Understanding the societal impact of research through productive interactions and realist theory-based evaluation: Select cases of agricultural research in South Africa

Harrie Willie Esterhuyse

Dissertation presented for the degree of Doctor of Philosophy in the Faculty of Arts and Social Sciences at Stellenbosch University

Supervisor: Prof. Nelius Boshoff
Co-supervisor: Prof. Johann Mouton

December 2019

DECLARATION

By submitting this research assignment electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

December 2019

Abstract

The study explored the concept of societal impact of research (SoIR) in four agricultural research projects in South Africa, as well as in a survey of the two commodity companies that funded those projects. Three objectives guided the study: (1) to investigate the SoIR by focussing on the productive interactions and effects as identified through the SIAMPI approach; (2) to use the logic of realist evaluation to assign value to productive interactions by using them to build theories of change, impact pathways and indirectly context-mechanism-outcome (CMO) configurations; and (3) to view the productive interactions and effects through the lens of research impact literacy. The study relied on four conceptual underpinnings, namely the SIAMPI approach, realist evaluation, theories of change and impact literacy.

The SIAMPI approach uses productive interactions to understand the effecting of research impact. Realist evaluation is concerned with understanding social programmes through CMO configurations. Theories of change are instruments that visualise the logic of how a programme builds impact. Lastly impact literacy looks at how impact works through the combination of 'what' is being aimed for (final impact), 'how' it is to be achieved, and 'who' will be engaging in activities to achieve 'what'.

The research followed an exploratory sequential mixed methods design, comprising three phases. In the **first phase**, four agricultural research projects, funded by the two commodity companies, were selected as case studies. As part of the case study execution, semi-structured interviews were conducted with case study participants. Project-specific documents were also collected and analysed. From these productive interactions were identified. The **second phase** involved the development of a theory of change for each of the four case studies, built from the productive interactions. From the theories of change, research impact pathways were identified. Follow-up semi-structured interviews with the primary investigators were used to validate the accuracy of the theories of change and to explore the impact pathways further. The **third phase** of the research made use of the theories of change, coupled with the concept of impact literacy, to explore the understanding of SoIR among research funders. A survey was used to assess research funders' views on SoIR. The findings were used to develop a Classification framework for research impact and to show the viability of building CMO configurations from the data produced through SIAMPI.

It was found that productive interactions can be used to develop coherent visualisations of research processes through theories of change. This showed that it is possible to make use of SIAMPI as a method within realist evaluation, though it is not recommended due to the myriad of possible different productive interactions that would need to be tested. Arguably most importantly the

research showed that CMO configurations applicable to research can be constructed based on information gathered through the SIAMPI method. Productive interactions can be used to build an understanding of the context in which research impact is effected (along with the outcomes and impacts) allowing for the development of CMO configurations.

Finally, the research produced the Classification framework for research impact. It provides a novel way of ‘defining’ research impact. The research recommends that, based on the value of productive interactions demonstrated in the dissertation, funders of research should consider including instruments in research reporting that are able to capture research interactions.

Opsomming

Hierdie studie het die begrip, 'sosiale impak van navorsing' (SoIN) ondersoek, deur vier landbounavorsingsprojekte in Suid-Afrika te bestudeer en ŉ opname te doen van die twee kommoditeitsorganisasies wat die bestudeerde projekte befonds het. Drie doelstellings het die ondersoek gelei: (1) om die SoIN te ondersoek deur op sogenaamde produktiewe interaksies en effekte, soos geïdentifiseer deur die SIAMPI-benadering, te fokus; (2) om die logika van realistiese evaluering te gebruik om waarde toe te ken aan produktiewe interaksies deur dit te gebruik om teorieë van verandering, impakroetes en indirek ook konteks-meganisme-uitkoms (KMU) konfigurasies te bou; en (3) om die produktiewe interaksies en effekte deur die lens van navorsingsimpakgeletterdheid te bestudeer. Die studie is op vier konseptuele begrippe gegrond, naamlik die SIAMPI-benadering, realistiese evaluering, teorieë van verandering en impakgeletterdheid.

Die SIAMPI-benadering gebruik produktiewe interaksies om die bewerkstelliging van navorsingsimpak te verstaan. Realistiese evaluering probeer van sosiale programme sin maak deur middel van KMU-konfigurasies. Teorieë van verandering is instrumente wat die logika van hoe 'n program tot impak lei, visueel voorstel. Impakgeletterdheid fokus op wat met impak bedoel word, asook hoe dit werk, op grond van ŉ kombinasie van drie kernbegrippe: 'wat' bereik moet word (eindimpak), 'hoe' dit bereik moet word, en 'wie' aan aktiwiteite sal moet deelneem om 'wat' te bereik.

Die studie het van 'n ondersoekende opeenvolgende gemengde-metode-ontwerp gebruik gemaak, wat uit drie fases bestaan. In die **eerste fase** is vier landbounavorsingsprojekte, wat deur die twee kommoditeitsorganisasies gefinansier is, as gevallestudies gekies. Die gevallestudies is uitgevoer deur semi-gestruktureerde onderhoude met belanghebbendes in die gekose gevalle te voer. Projek-spesifieke dokumente is ook ingesamel en ontleed. Die ontleding het tot die identifisering van stelle produktiewe interaksies vir elke projek gelei. Die **tweede fase** het die ontwikkeling van 'n teorie van verandering vir elk van die vier gevallestudies behels. Hierdie teorieë is uit die produktiewe interaksies gebou. Die teorieë van verandering, op hul beurt, het weer tot die identifisering van impakroetes gelei. Opvolgonderhoude (semi-gestruktureerd) is met die primêre ondersoekers van die gevallestudies gevoer en gebruik om die akkuraatheid van die teorieë van verandering te bekragtig en om die impakroetes verder te ondersoek. Die **derde fase** van die navorsing het gebruik gemaak van die teorieë van verandering, tesame met die idee van impakgeletterdheid, om die begrip van SoIN onder befondsers van navorsing verder te ondersoek. 'n Opname is gebruik om die

menings van befondsers oor SoIN te bekom. Die bevindinge is gebruik om ’n Klassifikasieraamwerk vir Navorsingsimpak te ontwikkel en om die lewensvatbaarheid van die bou van KMU-konfigurasies uit die data wat deur SIAMPI gegenereer is, te toon.

Daar is gevind dat produktiewe interaksies gebruik kan word om samehangende visualiserings van navorsingsprosesse te ontwikkel, deur die gebruik van teorieë van verandering. Hierdie bevinding het daarop gedui dat dit moontlik is om SIAMPI as ’n metode binne ’n realistiese evaluering te gebruik. Dit word egter nie aanbeveel nie, as gevolg van die magdom verskillende produktiewe interaksies wat in die proses getoets sal moet word. Van groter belang is die bevinding dat KMU-konfigurasies, wat van belang is vir die bewerkstelliging van navorsingsimpak, saamgestel kan word deur inligting wat deur die SIAMPI-metode gegenereer en versamel word. Produktiewe interaksies kan gebruik word om die verstaan van die konteks waarin navorsingsimpak bewerkstellig word (tesame met die uitkomste en impakte) te versterk, en ook om die ontwikkeling van KMU-konfigurasies binne ’n navorsingskonteks moontlik te maak.

