations. Researchers from countries in close proximity to Oman collaborate more frequently with Omani-based researchers than researchers from countries further away. Perhaps not surprisingly, the countries with the closest proximity are countries which have well-established research infrastructures, such as the US, France, Germany and Japan.

Similar to the institutional maps above, the network maps on country collaborations become increasingly dense over time, reflecting the increased total volume of publications and collaborations underlying these publications. The countries do not change position as their position has been fixed on the basis of the entire dataset from 1980 to 2011.
Figure 7.10: Network map of international collaboration with Oman, 1980-2000
Figure 7.11: Network map of international collaboration with Oman, 2000-2005
Figure 7.12: Network map of international collaboration with Oman, 2006-2011
8. Appendix 3: Survey analysis

8.1. Introduction

As part of RAND’s role in developing TRC’s research impact performance management system, we piloted the use of the ImpactFinder survey among TRC-funded researchers. The ImpactFinder survey is an online survey designed to identify research impacts. The methodology underlying the ImpactFinder survey was initially developed for the UK biomedical funding community and has been used by the National Institute for Health Research to evaluate high-quality research and health impacts, in addition to forming the basis of the Medical Research Council’s evaluation system. However, the ImpactFinder survey has itself been extended to other fields, such as engineering, the humanities and social sciences, and has been used in the UK university community to identify impacts across all these disciplines.

The structure and questions for the ImpactFinder survey are based on a methodology for identifying research that has contributed to impact: the RAND ARC Impact Scoring System (RAISS) developed by RAND Europe for the Arthritis Research Campaign. This, in turn, is based on a significant body of evidence about the impacts of research built up over many years through the use of the payback framework to evaluate research. In the payback framework any assessment of the scientific quality of research (e.g. journal articles, the training of future researchers and the development of careers) is part of the broader assessment of impact: the societal impact of research is the key issue in the multidimensional categorisation of the benefits from research.

The ImpactFinder survey is a methodology for identifying impactful research and innovative activities across an organisation’s investment portfolio. It aims to capture a broad range of impacts, from economic to social and cultural, to those that are purely about new knowledge generation. By providing an overview of impact in this way, an individual, department or organisation can begin to examine the ‘why and how’ of research translation and innovation processes. The data are presented in ‘impact arrays’, which have been developed as a way to display the impacts of research and give an instant overview of the research.

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portfolio. The presentation of research impact in this way provides TRC with a visual demonstration of impact across its research portfolio, as well as the means to select case studies for more in-depth qualitative analysis and demonstration of impact.

8.2. Methodology

The ImpactFinder survey is implemented as a web questionnaire and collects information across a range of scientific, social, cultural, environmental and economic impacts. The survey has just under 300 individual Yes/No questions that explore a wide variety of benefits and impacts a piece of research may have contributed to. The questions are built in a hierarchical fashion and secondary and tertiary questions are only revealed if the primary, ‘top-level’ question is answered in the affirmative. Therefore, most participants only see a fraction of the full questions (there are 60 top-level questions, so in theory a participant could answer ‘no’ to each question and see only 60 questions). This increases the effectiveness of the survey as it combats one of the key issues with many survey approaches, which is the burden on the participants. By being quick to complete, participants are not over-burdened, leading to high response rates and meaning the survey can be employed across the lifetime of funding programmes, rather than in a limited way after the research project is finished.

8.2.1. The TRC ImpactFinder question set

For TRC, we designed discipline-specific survey versions for four research areas:

- Medical, Health and Agricultural Sciences
- Engineering, Technology and Natural Sciences
- Social Sciences
- Humanities.

These four research areas cover the research TRC funds. We allocated all projects to these broad areas on a case-by-case basis in order to ensure that all project impacts would be appropriately captured by these discipline-specific surveys. These areas also aligned with previous deployments of the ImpactFinder survey by the research team across the UK and in preparation for the UK Research Excellence Framework 2014. Indeed, the TRC ImpactFinder survey is based on these previously tried and tested survey approaches, though the questions were tailored based on the Omani context as a growing research ecosystem. In particular, this meant there was a greater emphasis on research capacity building for this set of survey questions, both in relation to technical capacity building and human and other resources, as well as different barriers to research in relation to achieving impact. Due to the relatively young age of TRC’s funding programme, we also included questions in each section asking researchers to comment on potential future impacts. In addition, although the majority of questions are shared across all four research areas, questions were also tailored to reflect the differences in both the language used, the research outputs realised and the possible impacts which might be achieved by the different research disciplines. Researchers see 60 top-level questions, which can branch out to capture more granular information depending on the preceding responses. Many of the questions also allow free text to be entered by the researcher, in order to provide further detail or context for their responses.
The *ImpactFinder* survey question set was organised around six categories of research benefits and one open-ended comment section. The categories were defined in the survey as follows:

- **Human capital in research and a research culture.** This section asks whether research projects have led to wider benefits in human capacity building. It asks about any collaborative research that has taken place, and any impacts that might have emerged as a result of this collaborative activity.

- **Creating research infrastructure.** This section asks about whether research projects have led to wider benefits in building a research infrastructure in Oman.

- **National and international visibility.** This section asks about the dissemination activities and benefits associated with research more widely in society and business. It asks about dissemination activities to audiences outside of academia, and contributions to public knowledge creation.

- **Creating knowledge-based societies.** This section asks questions about the extent to which a broader culture for research is being created in Oman and how this is building a wider knowledge base which informs and meaningfully contributes to all aspects of society. This could be through public outreach and engagement in research, contributions to education and learning, business practices, and/or legal outcomes. It also asks about impacts on public policy, for example, if the work informed policymaking processes and/or decisionmaking in policy entities (e.g. national government, GCC, industry, etc.), and impacts on cultural activities, broadly defined, including contributions through cultural enrichment, public events, the creative industries and preservation of heritage.

- **Creating knowledge-based economies.** A knowledge-based economy is one which is diversified and draws on a world-class infrastructure, efficient delivery mechanisms, a highly skilled and productive workforce and creates opportunities for innovation and entrepreneurship. This section asks about the diversity of economic benefits which might arise from these elements and that can be associated with research, including employment opportunities, revenues, etc.

- **Inventions/Products including generating intellectual property (IP) and patents.** This section asks about long-term impacts through contributions to copyright/patented products and/or inventions.

- **Comments.** This section requests participants’ comments on the questionnaire so that subsequent versions can be improved. This section also asks researchers to identify the research that informed their answers to this questionnaire, to help with the synthesis and analysis of results.

### 8.2.2. Running the survey

Working from grant details provided by TRC, 138 researchers were invited to complete the TRC *ImpactFinder* survey questions. These researchers were contacts given by TRC as those who had received a grant from the Open Research Grant Program, the Strategic Research Grant Program, the Research Chair Program, the Industrial Innovation Assistance Program, the Education Innovation Assistance Program, the Academic Innovation Assistance Program and the Sustainable Development Research Program. We
invited all PIs/contact researchers to take the survey from all active projects, even if the project was not yet complete. This is because we wanted to collect data on all impacts that have arisen to date, while recognising that grants given in recent years are not likely to have had many impacts. When asking about the generation of intellectual property and inventions, respondents were also given the opportunity to state that the impacts were likely to occur in the future, and therefore some anticipated future impacts have also been captured which more recent grants may be able to report on.

By research area, the number of invitations were:

- Medical and agricultural sciences: 33 invitations
- Engineering and natural sciences: 58 invitations
- Social sciences: 45 invitations
- Humanities: 2 invitations.

The table below sets out how TRC’s research programmes break down into these areas. There is a discrepancy between the total number of projects (presented in the table) and the number of survey invites, given the number of duplicate PIs or research contacts.

### Table 8.1: Breakdown of TRC’s research programmes by field

<table>
<thead>
<tr>
<th></th>
<th>Medical and agricultural sciences</th>
<th>Engineering and natural sciences</th>
<th>Social sciences</th>
<th>Humanities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open research grant programme</td>
<td>29</td>
<td>40</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
<td>Strategic research grant program</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Chair program</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Industrial innovation assistance program</td>
<td>2</td>
<td>21</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Education innovation assistance program</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Academic innovation assistance program</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Sustainable development research program</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

The *ImpactFinder* survey was accessible through an online link for a window of 49 days, starting on 4 June and ending on 22 July 2014. Researchers received an email from TRC explaining the purpose of the
survey and the involvement of RAND. This was followed by an invitation email, sent by the survey, which provided a link to access the survey. Two reminder emails were sent to researchers who had not yet submitted their answers, which were tailored according to whether or not they had started the survey (see Section 8.3.1 below for response rates).

8.2.3. Analysis methodology

After the survey was closed, an analysis of survey data across the range of social, political, cultural and economic impacts was carried out using the ‘impact array’, a way of displaying multiple data points from the survey results by kinds of impact. The analysis involved investigating the survey responses across different impact categories within the survey described above in Section 8.2.1. First, the overall impact array was analysed for broad trends across the different impact categories of the survey. Areas of high impact were then explored further – the results of which are presented visually in figures and where appropriate, tables.

Second, individual impact categories from the survey were qualitatively analysed based on positive responses to the individual survey questions. Though each positive response to a question could be indicative of impact, a positive response in and of itself does not equate directly with impact. Some questions are indicative of potential impacts. For example, one of the opening questions in the first impact category asks about different types of collaborative research engagements. If a positive response were given to this question, it would be a good indicator that some kind of further benefit or impact might follow, but this is not a given. Further questions have to be analysed in order to understand whether, and what kind of impacts might have resulted from the engagements. However, in order to reach a point where we could more conclusively state that there was good evidence of impact, additional evidence around the actual benefits which accrued to the partner organisation needed to be indicated. These could include benefits such as tacit knowledge gains, more diversified expertise in the organisation, more targeted R&D activities, or economic gains. These economic gains were indicated by positive responses to benefits such as temporary employment contracts, increased R&D productivity, or more high-quality products being produced.

This analysis process proceeded for each of the six main impact categories and the questions within it. A few caveats though are important to state up front and will be referred to throughout the analysis. First, though our analysis attempted to identify researcher impact as consistently as possible across each discipline, it is inevitable that some researchers with significant impact will have been missed from our analysis. This is for two reasons. First, and simply, they have not completed the survey, and so we will not be able to show their impacts. Second, it could be that individuals may have had significant impact in only a few areas and so the significance of their impact in that area is not reflected because there are fewer positive answers overall. Because researchers did not provide additional comments on the questions, we were often unable to draw conclusions about the nature of impact aside from identifying positive responses across a given area. In other words, our analysis tends to err on the side of favouring broader

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68 Providing additional comments on the questions was an option for respondents, but was not a requirement of the survey.
impacts as opposed to deeper ones, but this should not be interpreted to mean one is more favourable than the other. It simply means that in the future the survey should be analysed both quantitatively and qualitatively, and triangulated with a case study approach where possible (see Appendix 4).

Second, although the impact arrays themselves are useful for the purposes of illustrating impact, they cannot be analysed simply by ‘counting’ positive responses across each discipline, without considering wider qualitative evidence about the nature and scope of impacts. Though we present impact arrays and the ‘counts’ of positive responses in the text below, these should be interpreted with caution and read alongside the qualitative analysis that follows. In addition, and in future, TRC will need to further develop ways to evidence the self-reported impacts as appropriate and suited to the intention of the exercise.

Third, because the ImpactFinder survey was completed by individual researchers, who may be working on more than one TRC project, the analysis is likely to be more reflective of experiences of individuals, not necessarily projects. This means that individuals involved in more than one research project would be potentially identifying a range of impacts which might hold across several projects, and indeed that some projects might have been commented on by several individuals, leading to potential over-representation of impacts. Equally, it may be the case that the PI is not aware of all of the impacts related to a project, leading to a potential under-representation of certain impacts. It is also worth noting that there could be a response bias for researchers in that it may be that only researchers with a large amount of impacts to report engaged with the survey – or that the researchers with the highest impacts were too busy to complete the survey. Future development of the survey will need to account for this and factor it into any analysis.

With these caveats in place we are now in a position to present the findings. In the analysis below we present comparisons which were made at the discipline and cross-discipline level. We recommend caution when making comparisons across fields in some cases, as, for example, the low response rate for Humanities makes direct comparisons with fields with larger response rates (Medical and Agricultural Sciences, Engineering and Natural Sciences, and Social Sciences and Innovation) unreliable. Moreover, the discipline groupings are very broad, which suggests that the nature of the projects and the impacts within each discipline grouping are likely to be very diverse.