Laastens het die navorsing ’n Klassifikasieraamwerk vir Navorsingsimpak opgelewer. Dit bied ’n unieke manier om navorsingsimpak te ‘definieer’. Op grond van die waarde van produktiewe interaksies soos in die proefskrif gedemonstreer, beveel hierdie studie aan dat die befondsers van navorsing dit moet oorweeg om instrumente wat navorsingsinteraksies vaslê, in hul navorsingsverslagdoening in te sluit.

Acknowledgements

National Research Foundation (NRF): The financial assistance of the NRF towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the NRF.

A special word of thanks to the following individuals:

- Professor Nelius Boshoff, for his steadfast guidance and quiet optimism through the research process. This dissertation could not have been written without his in-depth understanding of the topic, or without his vision and insight.
- Professor Johann Mouton, for his inputs in the writing of the dissertation.
- David Bester, for supporting me, staunchly believing in me and helping me keep a clear mind.
- Family and friends, who encouraged and supported me on this journey during which I could spend much less time with them than I would have liked.
- Colleagues at CREST, for all the words of encouragement and assistance.
- A special thanks to those who helped me to keep on dreaming during the last days of the research process.

Ek dra hierdie proefskrif op aan my ma, Annelieze Regel-Esterhuyse.

> "Ek bedank u vir u ondersteuning en u krag, maar bo alles vir u liefde".

I dedicate this dissertation to my mother, Annelieze Regel-Esterhuyse.

> *"I thank you for your support, your strength, but above all, for your love".*

Table of contents

List of figures

List of tables

List of abbreviations and acronyms

ADI	agricultural development Institutes
ANT	actor network theory
ARC	Agricultural Research Council
ASIRPA	Socio-economic analysis of the impacts of public agricultural research project
CASP	Comprehensive Agricultural Support Programme
CGIAR	Consultative Group for International Agricultural Research
CIRAD	French Agricultural Research Centre for International Development
CMO	context–mechanism–outcome
CSIR	Council for Scientific and Industrial Research
DAD	Department of Agricultural Development
DAEM	Department of Agricultural Economies and Marketing
DAFF	Department of Agriculture, Fisheries and Forestry
DAFS	Directorate of Agricultural Field Services
DAR	Directorate of Agricultural Research
DATS	Department of Agricultural Technical Services
DAWS	Department of Agriculture and Water Supply
DBRI	Department-based research institute
DCIS	Department of Government Communication and Information Systems
DFPT	Deciduous Fruit Producers' Trust
DORA	Declaration on Research Assessment
ESRC	Economic and Social Research Council
FEMA	Forelle early market access
GA	gibberellic acid
GDP	gross domestic product

IGDP 2012	Integrated Growth and Development Plan 2012
IGWS	Institute for Grape and Wine Sciences
ImpresS	IMPact of RESearch in the South
INRA	Institut national de la recherche agronomique
IST	International Sustainability Transitions
IWBM	Institute for Wine Biotechnology
KVC	knowledge value collective
KWV	Koöperatiewe Wijnbouwers Vereniging van Zuid-Afrika
M&E	monitoring and evaluation
MEL	monitoring, evaluation and learning
NAFU	National Agricultural Farmers Union
NPM	new public management
NRF	National Research Foundation
OECD	Organisation for Economic Co-operation and Development
PIPA	participatory impact pathway analysis
PLAAS	Poverty, Land and Agrarian Studies
PIs	principle investigator
PwC	PricewaterhouseCoopers
RDC	regional development centres
REF	research excellence framework
RIA	research impact assessment
SA	South Africa
SAAPPA	South African Apple and Pear Producers' Association
SALS	South African Literary Society
SAPO	South African Plant Improvement Organisation

SASPA	South African Stone Fruit Producers' Association
SAWB	South African Wine and Brandy Company
SAWIC	South African Wine Industry Council
SAWIS	South African Wine Industry Information and Systems
SAWIT	South Africa Wine Industry Trust
SIAMPI	Social Impact Assessment Methods through Productive Interactions
SoIR	Societal impact of research
SPSAA	Strategic Plan for South African Agriculture
SROI	social return on investment
THRIP	Technology and Human Resources for Industry Programme
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
USSR	Union of Soviet Socialist Republics
VOC	Vereenigde Oostindische Compagnie
WCDOA	Western Cape Department of Agriculture
WoS	Web of Science

Chapter 1

Introduction

1.1 Setting the scene: a concise overview of the societal impact of research

The academic study of the societal impact of research (SoIR) aims to understand the ways in which research affects society. Studies of the impact of research have primarily focussed on scientific impact, often relying on bibliometric indicators and the peer-review process to explore aspects of 'research quality' (Grant, Brutscher, Kirk, Butler & Wooding, 2009; Lepori & Reale, 2012; Ozor, 2014). SoIR, on the other hand, extends the focus of research assessment to the world beyond science and academia. An exclusive use of bibliometric indicators of impact, informed by journal impact factors and citation counts, risks overlooking the impacts of research on society at large (Campbell & Grayson, 2014).

The Declaration on Research Assessment (DORA), which originated from the December 2012 meeting of the American Society for Cell Biology in San Francisco (see American Society for Cell Biology, 2012), has since become global and underscores the broad consensus that new ways of measuring research impacts are needed. The declaration mentions the limitations of assessments based on journal impact factors, and provides suggestions on how to improve "the ways in which the output of scientific research is evaluated by funding agencies, academic institutions, and other parties" (American Society for Cell Biology, 2012). Although DORA does not focus on SoIR specifically, it includes SoIR assessment as part of its suggestions on how to understand the value of research better. For instance, DORA recommends that funding agencies should consider different "impact measures including qualitative indicators of research impact, such as influence on policy and practice" (American Society for Cell Biology, 2012). The declaration signals a wide-ranging agreement that the current measures used to assign quantitative values to research are too limited and potentially misleading.

The current push for SoIR is not only limited to academics, universities, research institutes and research funders, which are the typical organisations that undersigned DORA. The momentum comes from almost every level of organisation involved in producing research or the effecting of research impact. National governments around the globe are a significant driving force behind assessments and demonstrations of and at times mere reflections on SoIR. From the United Kingdom (UK) and the Netherlands to Australia, the aim of governments has been to make science accountable to the taxpayers who are funding research at public institutions (Demeritt, 2010).

Given the diverse organisational interest in SoIR, the term 'SoIR' is broad and generic and encapsulates all assessment approaches seeking to assess research impact beyond academia, often involving different units of assessment. The interested entities (for example funders ranging from international to national and sector-specific) all have different ideas of what is meant by 'societal' and 'impact'. Their reasons for being interested in SoIR also vary. Moreover, the concept of what is 'valued' differs from entity to entity; yet, the desire to evaluate and understand the broader impact of research in society remains. There are numerous reasons for these entities to be interested in the SoIR, including:

- assisting research funders to understand which circumstances promote research impact so that optimal circumstances can be promoted for new projects (Economic and Social Research Council [ESRC], 2009);
- assisting research funders to develop ways in which to steer research projects in increasing their impact. This can allow funders to assist active research projects to work towards optimal societal impact (ESRC, 2009);
- providing government agencies with the tools needed to evaluate research projects they fund to ensure accountability (Hanney, Packwood & Buxton, 2000);
- proving the value of research by expanding the understanding of the interplay between research and society that might expose unknown research impacts (Spaapen *et al.*, 2011); and
- increasing the economic competitiveness of a national economy through stimulating scientific and technological breakthroughs (by promoting the production of research with societal impact) required in the modern knowledge-based global economy (Meijer, 2012; Spaapen *et al.*, 2011).

Even though a better understanding of SoIR will potentially benefit individuals, organisations or even national economies, the methods that assess SoIR are not nearly as developed as those that look at scientific impact (Meijer, 2012). There are many reasons for this. A key reason is a lack of data needed to analyse SoIR. In bibliometric analysis, for example, there are databases such as the Web of Science (WoS) or Scopus with information on published research. In SoIR, the question of data is more complex:

"Quantitative data are hardly available, monitoring of data is practically non-existent and there is a lack of consensus about what data to gather" (Spaapen & Van Drooge, 2011:211).

In other words, it is very hard to know which data are needed when you do not know exactly what you are measuring in terms of SoIR. Even if there is consensus on what is being measured, the chances are that the data have not been pre-captured in any form of database.

The data challenges are compounded by the problem of attribution, which refers to the problem of how to prove that a specific impact was the consequence of a research result (Meijer, 2012; Spaapen & Van Drooge, 2011). For instance, research impact in the broader society is indirect in nature, which makes it hard to identify impacts explicitly related to specific research. Only part of a research result might be used to build new ideas in conjunction with other research. Research results might also only be used decades after they were published (Morton, 2015). The latter relates to the problem of temporality. With research, the impact might be immediate, or it might be 40 years down the line (Spaapen & Van Drooge, 2011; Spaapen *et al*., 2011). Temporality presents a challenge for evaluators of research because it does not make sense to evaluate something before it has had an impact, or was supposed to have had an impact.

With different ways of approaching the SoIR, and with varying views on its exact scope, different levels at which it can be studied and diverse opinions on what should be valued, there are numerous points of entry from which to begin a study on SoIR. Previous research looked at the economic benefits of research, but this is not compatible with some fields where possible research impacts (or results) are difficult to quantify. Economic benefits tend to focus on a linear system of research production leading to benefit (Spaapen *et al.*, 2011). As will be discussed later (see 2.2.2-2.2.6), this so-called 'linear model' of science (see Bush, 1945), has increasingly lost favour due to its misrepresentation of the complexity involved in research impact.

In agricultural research – which provided the setting for the current study – SoIR has developed in much the same way as in other fields. The focus in assessing the impact of agricultural research has mainly concentrated on economic impacts and the development of new technologies (Weißhuhn, Helming & Ferretti, 2017). Similar to other disciplines or fields, the activities (or interactions) of agricultural research likewise led to impacts that are difficult to capture or quantify. Agricultural research also takes a long time (temporality) before any impacts are realised (Esterhuizen & Liebenberg, 2001). A study by the French *Institut national de la recherche agronomique* (INRA) found that agricultural research often takes up to 19 years before any impacts begin to appear (INRA, 2017).

With all the limitations to studying SoIR, case studies have generally emerged as one of the preferred assessment methods since they allow for impacts to be placed in a context and accommodate the use of qualitative data (Penfield, Baker, Scoble & Wykes, 2014).

"As a method, case studies can capture not only impacts but also roles, routes, processes and lessons learned – thus contributing to understanding and potentially enhancing future processes" (Meagher, 2013:VI).

Case studies are sufficiently flexible to be used within new interaction-oriented approaches to SoIR that prioritise the studying of impact mechanisms. One such approach is SIAMPI which is an abbreviation for the "**S**ocial **I**mpact **A**ssessment **M**ethods for research and funding instruments through the study of **P**roductive **I**nteractions between science and society" (Spaapen *et al.*, 2011:1) (also see Spaapen & Van Drooge, 2011).

1.2 The study rationale: applying and adding value to the SIAMPI approach

In 2011, Spaapen *et al.* published a new approach to SoIR, SIAMPI, which focusses on impact mechanisms and immediate effects (and less on the eventual impacts that could take years to manifest) (Spaapen *et al.*, 2011; Spaapen & Van Drooge, 2011). Productive interactions, whose systematic application and expansion constituted the main focus of the current research, are the impact mechanisms of the approach and are defined as: "[e]xchanges between researchers and societal actors in collaborative settings (networks) in which knowledge is produced and valued that is at the same time scientifically and socially robust and relevant*"* (Spaapen *et al.*, 2011:4).

Specifically, productive interactions are moments of contact between researchers (or research) and stakeholders, that are made "productive when it leads to efforts by stakeholders to somehow use or apply research results or practical information or experiences" (Spaapen & Van Drooge, 2011:212). The term 'stakeholder' is used very broadly and refers to anyone who comes into contact with the research and engages with it. This contact can be facilitated through direct or indirect interactions. A direct interaction can be a conversation, a phone call or an email. Indirect interactions take place through mediums, such as reports, articles and other artefacts. A third type of interaction is also identified, that of material interactions (originally called 'financial interactions' [see Spaapen *et al.*, 2011:6]). This is a direct interaction through which a stakeholder provides any form of material or financial assistance or input to the research project (Spaapen & Van Drooge, 2011; Spaapen *et al.*, 2011; Van den Akker & Spaapen, 2017).

According to SIAMPI, the three sets of interactions, proximal in relation to the researcher, can more easily be observed and captured than comparable distal connections that cause impact beyond the reach of the researcher and project. Under the influence of SIAMPI, the focus of SoIR shifts from final distant impacts to smaller effects closer in time and space to the researcher (Spaapen & Van Drooge, 2011; Spaapen *et al.*, 2011). In this way, the SIAMPI approach might illuminate impact pathways closer in time and space to the researcher. The focus on effects that occur in time and space close to the research might overcome the problem of attribution since such effects and their associated interactions are suitable candidates for demonstrations of contribution (De Jong, Barker, Cox, Sveinsdottir & Van den Besselaar, 2014).

Even so, productive interactions have not been widely studied (at least not empirically) since publication of the original SIAMPI project report (Spaapen *et al.*, 2011) and the writing up of key insights and cases in a journal article (Spaapen & Van Drooge, 2011). Other articles making use of productive interactions followed, including a study on the use of the SIAMPI method within information and communication technologies research (De Jong *et al.*, 2014), and a study that explored the use of SIAMPI within social sciences (Molas-Gallart & Tang, 2011). Although hundreds of references to productive interactions have emerged in the academic and grey literature since publication of the SIAMPI project and its spin-off articles, little evidence exists of any systematic and empirical applications of the approach. A first rationale for the current research was therefore to address this vacuum by empirically applying the SIAMPI approach with its focus on productive interactions to select cases of agricultural research and, in doing so, expand the body of scholarship on SoIR.

There is, however, a caveat to the SIAMPI approach. A productive interaction is productive when a stakeholder tries to use or apply research (Spaapen *et al.*, 2011). This use or application can be large or small, for example the adoption of a new technique in an entire industry (probably large), or influencing the way someone thinks about a topic with no visible outputs (probably small). An interaction can also be positive (increasing someone’s knowledge on a topic) or negative (for example an adverse reaction to a changed product by consumers). Productive does not imply desired. Although the SIAMPI approach sets out how to identify productive interactions, it is not prescriptive on how to value productive interactions (Spaapen *et al.*, 2011). If productive interactions are to have value to a funder in the monitoring of research, it is important to be able to identify positive and crucially wanted impacts that have an effect on the intended populations served by a research funder. SIAMPI makes the assumption that “quantitative indicators and qualitative data (e.g. narratives, case studies) [of the different productive interactions] can be collected that can be used in assessment procedures", but it does not provide further guidance (Spaapen & Van Drooge, 2011:213). SIAMPI then, or more correctly productive interactions, by design almost, requires the addition of another approach to provide the structure for the identification and testing of possible impact indicators. SIAMPI presents the idea of productive interactions and explains how to identify them, but leaves open for interpretation any further use and valuing of these productive interactions.