The findings are presented with both graphical representations of responses (expressed as percentages in most cases), and with the corresponding section of the impact array. While the graphs may be easier to read, the impact array provides a concise overview of both breadth and depth of impact. Impact arrays display the impacts of research across a range of projects and therefore give an instant overview of the research portfolio. The columns represent different types of research outputs, outcomes or impacts and the rows different researcher/project responses. Thus, reading across the impact array by row allows one to see the different kinds of outputs and impacts an individual researcher has had, while reading across it by column allows one to see what kind of outputs or impacts have been realised across TRC’s entire research portfolio. Further descriptions of how to read the impact arrays for this study are provided in each section and section 8.4 provides information on how to interpret the impact array shading.
8.3. Analysis of ImpactFinder results

8.3.1. Description of the responses

Table 8.2: Number and percentage of responses to the survey

<table>
<thead>
<tr>
<th></th>
<th>Agricultural and medical sciences</th>
<th>Engineering and natural sciences</th>
<th>Social sciences</th>
<th>Humanities</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of responses</td>
<td>21</td>
<td>31</td>
<td>20</td>
<td>1</td>
<td>73</td>
</tr>
<tr>
<td>Percentage across all respondents</td>
<td>28.8%</td>
<td>42.5%</td>
<td>27.4%</td>
<td>1.4%</td>
<td>100%</td>
</tr>
<tr>
<td>Response rate relative to size of field (TRC funding portfolio)</td>
<td>63.6%</td>
<td>53.4%</td>
<td>44.4%</td>
<td>50%</td>
<td>52.9%</td>
</tr>
</tbody>
</table>

The table above provides an overview of the responses to the TRC ImpactFinder survey (Table 8.2). The table shows that we received a relatively even response rate across the discipline areas relative to the size of the field in the TRC funding portfolio (represented in the bottom line of the table). Therefore, although only 1.4 per cent of overall survey responses represent the humanities, this is reflective of TRC’s funding portfolio, as the survey was only sent to two respondents in the humanities. With this in mind, it should be noted that all survey data relating to the humanities only reflect the experience of one respondent, and as such caution should be exercised in comparing humanities with other disciplines in the survey.

8.4. Creating human capital in research and a research culture

Questions in this section of the survey addressed whether and how research projects have led to wider benefits in human capacity building. By human capacity building, we mean the development of skills, resources, training and other research-related capabilities. This section also asked a series of detailed questions about any collaborative research that has taken place, and any impacts that might have emerged as a result of this collaborative activity.

There were two sets of questions for this section of the survey. The first asked about the development of skills and career progression of TRC researchers. The second asked about different kinds of benefits which might be arising from collaborative research efforts. The impact array for this section is displayed below. As with all impact arrays that will be discussed in this chapter, the dark red shading indicates that a ‘yes’ response was given for one of the questions (or that an option was selected from a multiple choice list, indicating an impact); the light pink shading indicates that a ‘no’ response was given; the grey shading
indicates that a ‘don’t know’ response was given – i.e. respondents did not know whether a particular impact had occurred or not; and no shading means that the question was not answered. This may have been because they were questions which required an initial ‘yes’ response to appear in the survey, or because they were options in a multiple choice list that were not selected. It should also be noted that each impact array presents the research projects according to the start date of their grant. The oldest projects are at the top of each discipline section, working down towards the newest. Therefore we might expect to see more impacts at the top of each discipline section in each of the impact arrays.

Figure 8.1: Impact array for each field in the area of building human research capacity

8.4.1. Development of skills and career progression

The first set of questions in the survey asked respondents to outline which groups of people had been involved in their research. The results are presented in Figure 8.2 below. They show that almost all projects had Omani nationals participating in research across all fields, indicating that Oman is building in-country research capacity rather than relying on expertise from outside of Oman. The high numbers of projects reporting the training of Omani residents (85.7 per cent of medical and agricultural sciences respondents, 83.9 per cent of engineering and natural sciences respondents, 85 per cent of social sciences respondents and 100 per cent of humanities respondents) also reveal that Oman is building research capacity through its research programmes. Research capacity is also being built through the inclusion of junior researchers in research projects, although this is happening to a lesser extent (only 42.5 per cent of respondents reported this across all fields).
One of TRC’s aims is to attract young people into science and research, and therefore the survey asked respondents how many Omani nationals under the age of twenty-five had been involved in research. The survey found that a large proportion of projects did include young people across all fields, showing that TRC is fulfilling its aim. However, agricultural and medical sciences as well as engineering and natural sciences had a lower proportion of young people than the social sciences. That being said, a large proportion of undergraduate and graduate students were involved in research across all fields, with 100 per cent of respondents in panel B reporting this. Given the discrepancy between these figures and those associated with Omani nationals under twenty-five participating in research, it may be that a proportion of these undergraduate and graduate students are not Omani nationals.

There was a significant number of additional research staff moving to Oman to support research projects in engineering and natural sciences (67.7 per cent), which may be indicative of growing awareness of TRC and the research system in Oman internationally, as well as the quality and credibility of research undertaken in Oman. This also strengthens the idea that a proportion of undergraduate and graduate students are not Omani nationals.

Figure 8.2: Involvement of different groups in TRC-funded research
In addition to capacity building through the inclusion of Omani researchers and training programmes, a number of respondents also indicated that formal qualifications had been achieved through their research, as presented in Figure 8.3 below. For agricultural and medical sciences as well as social sciences, a master’s degree was the most common qualification gained by the research team. This may be due to the difference in time to complete a master’s degree in comparison to an undergraduate or doctoral degree. Indeed, there were fewer doctoral degrees obtained than any other degree across the fields, which may be due to the time delays, as doctoral degrees can take up to five years to complete. However, it is interesting to note that in the fields of social sciences, more doctoral degrees were obtained than master’s degrees. This may be because the establishment of TRC programmes has encouraged those who already had undergraduate or master’s degrees to gain doctoral qualifications.

**Figure 8.3: Proportion of respondents who reported types of qualifications gained by TRC-funded researchers per field**

A high proportion of respondents also reported that their TRC-funded research made a significant contribution to the career advancement of the research team (see Figure 8.4 below). There was a relatively even rate of responses across all fields, with 95.2 per cent of agricultural and medical sciences respondents, 93.5 per cent of engineering and natural sciences respondents, and 90 per cent of social sciences and innovation respondents reporting that TRC funding significantly contributed to career progression.

A large proportion of respondents also reported that TRC funding helped establish a new research group, sustain the existing research group and increase the size of the research group. The break-down of these impacts by area can be seen in Figure 8.4 below.
8.4.2. Benefits from collaborative research

The next set of questions in this section of the survey asked respondents to indicate the extent of any collaborative agreements with research stakeholders inside and outside Oman, as well as any benefits which may be accruing to these organisations and the researchers’ home institutions. Figure 8.5 presents the total number of collaborations with organisations inside and outside Oman. Engineering and natural sciences had the largest total number of collaborations (with 52 collaborations inside Oman and 58 collaborations outside Oman), followed by social sciences (39 collaborations inside Oman and 27 collaborations outside Oman) and agricultural and medical sciences (19 collaborations inside Oman and 25 collaborations outside Oman). Humanities did not report any collaborations (although again, these data are only representative of one respondent). However, it should be noted that a minority of respondents reported a large number of collaborations. Figure 8.6 shows the percentage of respondents who reported any number of collaborations inside and outside Oman, which is much more even across the fields. It is interesting to note that the percentage of respondents who reported collaborations with organisations inside Oman is fairly similar to the percentage of respondents who reported collaborations outside Oman, which is perhaps surprising given that national collaborations are responsible for a very small percentage of published research outputs (see Figure 4.4). This suggests that national research collaborations publish less frequently.
We also examined the types of stakeholder bodies that these collaborative agreements were made with. The results are shown below in Figure 8.7. In all fields reporting collaborations, those with universities were the most common (accounting for 62.9 per cent in agricultural and medical sciences, 58.1 per cent in engineering and natural sciences and 60 per cent in social sciences). Social sciences had more collaborations with governmental bodies (25 per cent) than both agricultural and medical sciences (14.3 per cent) and engineering and natural sciences (19.4 per cent), which is perhaps unsurprising given that social sciences may be more likely to strive for policy change through directly engaging governmental bodies. Engineering and natural sciences had the most collaborations with industry (29 per cent).
compared to other fields, which is to be expected given that the majority of grants under the industrial innovation assistance programme were allocated to this field (see Table 8.1). Respondents in the social sciences field also collaborated with charities and independent NGOs more frequently than any other field.

**Figure 8.7: Percentage of collaborative agreements made with stakeholder bodies by field, inside and outside Oman**

![Percentage of collaborative agreements](image)

Respondents were also asked about the type of benefits that accrued as a result of these collaborations, both for their organisation and for the collaborating organisation. When asked if there were benefits for their organisation as a result of collaboration, 66.7 per cent of respondents in the agricultural and medical sciences reported there were, followed by 61.3 per cent of respondents in engineering and natural sciences, and 50 per cent of respondents in social sciences. Fewer respondents reported benefits for the collaborating organisation across the fields comparatively, which is to be expected in a fairly young research system. It may also show that TRC-funded researchers are looking for collaborations with more established institutions which may have positive impacts on capacity building. When asked if there were benefits for the collaborating organisation, 54.8 per cent of respondents in the engineering and natural sciences field reported there were, followed by 50 per cent in the social sciences and 42.9 per cent in the agricultural and medical sciences. There is a considerable drop then, in the number of respondents who considered that there were benefits to the collaborating organisation compared to their own – particularly in the field of agricultural and medical sciences. The kinds of benefits that were reported for both the researchers’ organisations and those with which they collaborated are shown in Figure 8.8 and Figure 8.9.
Figure 8.8: Types of benefits for TRC-funded researchers and their research organisations as a result of collaborations
Figure 8.9: Types of benefits for organisations collaborating with TRC-funded researchers
8.5. Creating a research infrastructure

The questions in this section of the survey asked about whether research projects have led to wider benefits in building a research infrastructure in Oman. The intention was to explore what tools, resources and additional infrastructure TRC-funded research produced, or further supported, that could be used for further research inside and outside Oman. Figure 8.10 below shows where the main impacts arose in each section of the survey by field. Each of these areas is then explored in more depth below.

**Figure 8.10: Impact array for each field in the area of technical capacity building**

The impact array shows that relatively few impacts were reported in this area. It should be noted that the alternate shading in the array between agricultural and medical sciences and engineering and natural sciences on the one hand and social sciences and humanities on the other hand reflects that different sets of questions were asked to these two groups.

The first set of questions asked about the characteristics of any databases produced in Oman. A large proportion of respondents across all fields reported that they have produced a database or collection of
research material from their TRC-funded research. This is shown in Figure 8.11 below. However, although a high proportion of respondents have produced a database or collection of research material, very few of these resources are actually being used – either inside or outside Oman. Only the fields of engineering and natural sciences (which reported the highest levels of use) and social sciences reported any kind of use. Universities in Oman were the group which used the resources most, although only 12.9 per cent of engineering and natural sciences respondents, and 10 per cent of social sciences respondents reported use. The only other groups in Oman reported to use these resources by social sciences respondents were charities or not-for-profit organisations (5 per cent) and international organisations (5 per cent). Engineering and natural sciences respondents reported usage by more groups inside and outside Oman, including private sector research organisations or consultancies (9.7 per cent inside Oman and 3.2 per cent outside Oman), public sector agencies (9.7 per cent inside Oman and 6.5 per cent outside Oman) and educational organisations outside the higher education sector (9.7 per cent inside Oman and 3.2 per cent outside Oman).

The second set of questions asked about the development of a new technology or methodology. Interestingly, fewer respondents reported the development of a new technology or methodology than a new database, although reportage of use was comparatively much higher (shown in Figure 8.13 below). Figure 8.12 below presents the percentage of respondents who reported the production of a new technique or methodology for analysing research material. Respondents from the social sciences field reported producing techniques or methodologies for others to use the most, and the humanities field did not report the production of any techniques or methodologies (although the humanities data are only representative of one respondent).
When asked about the kinds of organisations that use these techniques, universities were reported most frequently across all fields (excluding humanities). Private sector research organisations and consultancies were the next highly reported group for the engineering and natural sciences field. A break-down of the groups using the new technique or methodology can be found in Figure 8.13 below.

**Figure 8.13: Organisations that have used the new technique or methodology for analysing research material**
Figure 8.14 shows the percentage of respondents who have produced a database or technique not previously accessible in Oman as a result of their TRC-funded research. Respondents from the agricultural and medical sciences field reported the production of such material the most (61.9 per cent), followed by respondents from engineering and natural sciences (48.4 per cent) and the social sciences (40 per cent). Universities were reported as the main user of this material across all fields, followed by public sector research organisations for engineering and natural sciences (23 per cent) and public sector agencies for all other fields (excluding humanities).