One approach that shares similarities to SIAMPI is realist evaluation. Realist evaluation is one of the most widely used theory-based approaches in programme evaluation and is as a possible natural evaluation 'home' for the SIAMPI approach (Blamey & Mackenzie, 2007; Green *et al*., 2015). The main evaluative question for realist evaluation is not just, 'what works' but rather, "what works for whom, in what circumstances, in what respects and how?" (Pawson *et al*., 2005:21).

Realist evaluation is a brand of theory-based evaluation and predates SIAMPI by 14 years (Wildschut, 2014). Similar to SIAMPI, realist evaluation seeks to understand impact in terms of how it is effected, and not just in terms of what the final impacts are. Realist evaluation wants to look into the 'black box' of how a social programme works (Pawson & Tilley, 1997). The idea of the 'black box' is often equated to a clock. When looking at a clock, one can tell the time from its face, but one cannot see how the clock works since the mechanisms of the clock are hidden. To understand how the clock works, one will need to look at these mechanisms inside the clock (Pawson & Tilley, 1997). Realist evaluation does this by making use of context–mechanism–outcome (CMO) configurations, or impact mechanisms (SIAMPI makes use of productive interactions). The **context** comprises the circumstances in which a programme is introduced; the **mechanisms** are the aspects of a programme that bring about change (providing choices or capacity), and the **outcomes** (or outcome patterns) are intended and unintended consequences of a programme (Pawson & Tilley, 2004). Similar to SIAMPI, these impact mechanisms (in CMOs) show causality on a smaller scale, which potentially builds up to the impacts of a programme (Shaw, 2010).

Realist evaluation, similar to SIAMPI, is also not prescriptive in its methods, but rather embraces quantitative and qualitative methods to allow for the investigation of processes and impacts as required (Pawson *et al*., 2005). Realist evaluation is open to new methods that allow the collection of needed data. Realist inquiry and the principles expanded on in realist evaluation are based on realism, which is a "logic of enquiry" rather than a research technique (Pawson & Tilley, 2004:10). It is this logic of enquiry, espoused by realist evaluation, that was applicable to the research on which this dissertation reports. Realist evaluation is more developed and more established than SIAMPI. Realist evaluation works by developing hypotheses of how a programme will work in the form of impact mechanisms called CMO configurations. Through a realist evaluation, the predetermined hypotheses are tested and later adapted. In this way, realist evaluations are built on theory and produce theory (Pawson & Tilley, 1997).

Research projects however work differently from programmes. Research impact is an iterative process that often involves numerous actors, including ones that might not have been linked to the research project in any way, at times making it hard to develop a theory of how the research will produce an impact (Spaapen *et al.*, 2011). However, SIAMPI and its productive interactions might be able to produce the theory needed for a realist evaluation on research. To achieve this, SIAMPI must be able to provide productive interactions that could be used to construct theories of change and impact pathways. In fact, the current research proposed that SAIMPI and its productive interactions are compatible with realist evaluation and that by making explicit the value of productive interactions in theories of change (often part of the initial phase of a realist evaluation), the SIAMPI approach could be considered a method within realist evaluation. A second rationale for conducting the current research was therefore to add value to the SIAMPI approach by exploring its compatibility with realist evaluation. This is an exploration that constitutes a novel focus in the body of scholarship on SoIR. Defining SoIR is however not a straightforward activity.

SIAMPI views SoIR as “measurable effects of the work of a research group or program or a research funding instrument in a relevant social domain” (Spaapen *et al.*, 2011:9). The problem with definitions of SoIR is that “impact fundamentally precludes templating” (or in other words drafting a ‘universal’ or single definition of impact is probably not possible) (Bayley & Phipps, 2017:2). There is however a useful way of looking at SoIR, which provides a broad framework within which to view SoIR, namely by using the concept of ‘impact literacy’. The concept ‘impact literacy’ was developed to “strength[en] [the] core comprehension of impact” (Bayley & Phipps, 2017:3), doing so with the understanding that a definition cannot include all of the thousands of possible ways in which research could lead to societal impact. Impact literacy is not the same as SoIR, but as a concept, its comprehension can be used as a “central principle of impact practice” (Bayley & Phipps, 2017:3).

Impact literacy sees impact as a combination of three elements of research impact, namely the ‘how’, ‘what’ and ‘who’. ‘How’ refers to the practices through which impact is effected; ‘what’ is the identification of impact endpoints; and ‘who’ looks at how different stakeholder come together in research impact-effecting networks (Bayley & Phipps, 2017). Through these three elements, one can approach the literacy of research impact (the level to which actors understand what it is), but it also lends itself to being a definition of sorts for the SoIR (or other forms of impact). It is a frame through which to look at the SoIR rather than a definition, and that is exactly what is required when a single understanding has to be created for the countless 'impact pathways' (impact stories, ways of achieving impact) that are possible through different disciplines.

With a lack of a single definition of SoIR, the current study needed a different way of understanding research impact to ensure that the concept was explored and expanded on in a nuanced and systematic manner in the research. The concept of impact literacy, which only recently emerged in the academic literature, provided a lens with which to assess the way in which research looks at impact (Bayley & Phipps, 2017). In the current study, impact literacy was used to show that the identified productive interactions and their effects – configured as theories of change and impact pathways – shed light on the 'who' and 'how' of impact (particularly from a research perspective), but lack a deeper understanding of the 'what', especially in terms of what research funders view as SoIR. To overcome this problem, the current research made use of a survey to assess, among others, the way in which the funders of the select cases of agricultural research view the SoIR. A third rationale for conducting the research was therefore to add value to the SIAMPI approach, specifically by investigating the impact literacy of research funders and relating the insights to the productive interactions and effects identified from application of SIAMPI to the funders' projects.

Finally, the current study approached the study of SoIR, using SIAMPI, through agricultural research case studies. Agricultural research is directly related to issues that confront societies around the world, including climate change and food security. These grand societal challenges are, among other agricultural-related issues, for example those mentioned in the United Nations (UN) Sustainable Development Goals (Weißhuhn *et al.*, 2017). Agricultural research, by nature, is connected to societal impact and can change society. In South Africa, agricultural sciences is also a field where researchers are most likely to self-report the aim of their research as "the solving of technical or applied problems" (Boshoff, 2017:57). With a clear relationship between agriculture and society, the proximity of the agricultural research funders and an affinity for 'research with a visible impact', agricultural research presented a promising point of departure.

1.3 Aim and objectives of the study

The aim of the current research was to increase the understanding of the SoIR towards the goal of improving research monitoring and evaluation (M&E), by using the SIAMPI approach with productive interactions, influenced by the logic of realist evaluation. The use of SIAMPI allowed the research to overcome the previous obstacles (issues of attribution and temporality) that have hindered the developed of SoIR M&E methods.