Respondents from agricultural and medical sciences, as well as engineering and natural sciences, were also asked about the production of a research laboratory and basic or specialised research equipment as a result of their TRC-funded research, the results of which are presented in Figure 8.15. A high proportion of respondents reported that their research led to new laboratory equipment or infrastructure being introduced into Oman in both the agricultural and medical sciences (85.7 per cent) and the engineering and natural sciences (83.9 per cent). However, a far higher proportion of respondents from the engineering and natural sciences field had had a laboratory built from scratch (67.7 per cent) compared with respondents from the agricultural and medical sciences (33.3 per cent). Given that both of these fields require large specialised equipment in order to conduct research, it is perhaps unsurprising that they have had an impact on research infrastructure. Indeed, the percentage of respondents who reported the production of highly specialised equipment or material was significantly higher than those who reported the production of basic equipment or material.

Respondents also reported fairly high usage rates of both the new laboratories and the new equipment. In terms of the laboratory use, other TRC-funded research groups were the primary user in both fields, reported by 32.3 per cent of agricultural and medical science respondents and 14.3 per cent of engineering and natural sciences respondents. Educational organisations not funded by TRC were also a
significant user for respondents from the engineering and natural sciences field (22.6 per cent). In relation to equipment use, universities inside and outside Oman were the primary user for both fields, followed by public sector agencies and private sector research organisations.

Figure 8.15: Percentage of respondents who have produced a laboratory, basic or specialised equipment as a result of their TRC-funded research

8.6. National and international visibility

This section asks about the dissemination of research outputs in order to enhance visibility both inside and outside Oman. Questions were asked which sought to determine how research was communicated to audiences outside of academia, and how this might contribute to public knowledge creation. Figure 8.16 shows the impact array for the responses in this impact category across all disciplines.
Overall, 57.5 per cent of respondents indicated that they had made their TRC-funded research accessible to the public outside of the academic community. The spread of this response was relatively similar across fields (agricultural and medical sciences 57.1 per cent; engineering and natural sciences 58.1 per cent; social sciences 45 per cent; humanities 100 per cent – although there was only one respondent). The number of times an outlet was reported is shown by field below.
## Table 8.3: Number of responses reporting dissemination in non-academic research outputs by field

<table>
<thead>
<tr>
<th>Field</th>
<th>Article in an open source journal</th>
<th>Article in a general circulation publication</th>
<th>Textbook</th>
<th>Entry in reference books</th>
<th>Online research resource</th>
<th>Programme notes for art or architecture exhibitions</th>
<th>Editorials or opinion pieces</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural and medical sciences</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Engineering and natural sciences</td>
<td>17</td>
<td>9</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Social sciences</td>
<td>9</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Humanities</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

As can be seen from the table above, a range of outputs were identified in all fields. Articles published in open source journals were the most popular research outlets, with other popular outlets including articles in a general circulation population and online research resources. Further analysis of this in the future might explore where researchers are publishing and how this is contributing to sharing TRC-funded research. In particular, it would be worth assessing the extent of the use of social media, open access, online-based journals and other outlets available to researchers – possibly through novel bibliometric tools such as Altmetrics.

We also asked respondents about the methods they had used in communicating their research to the public – the results of which are presented in Figure 8.17 below. A significant proportion of engineering and natural sciences, and social sciences respondents reported presenting their findings of TRC-funded research to the public, 64.5 per cent and 65 per cent respectively, and 38.1 per cent of agricultural and medical sciences respondents also reported communicating their research to the public. The humanities respondent reported they had not reported findings to the public – although these data are only representative of one respondent. Moreover, the humanities respondent did report that their research had been disseminated by a press release, suggesting that some communication to the public had taken place. The majority of engineering and natural sciences and social sciences respondents also reported that their research had been the subject of a press release – 54.8 per cent and 60 per cent respectively.

The use of online publications was a popular means for communicating research findings to the public and was reported by 33.3 per cent of agricultural and medical sciences respondents, 61.3 per cent of engineering and natural sciences respondents and 60 per cent of social sciences respondents. However, a minority of respondents across all disciplines reported their research had been communicated by either a press conference (19.2 per cent) or a media interview (9.6 per cent). This is not surprising as these formats are indicative of sustained interest in an area and actual uptake of the research findings or very topical ‘breakthrough’ findings. Nevertheless, the findings do show that a range of communication and engagement activities have been employed in disseminating research findings to the public.
We also asked respondents what the intended purpose of their dissemination activities were in relation to public knowledge and debate. The results to this question are displayed in Figure 8.18 below. The primary purpose for public dissemination in the agricultural and medical sciences and the engineering and natural sciences was helping to improve the public appreciation of research (reported by 61.9 per cent and 64.5 per cent of respondents respectively) – although it should be noted that this option was not provided to social sciences respondents in the survey. The primary reasons for public dissemination in the social sciences were helping to structure the public debate (65 per cent), changing how the public reads and/or understands research (55 per cent) and providing salient, high-quality evidence to inform the public debate better (40 per cent). It is perhaps not surprising that the purpose for social science dissemination was more focused on public debate than the hard sciences, as the ultimate intended impact of scientific research is generally not to feed into debate – it is rather to produce new innovations or scientific expertise. Finally, the humanities respondent noted that their research had provided salient high-quality evidence to feed into the public debate.
8.7. Creating knowledge-based societies

This section asked questions about the extent to which a broader culture for research is being created in Oman and how this is building a wider knowledge base which informs and meaningfully contributes to all aspects of society. This could be through public outreach and engagement in research, contributions to education and learning, business practices and/or legal outcomes. It also asked about impacts on public policy, for example if TRC-funded research was informing policymaking processes and/or decisionmaking in policy entities (e.g. national government, GCC, industry, etc.) as well as cultural impacts – such as contributions to cultural enrichment, public events, the creative industries and preservation of heritage.

Figure 8.19 below shows the impact array for this section of the survey. Compared to other types of impacts, there are relatively few impacts in this area across the disciplines. However, the social sciences field has reported a number of impacts in relation to benefits for business and professional practices and benefits for public policy. Engineering and natural sciences and the social sciences also have a number of impacts in relation to benefits for education and learning.

We will discuss the results across the survey in turn, following the order set out in the impact array.
Figure 8.19: Impact array for each field in the area of creating a knowledge-based society

8.7.1. Benefits for education and learning

Figure 8.20 below shows that a number of researchers from all fields excluding the humanities have contributed to teaching activities at school, university and professional practice levels as a result of their research - outside of their own standard teaching activities. Respondents in the social sciences discipline were active influencers of teaching activities at school and professional practice levels, with 40 per cent of respondents in that discipline reporting impacts on teaching in these areas. The primary ways in which social sciences respondents reported they had influenced teaching activities at the school level were presentations to students in Oman (20 per cent) and contributions to school curriculum content (20 per cent) (although there was a spread across a range of ways in which they influenced school teaching). The primary ways in which social sciences respondents reported influencing teaching activities at a professional practice level were through contributing to ongoing professional development course content (20 per cent), contributing to online research tools/resources (20 per cent) and providing mentoring or consultancy to practitioners (20 per cent), although again, there was a spread across a range of ways in which they influenced teaching in professional practice. As seen in the figure below, 30 per cent of social sciences respondents also reported an influence on teaching activities in further or higher education.

In addition, 32.3 per cent of engineering and natural sciences respondents reported an impact on influencing teaching activities in further or higher education. The primary ways in which respondents had achieved this were through involving undergraduates in the research (29 per cent) and informing a live presentation for students (16.1 per cent). Respondents in this discipline also reported impacts on school students (12.9 per cent) and practitioners (19.4 per cent).

Relatively few respondents reported influencing teaching activities in the agricultural and medical sciences, although 14.3 per cent did note an impact on the training of professional practitioners, and 9.5 per cent reported an impact on teaching activities in further or higher education.
Figure 8.20: Percentage of respondents from each field influencing teaching activities

8.7.2. Benefits for business or professional practice

Figure 8.21 below shows how TRC-funded research has impacted on business or professional practice across the disciplines. It illustrates that very few respondents have reported influence in this area, although 45 per cent of respondents in the social sciences discipline reported an influence on organisations’ regulations, policies and procedures. Respondents reported they achieved this in a diverse number of ways including through the use of their research in training or helping improve the skills of practitioners (20 per cent), improving the accessibility and use of business services by clientele (15 per cent), improving the effectiveness of business practice in meeting its objectives or serving its clientele (15 per cent) and improving the conservation of natural resources by helping to change business activities or procedures (15 per cent).

An impact on professional practice through improving the social welfare of employees or clients in an organisation was also reported by 14.3 per cent of agricultural and medical sciences respondents, 12.9 per cent of engineering and natural sciences respondents and 20 per cent of social sciences respondents. Across all disciplines, the primary way in which this was done was through introducing more culturally appropriate procedures or practices (10.9 per cent) followed by changes to policies and practices for corporate social responsibility or ethical standards (6.8 per cent).
8.7.3. Benefits for public policy and public services

Figure 8.22 below outlines how respondents have impacted on various stages of the policymaking process within Oman. As outlined above, respondents from the social sciences discipline reported the highest number of impacts in the area of public policy and public services. This is likely to be due to the fact that informing the policy process is often the intended end-point of research activities in this discipline. The humanities respondent did not report any impacts on policy from their research, although again these data are only representative of one respondent.

As shown below, 50 per cent of social sciences respondents reported identifying policy issues, while 45 per cent reported both communicating their research to policymakers and informing the policymaking process through their research. Respondents reported it was primarily government institutions and other organisations in Oman who had used or considered their research. The primary way in which research had impacted on the policymaking process in the social sciences was through influencing the writing of policy guidelines (15 per cent).

Interestingly, for the engineering and natural sciences discipline, fewer respondents had identified policy issues than had communicated their research to policymakers. It may be that communication to policymakers had not taken place with a particular policy change or recommendation in mind. Respondents in this discipline reported that the primary means of communicating the findings of their research to policymakers was written research papers or oral briefings for His Majesty Sultan Qaboos (9.7 per cent).

Finally, the agricultural and medical sciences had a particularly low number of respondents who had communicated their research to policymakers (9.5 per cent) compared with the number that identified policy issues (23.8 per cent) and those who had informed policymaking (19 per cent). When asked
whether their contributions led to any changes in the policy process, one respondent noted that their research improved the knowledge base for policy development, although no other answers were given. Given that most TRC-funded research is relatively recent, it is not surprising that there have not been large impacts in the policymaking process, as there is usually a time delay in this process.

Figure 8.22: Percentage of respondents who have influenced various stages of the policymaking process within Oman

Only 3 (4.1 per cent) respondents across the disciplines reported their research being used to inform the policymaking process outside of Oman.

8.7.4. Cultural benefits

Questions in this section of the survey asked about the nature of different cultural benefits which might have resulted from TRC-funded research. As can be seen from the impact array for this section (see Figure 8.19), very few cultural impacts were reported across the disciplines. Table 8.4 below shows the small amount of cultural impacts which were reported in the survey across the disciplines. However two of the cultural categories were not asked of the agricultural and medical sciences and the engineering and natural sciences.
### Table 8.4: Number of respondents reporting various cultural impacts

<table>
<thead>
<tr>
<th></th>
<th>Agricultural and medical sciences</th>
<th>Engineering and natural sciences</th>
<th>Social sciences</th>
<th>Humanities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery of cultural activities or events</td>
<td>2 (9.5%)</td>
<td>5 (16.1%)</td>
<td>4 (20%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Preservation of cultural heritage</td>
<td>N/A</td>
<td>N/A</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Production of new cultural goods to promote culture and creativity to the public</td>
<td>N/A</td>
<td>N/A</td>
<td>3 (15%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

#### 8.8. Creating knowledge-based economies and generating IP

The final two sections of the survey asked questions about impacts on creating a knowledge-based economy and whether any new products had been developed as a result of TRC-funded research. A knowledge-based economy is one which is diverse and draws on a world-class infrastructure, efficient delivery mechanisms, a highly skilled and productive workforce, and creates opportunities for innovation and entrepreneurship. Questions in this section asked about the diversity of economic benefits which might arise and that can be associated with TRC-funded research including employment opportunities, revenues and so on.