The study had three objectives:

- objective 1: to study the SoIR by focussing on productive interactions and effects as identified through the SIAMPI approach (Spaapen *et al.*, 2011);
- objective 2: to use the logic of realist evaluation to assign value to the productive interactions by using them to build theories of change, impact pathways and indirectly CMO configurations; and
- objective 3: to view the productive interactions and effects through the lens of research impact literacy – 'who' is responsible for effecting impact, 'how' it is effected, and 'what' is effected (Bayley & Phipps, 2017).

1.4 Research questions

The three research objectives translated into six research questions that were addressed by this study. There were two research questions for each of the objectives.

Objective 1	Question 1: Which *research interactions* (possible productive interactions) are identified through application of the SIAMPI approach in four cases of agricultural research in South Africa?
	Question 2: What do the identified research interactions reveal about the *SIAMPI approach* – in other words, what are possible strengths and weaknesses of the approach in capturing and understanding research impact?
Objective 2	Question 3: Which value do the *theories of change* provide to the research interactions (possible productive interactions) that are identified through application of the SIAMPI approach?
	Question 4: What do the identified, if any, productive interactions reveal about impact-generating mechanisms and the associated context(s) in which research takes place as captured by the *impact pathways* in the theories of change?
Objective 3	Question 5: Based on the 'what' element of *research impact literacy*, which kinds of impact are reflected in the effects as identified through the SIAMPI approach and to which extent are these impacts valued by funders?

Question 6: Based on the 'who' and 'how' elements of *research impact literacy*, how do the impact pathways developed for the four cases of agricultural research align with the funders' understanding of how impact is created?

1.4 Outline of the dissertation

The dissertation is divided into eight chapters. This chapter provided an introduction to the dissertation and set out the logic of the research. Below is a brief summary of the structure and contents of the remaining seven chapters.

Chapter 2 – Historical and current understanding of the societal impact of research

This chapter traces the history of SoIR through the processes that gave rise to its current demand. A main focus is the changes in the so-called 'science–society contract' over the last 150 years. During this time, the relationship between science and society continued to evolve. The chapter also looks at previous research on the assessment of SoIR and at the different stumbling blocks that have inhibited the study of research impact. The changes in the assessment of the societal impact of agricultural research are covered in detail. The chapter includes an overview of definitions of SoIR. The chapter anchors the concept of the SoIR in a changing context, showing where it comes from, what it is, and illuminating the forces that drive it.

Chapter 3 – An overview of the history of agricultural research in South Africa

In this chapter, the history of agricultural research in South Africa is traced over the last 200 years. Although it might seem like a long period to reference, the current agricultural system and many of the topics with which the industry (research and commercial) struggles have been built from this history. These topics include the elements of race, language, land ownership and the changing power of the state. South Africa's 'free' commodity companies (working outside state control) are relatively new, and are developed out of deregulation of agricultural industries in 1997. Before 1997, these industries and their research were dominated by successive agricultural government departments of the pre-democratic South African state. The commodity companies have been made the custodians of industries that were confronted by a history of dispossession and inequality stemming from the Apartheid system. Today they are professional bodies that aim to increase profits and exports, but they do so through a balancing act of maintaining social responsibility, for example through the protection of farm labour against mechanisation. Understanding the context of agricultural research in South Africa is part of the history, time and place of the research projects this study assessed.

Chapter 4 – Conceptual underpinnings: Productive interactions, realist evaluation, theories of change and impact literacy

Having provided a background to the study of agricultural research in South Africa, this chapter presents the different conceptualisations that were used during the study. These are the approaches of SIAMPI (Spaapen & Van Drooge, 2011; Spaapen *et al.*, 2011), theory-based evaluation (Weiss, 1997; 2004) focussing on realist evaluation (Pawson & Tilley, 1997); methods or tools used within these approaches such as theories of change (Weiss, 1995), and the related participatory impact pathway analysis (PIPA) (Douthwaite *et al.*, 2007); and the concept of impact literacy (Bayley & Phipps, 2017).

Chapter 5 – Research design and methodology

The chapter presents an account of the methods used in the study. The first two phases of the research comprised semi-structured face-to-face in-depth interviews with stakeholders, as well as document analyses. The third phase mainly relied on a survey. The survey explored 'what' research funders view as research impact, or as important impact for the research they fund.

Chapter 6 – Results: Productive interactions and theories of change

The chapter presents the results of the interviews with the researchers and different stakeholders who were interviewed during the first two phases of the research. It also includes data based on the document analyses of project documentation. The results focus on the first four research questions, which looked at productive interactions and the use of productive interactions in theories of change (impact pathways of how impacts and outcomes are effected during research).

Chapter 7 – Results: Research funders' understanding of the societal impact of research

The chapter focusses on the survey responses of the Winetech and Hortgro expert-funding committee members regarding their views on SoIR. The chapter also presents the application of a research impact classification scheme developed during the study. The scheme was developed to provide a way to classify the SoIR as viewed by the different stakeholders or actors in the research process. It expanded the data of how funders view impact and 'what' the SoIR is according to them.

Chapter 8 – Towards a deeper understanding of the mechanisms that drive the societal impact of research

The final chapter discusses the results of the previous two chapters. It presents the findings that productive interactions are indeed building blocks of impact, but that these need to be be combined into larger impact mechanisms or impact pathways. These impact mechanisms can be used to study the effecting of impact in various contexts, while CMO configurations can assist in building new theory on the effecting of research impact. Lastly, the chapter presents a final version of the research impact classification scheme, adapted through the results into a classification framework.

Chapter 2

Historical and current understanding of the societal impact of research

2.1 Introduction

Societal impact of research (SoIR) is many different things for many different people. In general terms, 'societal impact' can probably be seen as the effect of research on the world beyond academia or on society. The part that is not agreed on is who or which sections of society should be affected, or even, what does 'beyond academia' mean. Is having an impact on a different research discipline societal impact or scientific impact? This chapter addresses a number of topics directly related to these questions. The aim of the chapter is to provide a nuanced overview of the topic of SoIR and to motivate the use of a preferred definition of SoIR used in the dissertation. To study something one first needs to delineate and define it. This chapter boxes and defines SoIR.

The chapter is divided into five sections. The first section looks at the changes in the so-called 'science–society contract' over the last 150 years. The current drive for SoIR is a result of this 'contract' changing (Gibbons, 1999). The science–society contract refers to an implicit understanding of the place of science and its role in society. Society provides space for and funds science, and science delivers knowledge to or enlightens society (of course, this is the Vannevar Bush textbook example [Bush, 1945] and not the only or currently even the most popular view). The science–society contract is linked to the rise of research universities and begins with the Humboldt university model (also called the Humboldtian model of higher education) in Germany. The second section of the chapter provides an overview of how SoIR has been defined, followed by a third related section on the development of approaches used to measure SoIR. The fourth section of the chapter reflects the development of the societal impact of agricultural research methods specifically. The final section of the chapter then moves back to the general picture, detailing the pitfalls that have inhibited the development of methods to assess societal impact of research.