The impact array for the knowledge-based economy section is shown below (see Figure 8.23). There were relatively few positive responses across the disciplines in relation to questions on generating IP and patents, so this part of the impact array is not displayed here – although those results are explored in detail below. The impact array shows many respondents indicated impacts in relation to generating additional revenue and economic activity, although very few respondents reported that they had created a new business or that their research resulted in an existing business or company moving to Oman. A number of social sciences respondents and the humanities respondent also reported they had contributed to the development of sustainable, ethical or other alternative economic activities.
Some 76.7 per cent of respondents reported that their TRC-funded research has generated additional revenue and economic activity. Figure 8.24 below presents the ways in which this revenue was generated by field. The primary way in which economic activity was generated for both the agricultural and medical sciences, and engineering and natural sciences was through generating revenue for the university and community by attracting students (47.6 per cent and 41.9 per cent respectively), although it should be noted that this option was not given to the other disciplines. These disciplines also generated economic activity in a range of other ways, such as securing external funding (38.1 per cent and 22.6 per cent respectively), attracting new firms to use infrastructure (19 per cent and 32.3 per cent respectively) and contributing to employment in the public, private and not-for-profit sectors (19 per cent and 32.3 per cent respectively).
The humanities respondent noted two ways in which their research had generated economic activity – through contributing to the creative economy and contributing to employment in the public, private and not-for-profit sectors. In terms of social sciences, the main ways in which respondents reported the generation of economic revenue was through attracting capital investment and through generating revenue for not-for-profit organisations. The social sciences, like the humanities, is not a field which is traditionally linked with economic benefits. The fact that respondents have reported economic impacts in these fields is encouraging, and may be worth TRC exploring further in the future (through case studies for example).

Figure 8.24: Ways in which TRC-research has generated additional revenue and economic activity by field

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Social sciences and humanities respondents also reported a number of ways in which they contributed to sustainable, ethical or alternative economic activities – a question which was only asked of the social sciences and the humanities disciplines. The primary way in which research had this impact across the two disciplines was through economic activities that promote or further the decent work agenda (e.g. job creation, rights at work, social protection or gender equality at work) – reported by 35 per cent of social sciences respondents and the one humanities respondent.
The section of the survey specifically related to generating patents, products and intellectual property showed that a significant proportion of TRC-funded research has the potential to have impacts in this area in the future. This was most pronounced in the fields of agricultural and medical sciences and engineering and natural sciences, which is to be expected given the higher propensity of these fields to generate products and IP.

Table 8.5 below sets out the number and percentage of respondents who have generated inventions, products, IP or revenues to date, or expect to do so in the future. Cells which contain N/A signal that the type of impact is not relevant to the discipline in question, and therefore questions about that impact were not asked of survey respondents in that discipline. A significant proportion of respondents in the agricultural and medical sciences field noted the likelihood of impacts in this area in the future including the protection of research through patents or IP (52.4 per cent), the development of a complex intervention to improve patient health or care (52.4 per cent), the development or trialling of a therapeutic pharmaceutical product (33.3 per cent) and the development or trialling of a diagnostic test (38.1 per cent). Respondents in the field of engineering and natural sciences also reported a number of impacts in this area which are likely to happen in the future, including the protection of research through patents or IP (54.8 per cent), the commercial development of a product or process (61.3 per cent) and the development of a product or process which could have wide impacts on society (64.5 per cent). Respondents from the social sciences also cited the protection of research through patents or IP as a likely future impact (40 per cent) along with the production of a new product for the marketplace (40 per cent). The humanities did not report any impacts in this area – either which have already occurred or which are likely to occur in the future. This is not surprising as humanities research is unlikely to have impacts in these areas, and these data are only representative of one respondent.

Table 8.5: Number and percentage of respondents who have generated inventions, products, intellectual property and revenues

<table>
<thead>
<tr>
<th>Research cited by patents or IP protected through copyright or trademark</th>
<th>Agricultural and medical sciences</th>
<th>Engineering and natural sciences</th>
<th>Social sciences</th>
<th>Humanities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>Likely to be in future</td>
<td>Yes</td>
<td>Likely to be in future</td>
</tr>
<tr>
<td>Research cited by patents or IP protected through copyright or trademark</td>
<td>0 (0%)</td>
<td>11 (52.4%)</td>
<td>3 (9.7%)</td>
<td>17 (54.8%)</td>
</tr>
<tr>
<td>Complex intervention to improve patient health or care produced</td>
<td>2 (9.5%)</td>
<td>11 (52.4%)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Product or process developed commercially</td>
<td>N/A</td>
<td>N/A</td>
<td>2 (6.5%)</td>
<td>19 (61.3%)</td>
</tr>
<tr>
<td>New product designed for the marketplace produced</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Development or trialling of a therapeutic</td>
<td>0 (33.3%)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Impact Description</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Development or trialling of a diagnostic test</td>
<td>1</td>
<td>8</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>(4.8%)</td>
<td>(38.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development or trialling of a new medical device</td>
<td>0</td>
<td>3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>(0%)</td>
<td>(14.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product of process which is being developed for wider use in a non-commercial environment</td>
<td>N/A</td>
<td>N/A</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(16.1%)</td>
<td>(48.4%)</td>
</tr>
<tr>
<td>Development of a product or process which could improve health and/or well-being</td>
<td>N/A</td>
<td>N/A</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(19.4%)</td>
<td>(35.5%)</td>
</tr>
<tr>
<td>Development of a product or process which could improve public or private safety and security</td>
<td>N/A</td>
<td>N/A</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(6.5%)</td>
<td>(29%)</td>
</tr>
<tr>
<td>Development of a product or process which could have an impact on the environment</td>
<td>N/A</td>
<td>N/A</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(35.5%)</td>
<td>(38.7%)</td>
</tr>
<tr>
<td>Development of a product or process which could have other wide impacts on society</td>
<td>N/A</td>
<td>N/A</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(22.6%)</td>
<td>(64.5%)</td>
</tr>
</tbody>
</table>

### 8.9. Cross-cutting observations

Table 8.6 below shows the percentage of respondents who answered positively in each of the *ImpactFinder* categories, and serves as a numerical representation of the responses in the TRC impact array. In agricultural and medical sciences, and engineering and natural sciences, responses are concentrated on the left-hand side of the array, with the larger average responses occurring in these categories. However, a large proportion of respondents answered positively in the section on creating a knowledge-based economy, and these impacts primarily related to generating additional revenue and economic activity. Every respondent in the social sciences discipline answered positively at least once in all of the impact areas apart from generating inventions, products and IP – although, as explained above, a number of respondents in this field did suggest that these impacts are likely to arise in the future. It is difficult to interpret the humanities data, given that they are only representative of one respondent – and therefore all answers are either 100 per cent or 0 per cent.

A far smaller percentage of respondents answered positively to the section on generating inventions, products and IP than the rest of the impact areas across all of the disciplines. This is to be expected given that these are long-term impacts and the majority of TRC-funded projects are relatively recent.
8.9.1. Barriers to conducting research and attaining research impact in Oman

There were relatively few barriers identified through the survey, although respondents did highlight barriers in relation to bringing research equipment into Oman and disseminating their research. In relation to the former, a number of respondents highlighted problems with the procurement procedure, noting that the process is bureaucratic, time-consuming, and ultimately ineffective. Many commented on the delay in bringing in research materials, and one commented that it takes one year to bring research equipment to Oman. Others noted problems with finding an agent to bring the materials to Oman, heavy customs duty and the cost of bringing in specialised equipment as additional problems.

In relation to dissemination, some noted they do not feel there is a public audience for their research, while others noted that the process of dissemination is not well developed at their institution and suggested that TRC could play a role in helping them to disseminate their research.
9.1. Introduction

This chapter develops a model for case studies of TRC-funded research and also presents three example case studies. Each year, TRC can use the case study model presented here and conduct additional case studies that present current research. Three case studies presented in this chapter complement the findings of the other indicators.

Quantitative methods like bibliometric analysis and the ImpactFinder survey provide data on overall trends. Yet, these methods do not necessarily highlight the specific impact of particular research projects. Case studies offer a more detailed description of how research has had academic, social, economic or other impact.

A case study is an empirical inquiry that can combine both qualitative and quantitative analysis to provide a contextual and in-depth understanding of the subject in question. The case studies in this project were designed as to explore and illustrate the research impact that TRC’s funds have had thus far.

The rest of the chapter details the methodology that was used to design and conduct the case studies, and then presents the three cases that were selected for further development.

9.2. Methodology

The aim of the case studies is to formulate an answer to two research questions. The first question asks what impacts the project has had; the second question asks how this impact was achieved. In the case studies, the ‘what’ and ‘how’ of research impact are therefore explored in depth to generate an insight into the pathway by which funding of research can lead to impact. To conduct case studies, we apply a methodology consisting of four distinct phases: (1) identification and selection; (2) desk research; (3) interviews; (4) analysis and reporting. Each phase will be briefly discussed, and for the first phase we will outline how the current case studies were identified and selected.

9.2.1. Identification and selection

Case studies aim to illustrate particular cases of research or innovation impact. A prerequisite for potential case studies is therefore that the case has proven and tangible research impact. To identify and select case studies we have made use of the results of the ImpactFinder survey. Through the survey a number of cases
were identified with reported research impact. However, in order to create diversity within the sample, we did not simply select the three cases with the highest number of impacts. Our aim has been to select cases which cover different fields of science and different types of impact. Specifically, we shortlisted a number of cases for each Panel (Medical and agricultural sciences, Engineering and natural sciences, and Social sciences), and examined their respective policy, social, economic and technical capacity-building impacts (Table 9.1). This resulted in a list of potential cases with one case for each panel, and a diversity of impacts.

Table 9.1: Matrix for case study selection

<table>
<thead>
<tr>
<th>Policy impact</th>
<th>Economic impact</th>
<th>Societal impact</th>
<th>Technical capacity-building impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical and agricultural sciences</td>
<td>Potential case A</td>
<td>Potential case B</td>
<td>...</td>
</tr>
<tr>
<td>Engineering and natural sciences</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Social sciences</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

These researchers were then contacted to invite the researchers involved to participate in the case study. This invitation provided the researchers selected with the opportunity to request further clarifications, but also to indicate if they thought their case was suitable for selection. For one potential case, the research involved was still in an early stage, and the researcher deemed it too soon to conduct a full case study on the impacts. For this case an alternative was selected based on the same criteria. The final selection of three case studies thereby spans the diversity of impacts, ranging from technical capacity to social impacts.

9.2.2. Desk research

After the selection of the case studies, the second phase consisted of desk research to understand the background to the research and to examine any published outputs. The desk research drew on the following published materials:

- Summary of the successful grant application as stored in TRESS.
- Journal publications resulting from the grant (identified through the bibliometric analysis as well as Google Scholar searches) – verified through the acknowledgment on the paper of the TRC grant.
- Conference papers and presentation on the research under the grant.

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69 Panel D was omitted from the shortlist, as only one reply was received within Panel D.
The study of the published materials provided an understanding of the background to the research and was complemented by a detailed examination of the ImpactFinder survey results for the case. For each case, we extracted the exact impacts reported to gain a thorough understanding of the types of impacts that had been achieved by these cases. Combined, the published material and the ImpactFinder survey results provided the input for the interviews we then conducted with the lead researchers of the case.

9.2.3. Interviews

For each case one interview was conducted with the Principal Investigator on the grant. The interviews served multiple purposes and were used to:

- Understand the research underpinning the impact.
- Understand the nature of the impact and verify the findings from the desk research (i.e. establish the status of impacts reported in the ImpactFinder survey: were they still in progress or had they been fully achieved?).
- Understand the next steps.

In the interviews we also requested any other published material available on the research conducted under the grant to ensure nothing was missed.

9.2.4. Analysis and reporting

The data collected for the case study (published material, ImpactFinder survey results, interviews) were then analysed to obtain a rounded picture of the case and to establish a coherent story. In reporting we have adhered to a similar structure for each case to ensure that the results are easy to read and understand.

9.3. Limitations

The validity of the data and the generalisability of the findings are two of the common concerns in conducting case studies in general. Case studies by nature however, do not aim to be generalizable, but rather aim to illustrate in depth some of the impacts (“success stories”) of TRC funded research. In relation to the validity of data, critics of case studies point out that investigators are often subjective. To mitigate this risk as far as possible we considered two points. The first one was designing a set of explicit procedures that follow clear criteria and applying these procedures equally across the different cases. The second one was validating the data through the use of multiple data sources instead of only one source: the interviews, the project’s progress and final reports and TRC’s online documentation. Some case studies, however, had less available information than others.

We now present each of the three case studies. Each is presented according to a similar format, with a short summary of the case study provided to give an overview of the research and impact. Further detail is then given on the underpinning research, the description of the impact, and the next steps for the research team.
9.4. Case study 1: Medical Sterilisation Systems Using a Solar Concentrated Parabolic Dish Collector – a case with potential for high economic impact

9.4.1. Case study summary

This case study focuses on research undertaken at the chemical engineering department at Dhofar University by Dr Aref Wazwaz (PI), Dr Yousef Gharbia (Co-I) and Dr Said Grami (Co-I). As well as the PI and Co-Is, two undergraduate students from the chemical engineering department were involved as research assistants. The team set out to use a Solar Beam Station (SBS) to sterilise water and medical equipment. The SBS consists of a large parabolic dish collector which has a surface able to absorb all radiations in the solar range and convert them into heat.

The original SBS was purchased by the research team, although the purchased SBS has only previously been applied to heating water domestically. The research team developed a solar steriliser which can be used with the SBS in order to sterilise water and they intend to use the SBS for a wide range of applications which require heat energy in the future such as the sterilisation of medical equipment, the production of electricity using a sterling engine, the desalination of sea water, the production of thermal chemical reactions and the production of biofuel.

In addition to the development of the solar steriliser for use with the SBS, an Automated Weather Station (AWS) was purchased in order create a continuous solar database at the university. Situated on the roof of the chemical engineering department at the university, the AWS has three sensors:

- A pyranometer to measure the solar irradiance per m2 on Dhofar University
- A relative humidity sensor
- An atmospheric temperature sensor.

Together, it is hoped that the SBS and AWS will provide Dhofar University with the tools to measure and use solar energy effectively. It is hoped that this will bring a range of various impacts. A wide range of impacts were reported in the ImpactFinder survey, although it should be noted that on further investigation many of the reported impacts have not occurred yet and are anticipated to occur in future. Therefore the impacts from this project should be closely monitored over the next few years to ensure that resulting realised impacts are captured.

Firstly, the use of the SBS to sterilise water and medical equipment may have impacts on health and society more broadly. In addition, the use of the SBS to produce biofuel or to generate electricity would benefit the environment given that renewable energy could be used in the place of fossil fuels. Moreover, if the SBS is used to desalinate sea water, or purify other sources of water which are not safe to drink, it may be able to provide a cheap source of available drinking water for Oman.

The findings from this research have been published in the Journal of Purity, Utility Reaction and Environment as well as in two conference proceedings – the 2013 World Congress on Advances in Nano, Biomechanics, Robotics and Energy Research, and the 2013 Global Conference on Renewable Energy Approaches for Desert Regions (GCREADER). Two articles have also been submitted to the Sustainable Cities and Society journal and the Energy journal, and are currently under review.
Table 9.2: Case study 1 summary table

<table>
<thead>
<tr>
<th>Case study title</th>
<th>Collaborating institutions</th>
<th>Start and end dates</th>
<th>PIs and Co-Is</th>
<th>Main areas of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Sterilisation Systems Using a Solar Concentrated Parabolic Dish Collector</td>
<td>Dhofar University</td>
<td>June 2011-June 2014</td>
<td>Dr Aref Wazwaz (PI)</td>
<td>Technical capacity building</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Yousef Gharbia (Co-I)</td>
<td>High potential for economic impacts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Said Grami (Co-I)</td>
<td>Generation of products that could impact on the environment and society</td>
</tr>
</tbody>
</table>

9.4.2. Research underpinning the impact

The aim of this project was to develop an infrastructure which would allow the use of solar energy for a wide range of purposes. Prior to this project, a solar concentrated parabolic dish collector had not been used in Oman. This project specifically focused on sterilising water through the infrastructure, although a wide variety of other applications were also considered. Indeed, the project initially intended to sterilise medical equipment, although as facilities were not ready in time, the team suggested sterilising medical equipment in a solar autoclave in the future. As stated above, it is also hoped that a range of other research projects will be undertaken with the SBS in the future, enabling outputs such as the desalination of water, the production of electricity and the drying of fruit.

In using the SBS to sterilise water, a solar steriliser was developed which consists of U-shaped copper pipes inside a rectangular steal enclosure. Inside the enclosure there is a heat transfer fluid and a pumping system which allows polluted fluid to enter the system, flow through the system and leave the system. The process is also monitored digitally through the use of specialist software. Although other sterilisation systems exist, Dr Aref believed that the particular system developed through this research is unique and has not been used previously, either in Oman or elsewhere.

The project team found that the solar steriliser was successful in heating water to temperatures required for sterilisation. The research used tap water to test the system. The tap water was tested before sterilisation and was found to contain small amounts of E. Coli bacteria. After heating the water to 77°C and 84°C the tap water was retested and was not found to contain any E. Coli.

From October 2012 onwards the AWS was used to collect data on solar radiation, relative humidity and atmospheric temperature every 60 seconds. This research found that the maximum solar flux, the maximum accumulative solar flux, the maximum relative humidity and the maximum atmospheric temperature occurred in March, and therefore March is the best month in winter for solar energy conversion at Dhofar University. It also found that the Al Saadah-Salalah region receives a large amount of solar radiation and is therefore a good region for solar energy applications. As such, this research can be
used to enable solar energy to be employed most effectively when the environment conditions are at their optimum for supporting solar applications.

9.4.3. Impact description

This case study was selected since a wide range of economic impacts were reported to have resulted from this project in the ImpactFinder survey. Therefore, this section focuses particularly on the economic impacts which have arisen or may arise from the research, although it is also important to note the impacts this research has had in relation to creating research infrastructure. As noted above, a wide range of impacts were reported in the ImpactFinder survey although on further investigation many of the reported impacts have not occurred yet and are anticipated to occur in future. Therefore the impacts from this project should be closely monitored over the next few years to ensure that resulting realised impacts are captured. With this in mind, this research represents a case for high potential impact and marks a significant contribution to research infrastructure.

The creation of this solar infrastructure marks the development of a process which has the potential to improve health, have a positive impact on the environment and on society more broadly. The sterilisation of water may remove issues associated with bacterially infected water, which Dr Aref reported had been responsible for cases of illness in Oman, thereby improving population health, and the sterilisation of medical equipment through this cheap system may improve the outcomes of medical procedures and have an added economic advantage. The use of solar power to generate electricity, rather than the use of non-renewable fuels, would also have a positive impact on the environment. For the sterilisation of water, the project has reached the proof of concept, testing, design and development stage. However, the use of the parabolic dish collector for other applications still needs to be explored.

It is important to note the large contribution of this infrastructure to technical capacity building. This equipment is now available for use at Dhofar University, and it is hoped that chemical engineering students will use the SBS and the AWS for their research projects, which Dr Aref anticipates will attract more students to the university – thereby generating revenue. In the future Dr Aref intends to monitor how far students have been attracted by this infrastructure in order to evidence this impact.

The solar sterilisation system is not currently being used to provide clean drinking water to residents in Dhofar. However, Dr Aref noted that there are a high number of springs in the region, which would facilitate the use of the system to pump clean water to homes. If this system was introduced, it could have an impact on employment, given that it could take up to five employees to operate the system on each spring.

In terms of further future impacts, Dr Aref noted that the high number of applications for the parabolic dish collector may mean firms could be established which use this infrastructure, or a new business could be spun out of the research – for example a business to install systems to sterilise spring water in the Dhofar region.

9.4.4. Next steps

In terms of immediate next steps, Dr Aref stated that he will improve the system in the first instance. In the medium term, he will also apply for further funding in order to develop a number of other
Developing a research impact performance management system

applications for the parabolic dish collector, including the development of a solar autoclave for medical sterilisation, to explore how the dish can be used to make thermal chemical reactions and to dry fruit. Dr Aref expects this further research will be financially supported by Dhofar University, given that, given that the procedures required to receive a TRC grant are time-consuming.
9.5. Case study 2: Comparative, Phytochemical and Microbiological Study of Omani Luban (Boswellia Sacra) and Related Frankincense Species – a case of technical capital impact

9.5.1. Case study summary

The second case study focuses on research conducted at the University of Nizwa under the leadership of Professor Ahmed Al-Harrasi and Dr Javid Hussain. While the original research underlying this project started with the work of Prof. Al-Harrasi upon his return to Oman, after studies in Germany and the US (PhD and post-doc), the current research group at Nizwa combines experts from various disciplines and continues to grow. The central focus of the research has remained constant, however: Omani frankincense (Boswellia sacra).

Frankincense is an ancient and highly valued product native to Oman. Globally, various species of frankincense exist, such as the Indian and Ethiopian species. In many of the societies to which frankincense is native it has been used for therapeutic and medicinal purposes. More recent academic research on frankincense has been conducted on the Indian and Ethiopian species, yet the specific properties of the Omani frankincense remained unexplored. These studies provided clear indications of the medicinal properties of frankincense and triggered Prof. Al-Harrasi to explore the exact chemical nature of the Omani frankincense and to link possible compounds derived to medical treatment.

The work at the University of Nizwa that has now been funded through two TRC grants (ORG/CBS/10/002 and ORG/CBS/12/004) therefore roughly consists of two parts: the study of the composition of Omani frankincense and the exploration and further development of its compounds for medical treatment. Findings from both parts have already been published in a number of articles in Chemistry and Biodiversity, the International Journal of Phytomedicine, the Tropical Journal of Pharmaceutical Research, the Asia Pacific Journal of Tropical Biomedicine, and Records of Natural Products.

Table 9.3: Case study 2 summary table

<table>
<thead>
<tr>
<th>Case study title</th>
<th>Comparative, Phytochemical and Microbiological Study of Omani Luban (Boswellia Sacra) and Related Frankincense Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborating institutions</td>
<td>University of Nizwa</td>
</tr>
</tbody>
</table>
| Start and end dates | ORG/CBS/10/002: 2011-2014  
ORG/CBS/12/004: 2012-2015 |
| PIs and Co-Is | ORG/CBS/10/002: Prof. Al-Harrasi [PI], Prof. Al-Rawahi [Co-PI], Mr Al-Sabahi [Co-PI]  
ORG/CBS/12/004: Dr Hussain [PI], Prof. AHHarasi [Co-PI], Prof. Gibbons [Co-PI], Prof. Guillemin [Co-PI] |
| Main areas of impact | Technical capacity building  
Collaborations |
9.5.2. Research underpinning the impact

The research underpinning the work now stretches over several years and has been conducted in various stages. The first stage of the research consisted of the examination of the chemical properties of the Omani frankincense. While the properties of various other species of frankincense have been documented, the Omani frankincense had remained largely unexplored. In order to study the chemical constituents of the Omani frankincense they first have to be isolated. Column and high performance liquid chromatography techniques were used to isolate the chemical constituents. Moreover, the essential oil of the frankincense is obtained using distillation techniques, including both traditional hydro-distillation as well as a new method developed at the Chair of Oman’s Medicinal Plants at the University of Nizwa using microwaves. This second technique has been published.

Following distillation, the frankincense oils were analysed using gas chromatography mass spectroscopy (GC-MS) in order to identify the chemical compounds. Various chromatographic techniques were employed including Thin Layer Chromatography (TLC), High Performance Thin Layer Chromatography (HPTLC), Column Chromatography (CC) and High Performance Liquid Chromatography (HPLC). Furthermore, with the help of the TRC grants, the University of Nizwa was able to purchase a Nuclear Magnetic Resonance (NMR) Spectrometer through which detailed information about the structure of the compounds can be obtained. Through this study the researchers were able to establish and isolate the compounds present in Omani frankincense, which in turn could be used for the exploration of medical treatment. Two of the more important compounds identified have been 11-keto-β-boswellic acid and 3-O-acetyl-11-keto-β-boswellic acid, also known as KBA and AKBA, which have been linked to a number of medical properties, one of which is apoptosis (or programmed cell death) of cancer cells. The latter link, unsurprisingly, helped the researchers make media headlines.70

The second stage then consisted of applying the various compounds obtained from Omani frankincense in medical experiments to examine possible therapeutic effects. Several experiments were conducted both in vitro and in vivo (jointly with collaborators) to examine the effectiveness of the isolated compounds as a treatment. The studies showed the potential properties of frankincense oil to act as an antioxidant, anti-inflammatory, anti-glycation (linked as a treatment of diabetes), and as an analgesic (pain killer). In most studies, the frankincense oil proved to be as powerful, or more powerful, than existing medicines such as Aspirin. Current research now focuses on expanding the examination of the potential medical properties of Omani frankincense, in particular the compounds linked to cancer treatment, especially breast cancer.

9.5.3. Impact description

This second case was selected given the relatively high number of technical impacts reported in the ImpactFinder survey for grants ORG/CBS/10/002 and ORG/CBS/12/004. With regard to the technical

impacts, three main areas of impact emerged as a result of the research undertaken: the development of a new distillation method; the acquisition of the NMR; and the development of a database.

First, the traditional technique to extract oils from organic materials such as frankincense is hydro-distillation. This technique can, however, be assisted with the use of microwaves. For the extraction of oils from frankincense this combined technique has been explored and compared to traditional hydro-distillation. The results of this work are currently in press and have been patented under a 1-year Australian provisional patent.