2.2 Changing expectations between science and society

For a long time, scientific research held a very secure position in society where it was assumed that scientific research outputs equated to societal and economic impact. For much of the twentieth century, the logic behind national research funding was that governments would provide the funds needed for research, and mainly universities (along with research institutes) would produce research, which would translate into economic growth and societal benefits (Briggle, 2014; Guston & Keniston, 1994; Martin, 2003; Nowotny, Scott & Gibbons, 2003). After World War II and during the Cold War, this trend continued, with the United States (US) government pushing the 'endless frontier' of science. Following the end of the Cold War – an event that coincided with shrinking public budgets and an explosion in science which far outpaced available resources – governments down to small funders started coming under pressure to find better ways of distributing the relatively limited resources available for research (Bornmann & Bierman, 2012). The size of non-government funding also increased in making it necessary for research funders, for example a large medical research funder such as the Wellcome Trust, to find ways of understanding how research impact could be improved and measured. By 2014, the Wellcome Trust was awarding more than £530 million per year to medical and biomedical research (Dinsmore, Allen & Dolby, 2014). Such vast sums of money created a need for funders to be able to account for their spending, showing that it was efficient and effective.

The new demand for defining what is relevant knowledge has been studied under different forms, for example Mode 2 (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow, 1994), the triple helix (Leydesdorff, 1996), new public management (Lane, 2000) and others. Mode 2 research is concerned with research that is created in collaboration with parts of society and with relevance to a certain application in society. This is in contrast to Mode 1, which refers to research that is of mainly academic interest to the scientific community (Gibbons *et al.*, 1994; Spaapen, Dijstelbloem & Wamelink, 2007). The triple helix sees universities, governments and industry as equal institutional actors in the research network (Leydesdorff, 1996). Collectively this helix produces 'infrastructure' through research, each contributing in a unique way. The triple helix allows attention to be focussed on the need to manage expectations and communication between the three actors (i.e. universities, governments and industry) (Leydesdorff, 1996). New public management (NPM) refers to the desire to manage public affairs, including research, in a way similar to business. Some of the principles of NPM are standard and performance measures, increased competition and more efficient use of resources (Lane, 2000). The different perspectives all point to new attempts at understanding the value of scientific research, specifically the SoIR, and/or ways to increase this.

The current changes in what is expected of science are part of a process that has been going on for more than 150 years (as set out below). The 'understanding' between science and society is described as social contracts (Martin, 2003). As the national or international context in which research takes place change, so does the relationship between science and society. Events such as the end of the Cold War – or as will be shown later, success for the United States in World War II – could have direct effects on the funding structures of science.

The first example of a science–society contract was known as the Humboldt university model. The Humboldt model was the first 'contract' to be widely copied internationally. It was also the only major model that developed outside the United States. The next contract to form, which eventually replaced the Humboldt university model, was the Vannevar Bush social contract (see Martin, 2003), which originated in the United States. After victory in World War II, the United States maintained a position of global hegemony in military and political affairs, and also in terms of innovation. This dominance lasted into the twenty-first century. Some might argue that it still maintains this position today. As a result, much of what is discussed below has an overwhelming focus on the United States from the Vannevar Bush social contract to the present. The discussion is divided into five parts, consecutively looking at the Humboldt university model, the Vannevar Busch Social Contract, the Cold War era, the post-Cold War period and the current state of affairs.

2.2.1 Humboldt university model

The origins of the Humboldt university model (*Humboldtisches Bildungsideal* in German, or the Humboldtian education ideal) can be traced back to Humboldt University in Germany where it was developed by Alexander von Humboldt in the 1800s. The Humboldt model contained two main elements. Firstly, governments accepted it as their responsibility to fund universities out of public funds, and secondly, universities became dual spaces, where both research and teaching took place (Martin, 2003). With universities seen as both teaching and research spaces, the Humboldt model promoted four ideals. It called for universities to:

1. take on the obligation of knowledge creation, preservation and transmission;
2. provide freedom to lecturers to teach what they think best, and for students to be able to choose what they want to study;
3. become spaces that provide intellectual freedom and separation from the state and, in doing so, accommodate the pursuit of scientific truth; and
4. use seminars as the main medium of instruction (Krull, 2005:99).

During the nineteenth and twentieth centuries, the model was adopted by many other nations, mainly in the northern hemisphere. The funding provided by governments came with very few limitations. University management and individual academics were given the freedom to choose their own research topics and to pursue research as part of their jobs. In general, academics spent between 30 and 50 per cent of their time doing research (Martin, 2003).

France and some Eastern European countries adapted the model. In France, for example, a system was introduced in which separate institutions were responsible for teaching and research respectively. Research was undertaken by centres such as the *Centre National de la Recherche Scientifique*, while the *grandse écoles* (the 'great schools') were responsible for teaching students (Martin, 2003). Even with these adaptions, the main contribution of the Humboldt university model remained. It introduced the idea of universities as places of scientific discovery, intellectually free from the state, while financially supported by the state. The teaching and research directions taken by the universities were shaped by the universities themselves.

2.2.2 Vannevar Bush social contract

More than a century later, following World War II, the Vannevar Bush social contract emerged as the successor of the Humboldt model. This 'contract' was the result of a report by Vannevar Bush to the United States President Theodore Roosevelt published in 1945 (see Bush, 1945). In the report, "Science, the endless frontier: A report to the president on a program for post-war scientific research", he described a 'science-push' approach in which a linear model of innovation leads from basic research (Bush, 1945). The argument was that the funding of basic research would support the undertaking of applied research and lead to innovation (Bush, 1945).

This linear model was based on the experiences of the United States in World War II. Science and innovation had taken a prominent position in the war effort. Victory in the war was as much attributed to military strategy as to scientific progress (Martin, 2003:9). The notion is very clear throughout Bush's report, when he writes (1945:17):

> *In this war it has become clear beyond all doubt that scientific research is absolutely essential to national security. The bitter and dangerous battle against the U-boat was a battle of scientific techniques – and our margin of success was dangerously small.*

As is clear from this quote, science became a matter of national security; not just of societal improvement. For the United States, the new focus also came at a very opportune time. Since the 1800s, the United States had seen rapid economic growth supported by physical geographic expansion to the west. Once the frontier had reached the Pacific Ocean, however, physical expansion could no longer drive economic growth. The physical frontier of the American West, it was argued, could now be replaced by a new frontier to explore, the frontier of science (Byerly &

Pielke, 1995). Unlike a physical frontier, the frontier of science could be pushed indefinitely. The Vannevar Bush social contract established an agreement: government would provide the funding needed for science, and science would identify research areas that could provide discoveries that would in turn lead to development (such as economic development and social development). Scientists would also importantly identify the crucial areas to be researched by making use of peer review (Guston & Keniston, 1994).

Science in the period of the Vannevar Bush social contract was turned into a public good. Basic research was needed from which to undertake applied research, make discoveries and invent new technologies. It was argued by Bush (1945) that it would be too expensive for corporations to engage in basic research since application and possible profits that could be made from an innovation were not certain. Rather, government was encouraged to fund basic scientific research as part of an obligation to providing a public good. Corporations could then undertake applied research based on the pool of basic research, a much more direct road map to innovation and accompanying profits. As a public good, science was seen as a consumptive and a productive good. It was consumptive, similar to museums and public parks. However, it was also distinguished by being productive in that it was argued to be uniquely useful in stimulating economic growth (along with other benefits in society) (Byerly & Pielke, 1995; Guston & Keniston, 1994).

A second aspect of the Vannevar Bush contract was accountability and autonomy. It has already been mentioned that peer review came into its own in this period. This was part of the deal to balance the need for accountability to the representative government and the autonomy and independence of the professional academic community. Although the direction of science was free, in that it was not centrally directed, research-funding institutions could have mandates that focussed on specific areas. Some funders would be more focussed on medicine whilst others concentrated on weapons. However, even with these set funding criteria, federal funding agencies made use of peer review when determining how to rate funding applications. This is a practice that continues in many countries today. The peer-review process did not always only include academics; it also included other researchers or federal employees in the case of the United States. However, the general rule was that government selected areas of importance and scientists then worked towards expanding knowledge within the selected fields (Guston & Keniston, 1994).

Generally, the Vannevar Bush contract promoted the idea that research would lead to societal benefit. Research was seen as too complex to allow for the assessment of individual cases of research on their own. It was argued that the results from such cases would be arbitrary in that it would not be possible to generalise findings. As a whole, science somehow produced applied results, and it was sufficient to allow academics and researchers to continue directing science and its funding (Spaapen *et al.*, 2007).

According to Martin (2003), the Bush social contract can be summarised in a few essential characteristics:

- science was given a relatively high level of autonomy;
- scientists were given the scope to identify which areas of science should be funded, which led to institutionalised peer reviewing; and
- basic research was identified as best done at universities as a public good, rather than by the governments or private companies (Martin, 2003:9).

It can be added that there was a belief, as was shown above, in a linear model of innovation that led from basic research to applied research to innovation, which in turn produced public benefits.

2.2.3 The Cold War

One feature of the world after World War II, was the dominance (hegemony) of the United States in most aspects of international governance as was clear through its influence in the Bretton Woods institutions established after the war (for example the World Bank and the International Monetary Fund). In this world of hegemony, much of what the United States did was seen as a best practice example to be followed.

Within the United States, the Cold War – 1947–1991 – reinforced the perception that science was needed for national security, similarly to the perception expressed by Vannevar Bush to President Roosevelt after World War II (see Leffler, 2010). During the Cold War, the United States competed with the Union of Soviet Socialist Republics (the USSR) in military terms but also in science. Areas such as space exploration became an important symbol to show the superiority of capitalism or communism while military technology, such as missile development, took on a significant importance for national security (Leffler, 2010). Although the Cold War was not a society–science contract, it was a period of a unique relationship between science and society (or science and governments, specifically). The Cold War placed an importance on science in the United States to outmanoeuvre the USSR. Thus, although falling within the Vannevar Bush social contract period, it created a unique environment due to the perceived threat of an external enemy and the need for science to help defeat this enemy.

According to Sapolsky (1994:159), World War II ended with the atomic bomb, and the Cold War began with the atomic bomb. The combination of the atomic bomb and missiles (later in the period) would come to define the war. During the Cold War, university research gained much from the conflict, leading in a new era of science–society cooperation. Although the financial contributions to science made by the US government were not large compared to the entire defence budget, they were significant compared to other sources of university funding – also keeping in mind that universities were the main centres of research at the time. Military spending was a large source of funding; however, the military did not only contribute to weapons research; military spending also extended to funding for basic research (based on the mantra of the Vannevar Bush contract) and the training of science graduates as part of the understanding that basic research is needed in applied research. In this way, the Cold War delayed the democratisation of science by trumpeting the national interest and the importance of national security (Sapolsky, 1994). The Democratisation of science refers to the effect of a population's ideas as a collective influencing their support for certain research projects. This is discussed in detail in section 2.2.5.

Although the focus of this chapter is on the United States, this period of state–science cooperation was not only a US phenomenon. During this period, the world was broadly divided between those aligned to the United States or the USSR. In this way, the effects of the conflict was felt far beyond only the physical borders of these two superpowers.

In 1989, the so-called 'iron curtain' (see Wohlforth, 1995) unexpectedly began to crumble. This eliminated the need for sabre rattling and the continuation of the arms race between the United States and USSR. As the dangers of the Cold War receded, the military spending related to the war decreased. Politicians had mostly accepted the opinions of the military on matters of national security, but they now had their own opinions on scientific benefits related to healthcare, education and the like. With the military threat waning, these aspects took on a new significance. The end of the Cold War coincided with the end of the Vannevar Bush contract (Martin, 2003; Sapolsky, 1994).

2.2.4 After the Cold War: moving towards a greater need for societal impact of research

The end of the Cold War had an influence on the changes that emerged at the end of the 1980s in the relationships between science and society, governments and universities, funders and researchers, and research and corporations. The end of the Cold War meant that fields such as engineering and physical sciences lost much of their strategic military importance. They had been crucial in maintaining military superiority. Nuclear energy, a Cold War favourite, soon saw a sharp decline in its popularity with some countries announcing that they would be phasing out the use of nuclear weapons and nuclear power altogether (Martin, 2003).

Beyond the end of the Cold War, there were also a range of other aspects that started driving change in the relationship between society and science. These changes would in turn lead to a revised and still changing social contract. Martin (2003:10) mentions three “driving forces for change” that emerged after the Cold War and which are continuing today.

- *Increasing competition*: Globalisation is having a lasting impact on economic competitiveness in the modern world. With companies today being able to move from one country to another with unprecedented ease, developed countries with expensive labour have to compete with countries where labour is only a fraction of the cost. One of the ways for developed nations to remain competitive is through technological advancement. Continuous innovation in what has come to be called knowledge economies (see Rymer, 2011) has placed much emphasis on the need for research to be undertaken in a bid to improve productivity and competitiveness. Science has become a strategic competitive resource. Globally, countries are consequently working on improving the efficiency of their innovation systems. Societal impact can be used as a measure of improved efficiency within this process, leading to cost reduction through government programmes that show positive returns on investment (Rymer, 2011).
- *Constraints on public expenditure*: Governments are under pressure to apply expenditure constraints to manage with comparatively lower incomes. In developed nations, the ageing population is placing high demands on healthcare and social welfare, whilst the economic growth needed to fund these expenses can no longer be generated through growth-driven by population increases. Added to this is the increasing cost of research, which means that governments cannot support all avenues of research but have to be selective and strategic in terms of which scientific areas they prioritise (Martin, 2003). The economic slowdown in 2008 and the implementation of austerity measures in some countries sped up the process of stronger competition for grants. Assessment of the SoIR is important to identify which research to fund (Rymer, 2011). In the post-financial crash world, many economies in both the developed and developing world long struggled to maintain any form of significant economic growth. Even in the developed countries of the European Union, the financial crises and reduced economic growth went hand in hand with smaller science budgets (Makkonen, 2013).

- *Increasing importance of scientific and technological competencies*: With the increased importance of science and education within the knowledge economy, governments are faced by a demand for more educated labour. In a knowledge economy there "is a greater reliance on intellectual capabilities than on physical inputs or natural resources" (Powell & Snellman, 2004:199). This has meant that governments have had to shift from an elite-focussed higher education policy to one of mass teaching (Martin, 2003). In addition to this increased demand, the old system in which an individual could be educated in 20 years and then be 'set for life' has been replaced by a system in which continuous innovation has meant that there is also a need for continuous education. The reason for this is in how knowledge is used. In the knowledge economy, old knowledge can be replaced by new knowledge, making the older knowledge and technologies redundant (Arvanitidis & Petrakos, 2011).