Second, the acquisition of the NMR by the University of Nizwa with financial help from the TRC grants, helped to improve highly the accuracy of the analysis of frankincense. However, apart from making a direct technical and scientific contribution to the work of Prof. Al-Harrasi and colleagues, the purchase of the NMR proved to have much wider technical impacts. The NMR at the University of Nizwa is currently the only functioning NMR of this quality in Oman. This means that researchers from all of Oman, and indeed from the wider region (Pakistan, Iran, UAE) are interested to use the facility. As such, the NMR allows the researchers at Nizwa to collaborate with a broad number of researchers both within and outside of Oman, and has enabled them to expand their networks. It has even opened up collaborations with local industries. The direct technical impacts have thereby enabled further impacts in terms of collaborations which were also visible from the ImpactFinder survey.

Third, the research conducted has allowed for the construction of a database of ‘spectra’ of the frankincense studied. The different spectra indicate the presence and type of compound within certain materials, and thereby serve as a kind of library that will allow future researchers to pick up where current researchers left off, and hence will help to avoid duplication of efforts.

All these impacts in turn serve to enable future impacts related to the identification and testing of potential medical treatments using frankincense. These impacts will likely focus on the effects of AKBA and KBA, and their further analysis in relation to frankincense and possibly other plants native to Oman.

9.5.4. Next steps

The next steps will include an expansion of the current work undertaken. Currently, the University of Nizwa is building the facilities to conduct in vivo tests (e.g. on mice) and is expanding the research group dedicated to this study through the inclusion of biologists and medical experts. The major focus of the research will be on cancer, as breast cancer in particular has been identified as a major public health risk in Oman. A new grant application to TRC aims to ensure funding for the continuation of this work.

Finally, in order to share and disseminate the findings, Prof. Al-Harrasi and colleagues are planning to publish the findings arising from these various strands of research in a book. While results have already been published in journal articles, a book would bring the findings together in one place.

9.6.1. Case study summary

The third case study focuses on research conducted at Sultan Qaboos University under the leadership of Professor Mohamed Essa, and the social impact resulting from it. The research conducted under the TRC grant focused on the effect that fruits native to Oman might have on several cognitive diseases, such as Alzheimer’s disease. With the use of the TRC grant, Prof. Essa and colleagues were able to establish a new research group at SQU to conduct this work, named the Ageing and Dementia Research Group, which brings together specialists from a range of disciplines at both SQU and the Ministry of Health.

The original idea behind the work came from research that Prof. Essa had conducted in the US to study the capacity of walnuts to improve cognition. Based on this idea, Prof. Essa and colleagues at SQU then started research into the possible beneficial effects of Omani fruits. They selected ten fruits the effects of which were measured through human primary brain cell cultures. This research led to the identification of three fruits that proved best capable to slow down the degenerative process of dementia: pomegranates, figs and dates. The identification of these three fruits was the starting point of the work conducted under the TRC grant.

The work of Prof. Essa and colleagues points towards the importance of healthy lifestyles for the improvement of health outcomes. Fruits native to Oman show the potential of having beneficial effects on cognitive diseases such as Alzheimer’s disease. An important component in the project has therefore been to generate awareness of healthy lifestyles and to promote healthier dietary patterns in Oman. These efforts have resulted in a number of initiatives and activities which together have generated the social impacts related to the research.

As the work started in 2010, a large number of publications have already resulted from the study. At the time of writing, the research under the TRC grant has resulted in 2 books, 7 book chapters, and 15 articles. The articles have been published in different journals such as Neurochemical Research, Nutritional Neuroscience, Oxidative Medicine and Cellular Longevity, and Nutrition. More publications are expected to result from the research, especially as the third phase of the research, the study with humans, is reaching completion.
### Table 9.4: Case study 3 summary table

|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Collaborating institutions | Sultan Qaboos University  
Ministry of Health, Oman |
| Start and end dates | 2010-2015 |
| PIs and Co-Is | Prof. Mohamed Essa (PI)  
Prof. Abdullah Al-Asmi (Co-I)  
Prof. Samir al-Adawi (Co-I)  
Prof. Jawad Al-Lawati (Co-I)  
Prof. Ragini Vaishnav (Co-I)  
Dr Nandhagopal Ramachandiran (Co-I)  
Prof. Manickavasagan Annamalai (Co-I) |
| Main areas of impact | Social impact  
Technical capacity building |

#### 9.6.2. Research underpinning the impact

On the basis of the three fruits previously identified (pomegranates, figs and dates) the study consisted of three phases to study the effects of the fruits on cognitive decline.

**Phase 1: human primary brain cell cultures**

The first phase consisted of the study of the three selected fruits on the human brain in cell cultures. This phase examined the effect of the fruits to keep neurons intact which are otherwise destroyed by toxins associated with dementia. The examination of the cell cultures was conducted at the University of New South Wales in Sydney and showed positive effects for all three fruits. Rather than selecting one fruit, which had been the original aim of the first phase, all three fruits were selected for further study in the second phase of the research involving tests on mice.

**Phase 2: learning and memory in mice**

The second phase of the research involved the examination of the effects of the fruits on the learning and memory of mice with Alzheimer’s disease. Mice with specific gene mutations that give rise to Alzheimer’s (APPsw/Tg2576) were purchased in the US, as well as specially prepared diets. In order to ensure that the different treatment and control groups received similar diets, they were prepared by a specialist company to contain exactly the same amount of calories and vary only in the presence of fruits. The fruit contents differed slightly: for the pomegranate diet the concentration was 4 per cent, for figs 4 per cent and for dates 2 per cent and 4 per cent. At the baseline, the mice were all behaviourally assessed on learning and memory, after which the 15-month trial started. Every three months the mice were reassessed, and after
nine months the first signs of improvement appeared among the treated mice, which became more pronounced at 12 and 15 months. After 15 months the trial was ended and brain and blood samples were collected for further analysis, which showed that while all fruits had positive effects, pomegranate displayed the largest effect. Thus, pomegranate was selected for the third phase of the study involving humans.

**Phase 3: cognitive decline in Omani patients**

Using a diversity of patients with different levels of cognitive decline, including Alzheimer’s disease and Traumatic Brain Injury, the third phase of the research, which at the time of writing is still in progress, focuses on the effects of pure pomegranate juice in a treatment versus a control group. Akin to the trial with mice, the human study runs for 15 months (until March 2015) and started with a baseline behavioural assessment which is updated every three months. While the study is still in progress, Prof. Essa reported that similar to the study with mice, positive results have already been observed for the treatment group.

### 9.6.3. Impact description

This third case was selected given the relatively high number of social impacts that had been achieved. In the interview with Prof. Essa it became clear that the social impacts are of three different kinds, which shall be discussed in turn.

First, through the research projects, the Ageing and Dementia Research Group was able to contribute to the establishment of the Alzheimer Society Oman, which in 2013 was officially approved by the Ministry of Social Development. The launch in 2013 preceded a ‘Remember’ walkathon which was repeated in 2014 and aims to generate awareness of Alzheimer’s disease in Oman. The Alzheimer’s Society, and in particular the walkathons, have been an effective means to reach a broad public. Media attention has been substantial with a variety of newspapers covering the event. In turn, the public awareness of Alzheimer’s and the different activities organised through the society allow Prof. Essa and his team to come into contact with potential participants for research trials. Awareness raising is not, however, limited to Alzheimer’s disease, but includes the promotion of healthy lifestyles and healthy diets through newspaper articles and public lectures. This is done in particular in cooperation with the Director of the Department of Non-Communicable Diseases Surveillance and Control at the Ministry of Health, Dr Jawad A. Al-Lawati, who also acts as Co-Investigator on the project.

Second, these initiatives to raise awareness among the public are complemented by a second scientific symposium to be organised in October 2014 to discuss the research and to share ideas around the treatment of Alzheimer’s disease. The symposium will host international researchers and will have dedicated sessions for both the general public and specialist researchers.

Finally, through the project a substantial amount of training and capacity building was achieved. The project first led to the establishment of the Ageing and Dementia Research Group which brings together experts from both SQU and the Ministry of Health. Second, the project has allowed the financing of post-docs and other posts, and through the research conducted, master’s and bachelor’s students can now
also be trained in the research methods employed in the study. The project has also allowed for the training of volunteers in research methods, usually bachelor’s students seeking a job, to enable them to take up a research position.

9.6.4. Next steps

The third phase of the study is scheduled to finish in March, and the data analysis and reporting will constitute the next step in the project. Beyond the final steps within the project, however, the next major step in the research will be to establish exactly how the fruits contribute to the slowing down of Alzheimer’s disease. Thus, the work will focus on the identification of the active compounds within the fruits (i.e. the effective elements within pomegranates), and on the mechanisms by which these compounds are able to disrupt the degenerative processes of Alzheimer’s and other cognitive diseases. The identification of such compounds, furthermore, might allow for the development of pharmaceutical products to counter Alzheimer’s disease.
This appendix lists populated template frameworks for the selected TRC research and innovation programmes. They are a template, as for the majority of the programmes, the indicators listed only link directly to the TRC Top-Level Framework. Thus, they may not fully capture some of the detail of each individual programme at this stage. The programme frameworks presented here are drafts intended to stimulate ideas about additional research impact indicators. They are living documents which will be adjusted and modified as TRC matures. The actual programmes will be able to update and implement them. As such, these ‘templates’ serve as the basis for further development as TRC matures in the future.

Indicators highlighted in grey are the indicators we suggest to be phased in in the future.
## Open Research Grant (ORG) Program

<table>
<thead>
<tr>
<th>Programme name</th>
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<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
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</thead>
<tbody>
<tr>
<td>Open Research Grant Program</td>
<td>Number of graduate research opportunities supported by ORG research projects</td>
<td>Number of students enrolled in undergraduate or graduate research programmes supported by ORG research projects OR number of students funded by ORG research projects enrolled in undergraduate or graduate research programmes (or % change) (numbers by training stage)</td>
<td>Number of ORG-funded graduates/PhD students completing their course</td>
<td>Number of Omani-educated researchers becoming Principal Investigators (or Co-PIs) on ORG research projects (or % change) Number of ORG-funded graduates/PhD students who continue to work in research (or % change)</td>
<td>Building research capacity</td>
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<tr>
<td>Total number of applications to TRC for ORG</td>
<td>Proportion of applications for ORG that were funded</td>
<td>Number of publications resulting from ORG-funded research (or % change) Number of national/international research collaborations resulting from ORG-funded research (or % change)</td>
<td>Cited papers from ORG-funded research (or % change) (including highly cited papers) Number of nationally/internationally collaborated publications resulting from ORG-funded research (or % change) Field-weighted citation impact of ORG-supported publications Number of awards</td>
<td>Achieving research excellence</td>
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<tr>
<td>Total amount of ORG funding available. Possible break-downs: (1) Percentage of research funding spent on technical infrastructure (2) Funding available for dissemination activities</td>
<td>Number of ORG grants awarded to public and private bodies (non-universities) (or % change)</td>
<td>Number of ORG-funded research projects collaborating with/or funded by industry and other research stakeholders (or % change)</td>
<td>Number of ORG-funded projects that have had a social impact, a policy impact, an economic impact. Measurement options: - Annual ImpactFinder survey - Impact case studies</td>
<td>Building knowledge transfer and value capture</td>
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<td>No. of FTE researchers supported through ORG-funded research (or % change)</td>
<td>Elapsed time for delivery of equipment/consumables/infrastructure</td>
<td>Number of companies working with ORG-funded R&amp;D (or % change)</td>
<td>Number of patents resulting from ORG-funded research and innovation activities</td>
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<tr>
<td>% of total cost of ORG funding spent on research and innovation administration</td>
<td>Number of ORG-funded staff or researchers participating in knowledge transfer activities such as workshops or awareness-raising activities (or % change)</td>
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<td>Number of research-based solutions to practical problems faced in Omani society achieved through ORG-funded research</td>
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<tr>
<td>% increase in researcher satisfaction with ORG application process (collected through survey)</td>
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<td>Number of ORG-funded projects that are collaborating with industry and other research stakeholders (or % change)</td>
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<td>Average time from ORG application to award of grant</td>
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<td>Levels of additional research funding from external sources provided to ORG-funded research projects as a recognition of a strong environment for research and innovation</td>
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## Strategic Research Grant (SRG) Program

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<th>Programme name</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
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<td>Number of students enrolled in undergraduate or graduate research programmes supported by SRG research projects OR number of students funded by SRG research projects enrolled in undergraduate or graduate research programmes (or % change) (numbers by training stage)</td>
<td>Number of SRG-funded graduates/PhD students completing their course</td>
<td>Number of Omani-educated researchers becoming Principal Investigators (or Co-PIs) on SRG research projects (or % change)</td>
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<td>Total number of applications to TRC for SRG</td>
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<td>Number (or %) of applications to SRG deemed of high quality by peer review (or % change) (qualitative and quantitative component)</td>
<td>Number of publications resulting from SRG-funded research (or % change)</td>
<td>Cited papers from SRG-funded research (or % change) (including highly cited papers)</td>
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Number of SRG-funded graduates/PhD students who continue to work in research (or % change)
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<td>Elapsed time for delivery of equipment/consumables/infrastructure Number of SRG-funded staff or researchers participating in knowledge transfer activities such as workshops or awareness-raising activities (or % change)</td>
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<tr>
<td>Number of SRG-funded research projects collaborating with/or funded by industry and other research stakeholders (or % change)</td>
<td>Number of companies working with SRG-funded R&amp;D (or % change)</td>
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<td>Number of research-based solutions to practical problems faced in Omani society achieved through SRG-funded research</td>
<td>Number of SRG-funded projects that have had a social impact, a policy impact, an economic impact. Measurement options: - Annual ImpactFinder survey - Impact case studies</td>
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<td>Number of patents resulting from SRG-funded research and innovation activities</td>
<td>Levels of additional research funding from external sources provided to SRG-funded research projects as a recognition of a strong environment for research and innovation</td>
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<td>(2) Funding available for dissemination activities No. of FTE researchers supported through SRG-funded research (or % change)</td>
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<td>Providing an enabling environment for research and innovation</td>
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</table>
# Developing a research impact performance management system

## Research Chair (RC) Program

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<tr>
<th>Programme name</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
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<td>Number of patents resulting from RC-funded research and innovation activities</td>
<td>- Impact case studies</td>
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## Research Centers (RCS) Program

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<tr>
<th>Programme name</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
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<tr>
<td>Total number of applications to TRC for RCS</td>
<td>Proportion of applications for RCS that were funded Number (or %) of applications to RCS deemed of high quality by peer review (or % change) (qualitative and quantitative component)</td>
<td>Number of publications resulting from RCS-funded research (or % change) Number of national/international research collaborations resulting from RCS-funded research (or % change)</td>
<td>Cited papers from RCS-funded research (or % change) (including highly cited papers) Number of nationally/internationally collaborated publications resulting from RCS-funded research (or % change) Field-weighted citation impact of RCS-supported publications</td>
<td>Number of awards</td>
<td>Achieving research excellence</td>
</tr>
<tr>
<td>Total amount of RCS funding available. Possible break-downs: (1) Percentage of research funding spent on technical infrastructure (2) Funding available for dissemination activities</td>
<td>% of total cost of RCS funding spent on research and innovation administration % increase in researcher satisfaction with RCS application process (collected through survey) Average time from RCS application to award of grant Average time from grant award to the availability of RCS funds to the recipient (university or other institution)</td>
<td>Share (%) of total amount of RCS funding available actually disbursed (two ways of counting: actually spent and funding committed)</td>
<td>Levels of additional research funding from external sources provided to RCS-funded research projects as a recognition of a strong environment for research and innovation</td>
<td>Building knowledge transfer and value capture</td>
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<tr>
<td>Number of RCS grants awarded to public and private bodies (non-universities) (or % change) Elapsed time for delivery of equipment/consumables/infrastructure Number of RCS-funded staff or researchers participating in knowledge transfer activities such as workshops or awareness-raising activities (or % change)</td>
<td>Number of RCS-funded research projects collaborating with/or funded by industry and other research stakeholders (or % change) Number of companies working with RCS-funded R&amp;D (or % change)</td>
<td>Number of research-based solutions to practical problems faced in Omani society achieved through RCS-funded research Number of RCS-funded projects that have had a social impact, a policy impact, an economic impact. Measurement options: - Annual ImpactFinder survey - Impact case studies Number of patents resulting from RCS-funded research and innovation activities</td>
<td>Providing an enabling environment for research and innovation</td>
<td></td>
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</tr>
</tbody>
</table>
## Faculty Mentored Undergraduate Research Award (FURAP) Program

<table>
<thead>
<tr>
<th>Programme name</th>
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<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty Mentored Undergraduate Research Award Program</td>
<td>Number of applications to FURAP (or % change)</td>
<td>Number of students enrolled in undergraduate research programmes supported by FURAP or number of students funded by FURAP enrolled in undergraduate research programmes (or % change) (numbers by training stage)</td>
<td>Number of FURAP-supported undergraduates completing their research project</td>
<td>Number of FURAP-supported undergraduates going on to enrol in a graduate/PhD research programme (or % change)</td>
<td>Building research capacity</td>
</tr>
<tr>
<td></td>
<td>Number of applications to FURAP. Could be broken down by:</td>
<td>Proportion of applications to FURAP that were funded</td>
<td>Number of publications resulting from FURAP research projects</td>
<td></td>
<td>Achieving research excellence</td>
</tr>
<tr>
<td></td>
<td>- Geographic spread of applicants within Oman</td>
<td></td>
<td></td>
<td></td>
<td>Building knowledge transfer and value capture</td>
</tr>
<tr>
<td></td>
<td>- Subject spread of applicants</td>
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<td></td>
<td>- Gender split of applicants</td>
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<tr>
<td>Total amount of FURAP funding available</td>
<td>Average time from application to award of FURAP grant</td>
<td>Average time from FURAP grant award to the availability of funds to the recipient</td>
<td>Share (%) of total amount of FURAP funding available actually disbursed</td>
<td>Improved public awareness of FURAP-funded research and innovation (e.g. media mentions, re-tweets)</td>
<td>Providing an enabling environment for research and innovation</td>
</tr>
</tbody>
</table>
### Graduate Research Support Program (GRSP)

<table>
<thead>
<tr>
<th>Programme name</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduate Research Support Program</td>
<td>Number of applications to GRSP (or % change)</td>
<td>Number of students enrolled in graduate research programmes supported by GRSP OR number of students funded by GRSP enrolled in graduate research programmes (or % change) (numbers by training stage)</td>
<td>Number of GRSP-supported graduates completing their research project</td>
<td>Number of GRSP-supported graduates going on to enrol in a PhD research programme (or % change)</td>
<td>Building research capacity</td>
</tr>
<tr>
<td></td>
<td>Number of applications to GRSP. Could be broken down by: - Geographic spread of applicants within Oman - Subject spread of applicants - Gender split of applicants</td>
<td>Proportion of applications to GRSP that were funded</td>
<td>Number of publications resulting from GRSP research projects</td>
<td>Number of (student) awards for GRSP graduate research students</td>
<td>Achieving research excellence</td>
</tr>
<tr>
<td></td>
<td>Total amount of GRSP funding available</td>
<td>Average time from application to award of GRSP grant</td>
<td>Share (%) of total amount of GRSP funding available actually disbursed</td>
<td>Improved public awareness of GRSP-funded research and innovation (e.g. media mentions, re-tweets)</td>
<td>Providing an enabling environment for research and innovation</td>
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</tbody>
</table>
## Industrial Innovation Assistance Program

<table>
<thead>
<tr>
<th>Programme name</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Innovation Assistance Program</td>
<td>Number of TRC-supported innovation activities available to industry</td>
<td>Number of companies enrolled in the programme</td>
<td>Number of TRC/industry research collaborations</td>
<td>Number of TRC-supported graduates working in research within industry</td>
<td>Building research capacity</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Number of companies actively recruiting TRC-supported researchers to work for them</td>
<td>Number of new innovations generated by TRC-supported academics for industry</td>
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<td></td>
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<td></td>
<td>Number of companies approaching TRC-supported researchers for further research</td>
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</tr>
<tr>
<td></td>
<td>Total number of applications to the programme</td>
<td>Proportion of applications for innovation grants that were funded</td>
<td>Number of TRC/industry research collaborations</td>
<td>Number of TRC/industry collaborative publications</td>
<td>Achieving research excellence</td>
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<tr>
<td></td>
<td>Number of national and international companies at the Innovation Park</td>
<td>Number of innovation grants awarded to industry</td>
<td>Number of TRC grants collaborating with/or funded by industry and other research stakeholders (or % change)</td>
<td>Number of TRC funded grants that have had a social impact, a policy impact, an economic impact. Measurement options: - Annual ImpactFinder survey - Impact case studies</td>
<td></td>
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<tr>
<td></td>
<td>Number of TRC staff dedicated to innovation networking activities under the programme</td>
<td>Number of TRC-funded staff or researchers participating in knowledge transfer activities such as workshops or awareness-raising activities (or % change)</td>
<td>Number of companies working with TRC-funded R&amp;D (or % change)</td>
<td>Number of spin-offs/SMEs created as a result of TRC-funded projects/activities (or % change)</td>
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<tr>
<td></td>
<td>Number of venture capital initiatives supported</td>
<td></td>
<td></td>
<td>Strengthened ties (or increased linkages) with industry, companies and other stakeholders (national/international).</td>
<td>Building knowledge transfer and value capture</td>
</tr>
<tr>
<td></td>
<td>Amount of seed funding provided for incubation activities</td>
<td></td>
<td></td>
<td>Number of patents resulting from TRC-funded research and innovation activities</td>
<td></td>
</tr>
<tr>
<td>Efficiency of tech-transfer: aggregate indicator of the timeliness of, for example, obtaining patents and generating spin-offs</td>
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<td>Total amount of TRC funding. Possible breakdown:</td>
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<tr>
<td>- Funding available for dissemination activities within the programme</td>
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<tr>
<td>% of total cost of TRC funding spent on innovation administration</td>
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<tr>
<td>Average time from application to award of innovation grant</td>
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<tr>
<td>Average time from grant award to the availability of funds to the recipient (university or other institution)</td>
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<tr>
<td>Participation/attendance numbers at TRC-organised activities/events under the programme</td>
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<tr>
<td>Improved public awareness of TRC-funded innovation (e.g. media mentions, re-tweets)</td>
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<tr>
<td>Levels of additional funding from external sources provided to TRC as a recognition of a strong environment for innovation</td>
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<tr>
<td>Satisfaction with TRC as a whole (collected through survey) - questions could concern:</td>
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<tr>
<td>- efficiency</td>
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<td>- effectiveness</td>
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<tr>
<td>- administrative burden</td>
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<tr>
<td>Providing an enabling environment for research and innovation</td>
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<tr>
<td>Programme name</td>
<td>Input</td>
<td>Process</td>
<td>Outputs</td>
<td>Outcomes</td>
<td>TRC Strategic Objective</td>
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</tr>
<tr>
<td><strong>Education Innovation Assistance Program</strong></td>
<td>Number of TRC-supported innovation activities in the community</td>
<td>Number of students enrolled in innovation programmes supported through the TRC programme</td>
<td>Number of graduates who participated in the innovation curriculum from technical schools</td>
<td>Number of graduates from technical schools going on to enrol in graduate/PhD research or innovation programmes</td>
<td>Building research capacity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of teachers trained in the innovation curriculum</td>
<td></td>
<td>Number of graduates from technical schools who participated in the innovation curriculum continuing to work in innovation</td>
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</tr>
<tr>
<td><strong>Total number of applications to programme</strong></td>
<td>Proportion of applications for innovation grants that were funded</td>
<td></td>
<td>Number of schools which have incorporated innovation programmes into their curriculum</td>
<td>Number of awards the innovation curriculum receives</td>
<td>Achieving research excellence</td>
</tr>
<tr>
<td><strong>Number of TRC staff dedicated to innovation networking activities under the programme</strong></td>
<td>Number of TRC staff or supported researchers participating in knowledge transfer activities in schools such as workshops or awareness-raising activities (or % change)</td>
<td>Number of schools working with TRC to develop new innovation curriculums or other innovation activities</td>
<td></td>
<td>Number of TRC researchers who have had an educational impact</td>
<td>Building knowledge transfer and value capture</td>
</tr>
<tr>
<td><strong>Total amount of TRC funding. Possible break-down:</strong></td>
<td>% of total cost of TRC funding spent on innovation administration</td>
<td>Participation/attendance numbers at TRC-organised activities/events under the programme</td>
<td>Levels of additional infrastructural support from external sources provided to TRC for innovation programmes in schools as a recognition of a strong environment for innovation</td>
<td>Satisfaction of students and teachers with TRC as a whole (collected through survey) - questions could concern: - efficiency - effectiveness - administrative burden</td>
<td>Providing an enabling environment for research and innovation</td>
</tr>
<tr>
<td>- Funding available for dissemination activities within the programme</td>
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<tr>
<td>- Average time from application to award of innovation grant</td>
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<tr>
<td>- Average time from grant award to the availability of funds to the recipient (university or other institution)</td>
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</table>

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### Academic Innovation Assistance Project

<table>
<thead>
<tr>
<th>Programme name</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Innovation Assistance Project</td>
<td>Number of TRC-supported innovation activities in the community</td>
<td>Number of TRC-supported academics participating in academic innovation programmes</td>
<td>Number of TRC-funded researchers who complete the academic innovation project</td>
<td>Number of TRC-supported academics generating new innovations with industry</td>
<td>Building research capacity</td>
</tr>
<tr>
<td></td>
<td>Number of innovation opportunities for academics supported by TRC</td>
<td></td>
<td></td>
<td>Number of TRC-supported academics continuing to work with industry after the project ends</td>
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<tr>
<td></td>
<td>Total number of applications to programme</td>
<td>Proportion of applications for innovation grants that were funded</td>
<td>Number of TRC researcher and company/societal collaborations</td>
<td>Number of TRC and industry/societal collaborative publications</td>
<td>Achieving research excellence</td>
</tr>
<tr>
<td>Number of TRC staff dedicated to innovation networking activities under the programme</td>
<td>Number of TRC-funded staff or researchers participating in knowledge transfer activities such as workshops or awareness-raising activities (or % change)</td>
<td>Number of TRC grants collaborating with/or funded by industry and other research stakeholders (or % change)</td>
<td>Number of companies working with TRC-funded R&amp;D (or % change)</td>
<td>Number of awards for academic innovation assistance project outputs</td>
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<td></td>
<td>Building knowledge transfer and value capture</td>
</tr>
</tbody>
</table>
| Total amount of TRC funding. Possible breakdown:  
- Funding available for dissemination activities within the programme |
| % of total cost of TRC funding spent on innovation administration  
Average time from application to award of innovation grant  
Average time from grant award to the availability of funds to the recipient (university or other institution) |
| Participation/attendance numbers at TRC-organised activities/events under the programme |
| Improved public awareness of TRC-funded innovation (e.g. media mentions, re-tweets)  
Levels of additional funding from external sources provided to TRC as a recognition of a strong environment for innovation  
Satisfaction of academics with TRC as a whole (collected through survey) - questions could concern:  
- efficiency  
- effectiveness  
- administrative burden |
| Providing an enabling environment for research and innovation |
## Community Innovation Assistance Program

<table>
<thead>
<tr>
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<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Innovation Assistance Program</td>
<td>Number of TRC-supported innovation activities in the community</td>
<td>Number of community members participating in community innovation programmes</td>
<td>Number of community innovation projects successfully launched</td>
<td>Number of community outreach projects initiated from within the community</td>
<td>Building research capacity</td>
</tr>
<tr>
<td>Total number of applications to the programme</td>
<td>Proportion of applications for innovation grants that were funded</td>
<td>Number of research/community collaborations [Op.3]</td>
<td>Number of awards received for community innovation programmes supported by TRC [Oc.7]</td>
<td>Strengthened ties of TRC and TRC researchers with community organisations [Oc.8]</td>
<td>Achieving research excellence</td>
</tr>
<tr>
<td>Number of TRC staff dedicated to innovation networking activities under the programme</td>
<td>Number of innovation grants awarded to communities (diversity of awardee organisations)</td>
<td>Number of TRC grants collaborating with/or funded by industry and other research stakeholders (or % change)</td>
<td>Number of TRC-funded grants that have had a social impact, a policy impact, an economic impact. Measurement options: - Annual ImpactFinder survey - Impact case studies</td>
<td>Number of TRC-funded grants that have had a social impact, a policy impact, an economic impact. Measurement options: - Annual ImpactFinder survey - Impact case studies</td>
<td>Building knowledge transfer and value capture</td>
</tr>
<tr>
<td></td>
<td>Number of TRC-funded staff or researchers participating in knowledge transfer activities such as workshops or awareness-raising activities (or % change)</td>
<td>% of TRC-funded researchers involved in community activities (public lectures, community events, science cafes)</td>
<td></td>
<td>Strengthened ties (or increased linkages) with communities/policy and other stakeholders</td>
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<td></td>
<td>Strengthened ties (or increased linkages) with communities/policy and other stakeholders</td>
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</tbody>
</table>
Developing a research impact performance management system

| Total amount of TRC funding. Possible break-down: - Funding available for dissemination activities within the programme | % of total cost of TRC funding spent on innovation administration  
Average time from application to award of innovation grant  
Average time from grant award to the availability of funds to the recipient (university or other institution) | Participation/attendance numbers at TRC-organised innovation activities/events in the community | Improved public awareness of TRC-funded innovation (e.g. media mentions, re-tweets)  
Levels of additional funding from external sources provided to TRC as a recognition of a strong environment for innovation  
Satisfaction with TRC as a whole (collected through survey) – questions could concern: - efficiency - effectiveness - administrative burden | Providing an enabling environment for research and innovation |
## Adapting towards Sustainable Development Program (ASDP)

<table>
<thead>
<tr>
<th>Programme name</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapting towards Sustainable Development Program</td>
<td>Number of research assistant opportunities supported by ASDP research projects</td>
<td>Number of students enrolled in undergraduate or graduate research programmes supported by ASDP research projects OR number of students funded by ASDP research projects enrolled in undergraduate or graduate research programmes (or % change) (numbers by training stage)</td>
<td>Number of ASDP-funded graduates/PhD students completing their course</td>
<td>Number of Omani-educated researchers becoming Principal Investigators (or Co-PIs) on ASDP research projects (or % change) Number of ASDP-funded graduates/PhD students who continue to work in research (or % change)</td>
<td>Building research capacity</td>
</tr>
<tr>
<td>Total number of applications to TRC for ASDP</td>
<td>Proportion of applications for ASDP that were funded Number (or %) of applications to ASDP deemed of high quality by peer review (or % change) (qualitative and quantitative component)</td>
<td>Number of publications/studies resulting from ASDP-funded research (or % change) Number of national/international research collaborations resulting from ASDP-funded research (or % change)</td>
<td>Cited papers from ASDP-funded research (or % change) (including highly cited papers) Number of nationally/internationally collaborated publications resulting from ASDP-funded research (or % change) Field-weighted citation impact of ASDP-supported publications Number of awards</td>
<td>Achieving research excellence</td>
<td></td>
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<tr>
<td></td>
<td>Number of ASDP grants awarded to public and private bodies (non-universities) (or % change) Elapsed time for delivery of equipment/consumables/infrastructure Number of ASDP-funded staff or researchers participating in</td>
<td>Number of ASDP-funded research projects collaborating with/or funded by industry and other research stakeholders (or % change) Number of companies working with ASDP-funded R&amp;D (or % change)</td>
<td>Number of research-based solutions to practical problems faced in Omani society achieved through ASDP-funded research Number of ASDP-funded projects that have had a social impact, a policy impact, an economic impact. Measurement options: - Policy recommendations implemented</td>
<td>Building knowledge transfer and value capture</td>
<td></td>
</tr>
</tbody>
</table>
Developing a research impact performance management system

<table>
<thead>
<tr>
<th>Knowledge transfer activities such as workshops or awareness-raising activities (or % change)</th>
<th>Annual ImpactFinder survey</th>
<th>Number of patents resulting from ASDP-funded research and innovation activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Annual ImpactFinder survey</td>
<td>- Impact case studies</td>
<td></td>
</tr>
<tr>
<td>Knowledge transfer activities such as workshops or awareness-raising activities (or % change)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total amount of ASDP funding available. Possible break-downs: (1) Percentage of research funding spent on technical infrastructure (2) Funding available for dissemination activities</td>
<td>% of total cost of ASDP funding spent on management</td>
<td>Share (%) of total amount of ASDP funding available actually disbursed (two ways of counting: actually spent and funding committed)</td>
</tr>
<tr>
<td>No. of FTE researchers supported through ASDP-funded research (or % change)</td>
<td>% increase in researcher satisfaction with ASDP application process (collected through survey)</td>
<td>Levels of additional research funding from external sources provided to ASDP-funded research projects as a recognition of a strong environment for research and innovation</td>
</tr>
<tr>
<td></td>
<td>Average time from ASDP application to award of grant</td>
<td>Providing an enabling environment for research and innovation</td>
</tr>
<tr>
<td></td>
<td>Average time from grant award to the availability of ASDP funds to the recipient (university or other institution)</td>
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</table>
### International Relations and Cooperation

<table>
<thead>
<tr>
<th>Programme name</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Relations and Cooperation</td>
<td>Total funding available</td>
<td>Number of TRC-funded staff or researchers participating in knowledge transfer activities such as workshops or awareness-raising activities (or % change)</td>
<td>Participation/attendance numbers at TRC-organised activities/events: - Open days - Science Cafes - Seminars/Lectures - School visits - Website visits - Downloads</td>
<td>User satisfaction of International Relations and Cooperation funded activities. For example: - Did participants find the events useful (survey)</td>
<td>Building research capacity</td>
</tr>
<tr>
<td></td>
<td>Number of invitations issued by IR department to TRC staff to attend international events</td>
<td>Number of conferences/events organised/supported by TRC</td>
<td>Number of national collaborations established [Op.3]</td>
<td>Improved awareness of TRC-funded research and innovation (e.g. media mentions, re-tweets)</td>
<td>Achieving research excellence</td>
</tr>
<tr>
<td></td>
<td>Number of meeting requests for visits through website, phone calls, personal relations</td>
<td>Number of meetings initiated through Ministry of Foreign Affairs</td>
<td>Number of international collaborations established [Op.3]</td>
<td>Strengthened ties with industry/policy and other stakeholders. (For example through a network map of TRC-established connections/collaborations with industry/policy/other stakeholders, updated yearly)</td>
<td>Building knowledge transfer and value capture</td>
</tr>
<tr>
<td></td>
<td>Number of activities co-organised with other TRC departments</td>
<td>Number of TRC researchers participating in knowledge transfer activities [Op.8]</td>
<td>Number of TRC researchers participating in knowledge transfer activities [Op.8]</td>
<td>Number of MOUs, letters of intent, and agreements with international organisations approached by TRC</td>
<td>Providing an enabling environment for research and innovation</td>
</tr>
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<td>Number of visiting professors invited to Oman in areas of national priority</td>
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<td></td>
<td></td>
<td>Number of companies coming to TRC for connections</td>
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<td>Number of companies coming to TRC for connections</td>
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</tr>
</tbody>
</table>
### Innovation Park Muscat

<table>
<thead>
<tr>
<th>Programme name</th>
<th>Input</th>
<th>Process</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>TRC Strategic Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation Park Muscat</td>
<td>Number of national and international companies at the Innovation Park. Can be broken down by: - National/international - Omani graduate start-up</td>
<td>Number of TRC-funded staff or researchers participating in knowledge transfer activities such as workshops or awareness-raising activities (or % change)</td>
<td>Number of Innovation Park companies collaborating with industry and other research stakeholders (or % change)</td>
<td>Number of spin-offs/SMEs created at Innovation Park (or % change)</td>
<td>Building knowledge transfer and value capture</td>
</tr>
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<td>Number of TRC staff dedicated to innovation networking activities under the programme</td>
<td>Number of conferences/events at Innovation Park hosted by TRC</td>
<td>Number of companies working with TRC-funded R&amp;D (or % change)</td>
<td>Strengthened ties (or increased linkages) with industry/policy and other stakeholders (national/international)</td>
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<td></td>
<td>Number of venture capital initiatives supported</td>
<td>% of space filled at the Innovation Park</td>
<td></td>
<td>Number of patents resulting from TRC-funded research and innovation activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amount of seed funding provided for incubation activities</td>
<td>TOTAL amount of TRC funding available for the park (this should decrease year on year as IPM becomes self-sustaining)</td>
<td>Efficiency of tech-transfer: aggregate indicator of the timeliness of, for example, obtaining patents and generating spin-offs</td>
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<td>% of total cost of TRC funding spent on innovation administration</td>
<td>% of total cost of TRC funding spent on innovation administration</td>
<td>Improved public awareness of Innovation Park (e.g. media mentions, re-tweets)</td>
<td>Providing an enabling environment for research and innovation</td>
</tr>
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<td>% increase in company satisfaction at the Innovation Park</td>
<td>% increase in company satisfaction at the Innovation Park</td>
<td>Levels of additional funding from external sources provided to Innovation Park as a recognition of a strong environment for innovation</td>
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<td></td>
<td>Participation numbers at TRC-organised activities/events at the Innovation Park</td>
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<td>Satisfaction of companies with Innovation Park (collected through survey) – questions could concern: - efficiency - effectiveness - administrative burden</td>
<td></td>
</tr>
</tbody>
</table>

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