With the increased demand for teaching (due to the needs of the economy and the need for updating skills) governments are faced with a conundrum. They can pay for mass higher education, which they are willing to do, as skilled labour is critical for a growing economy, and alongside this, they could increase the scale of academic research. Yet, with the increased cost of academic research, the inevitable consequence is either that not all academics will be able to continue to do research or that academics will have to begin to spend less time on research and more time on teaching (Martin, 2003). Assessment of the SoIR is important to identify which research to fund.

Rymer (2011) mentions two other post-financial crash trends that are contributing. These are:

- *government accountability*: governments are expected to show where funding was allocated and how this made a tangible difference. SoIR is an important measure of a government's success in addressing the needs of citizens; and
- *drive to measure academic excellence*: societal impact is viewed as a promising measure of the academic rigour of the outputs of an institution. The societal impact of the research done by a university could be used as a measure of its academic excellence (Rymer, 2011).

The time of the Bush contract is over. According to Guston and Keniston (1994), the Bush science–society contract, with government providing the funds and science providing results, was already oversimplified when it was drawn up. In the years following World War II, there was the assumption of identical interest between government and science. As will be discussed in the following section, this assumption has receded.

2.2.5 State of the current revised social contract: The democratisation of science

The scope of research undertaken today has expanded vastly with a range of interests existing together, from private to public and from individual to international interests. To some extent related to this larger scope of interest, research has become increasingly integrated into the national and global economies (Guston & Keniston, 1994).

In the old system, science was a 'protected' domain. Tax money provided an economic buffer and could be used with the hope that this investment would contribute to economic growth (Byerly & Pielke, 1995). However, by the end of the 1980s the consensus model of the post-World War II political economy (see sections 2.2.2-2.2.4 above) broke down. According to Nightingale and Scott (2007), this coincided with a change from 'government' to 'governance'. The role of the state changed from a driving force that directly engaged in undertaking research to a position more akin to a conductor that steers the direction of research (Nightingale & Scott, 2007).

Even though the role of the state has changed, research policy has become politically more important. Research (with all its benefits) is seen as important in increasing international (economic) competitiveness for countries, maintaining welfare and stimulating growth. Overall, investment in research globally has increased compared to the earlier Bush era (i.e. roughly 1945 to 1989). However, according to Bloch *et al*. (2014:105), there is "[a]n increasing demand for improved quantitative evidence on the impacts of research funding and to establish the causal relations between funded projects and results".

In the post-Bush era, the assumptions on the value of research have nonetheless not changed completely. Research investment is still viewed as important in stimulating innovation, advancing social development, propelling economic growth and expanding on the current knowledge base (Powell & Snellman, 2004). The most vivid change, however, is the demand for research both to be of a high quality but also to show a visible impact that benefits society (see Research Councils UK, 2011). The reasons for this are related to the increase in the size and cost of research undertaken, which, in relation to the available research funding, far outstrips the resources needed to fund all projects. Research funding in the new system is directed towards cost-effective interventions that can provide returns and overcome translation blocks (in other words that can be adapted easily from the laboratory to provide real-world application) (Banzi, Moja, Pistotti, Facchini & Liberati, 2011). Research is expected to have visible and measurable benefits, and evaluation of research projects seeks to identify the best projects to fund.

Although the state is one of the main 'conductors' influencing what is needed from research, a number of other interest-generating entities also exist. Elzinga (1997) touches on this idea when he says there is a change in the make-up of research communities from academic to hybrid communities. In a hybrid community, the values and needs of external organisations, especially funders, can take precedence over internal 'scientific interests' or even values. This is in contrast to the earlier era during which the state and science were seen to have similar interests and in which science was allowed to determine what valuable research was. Elzinga argues that science should be relevant to society, but also notes that the vast sums of external funding in the modern research system have the potential to change the loyalty of researchers, moving from disciplinary academic research communities to hybrid communities (Elzinga, 1997).

Elzinga further notes that scientists might not always be aware that they are not steered by the interests of science alone, but by political or other 'un-scientific' interests as well. He mentions scientists who worked on post-World War II Big Science in the United States. At the time, these scientists expressed their "disengagement from business and society" (Elzinga, 1997:417). However, looking back, it is clear that these scientists were "very much influenced by […] the military-strategic interests of the United States" (Elzinga, 1997:417). What this example shows is that with an expansion of non-governmental funding, there is a risk of scientists being influenced by 'private' interests.

This is where the democratisation of science becomes important since scientist influenced by private interests could have an impact on public opinion. In 2015, Van Linden, Der Leiserowitz, Feinberg and Maibach published an article in which they showed "that perceived scientific agreement is an important gateway belief, ultimately influencing public responses to climate change" (climate change is used as an example) (Van Linden *et al*. 2015:1). In the article, they report that even though "97% of climate scientists have concluded that human-caused climate change is happening […] only one in ten Americans (12%) correctly estimate scientific agreement at 90% or higher" (Van Linden *et al.*, 2015:1). The problem with this statement is that no matter whether the public has a good understanding of scientific 'truth' (in other words, whether they know what scientific consensus on a topic is), the public's perception of scientific agreement influences their beliefs on key issues. These beliefs are built on their perceptions that drive public political support for different policies (Van Linden *et al*., 2015:2). This shows that, unlike during the Bush era, science and scientists have to engage with the public, as it is in the interest of science that the public be informed on current scientific consensus.

The public and government no longer automatically assume that what scientists do and say is correct or, as in the example, the public might have an incorrect assumption of what scientific consensus is. Science has to prove its worth, engage with stakeholders and communicate its findings better, or risk being derailed by policies that are driven by public perception and not by scientific consensus. For Elzinga, it would then be best if governments could work with science (i.e. scientific experts), plotting and planning future areas of growth (Elzinga, 1997).

Nowotny, Scott and Gibbons (2002) published their take on the changes taking place in the relationship between science and society in their book, *Re-thinking science: Knowledge and the public in an age of uncertainty*. Similar to Elzinga, they perceive a change in the system to one where science and scientists are accountable to different interests or interest groups. In their book, they discuss the idea of so-called Mode 1 and Mode 2, a change from an older paradigm of scientific discovery to a newer paradigm of knowledge production. The term 'Mode 2' was coined by Gibbons and colleagues in 1994 (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow, 1994).

Mode 1 is characterised by the dominance of experimental science, the dominance of different scientific disciplines each with its own delimitations, and the autonomy of science (scientists and universities) to choose the direction of science (Nowotny *et al.*, 2003). The new paradigm of knowledge production, Mode 2, in contrast, is characterised by being socially distributed, application-oriented, trans-disciplinary and accountable to a number of different interest groups (Nowotny *et al.*, 2003). Nowotny *et al.* (2003) explain that they are not claiming that Mode 2 is replacing Mode 1, but rather that there is increasingly more Mode 2 research and less Mode 1. According to them, it is the nature of the research process that is being transformed (Nowotny *et al.*, 2003). Weingart (1997) argues that Mode 2 has been accepted widely because of the reality of limited research budgets compared to years of growth and the rise in importance of science being subject to societal values as a way of proving its legitimacy. Nowotny *et al*. (2003:181) identify three trends that they claim are "generally accepted to be significant" in the Mode 2 change. These are "the 'steering' of research priorities; the commercialisation of research; and the accountability of science" (Nowotny *et al*., 2003:181).

The first trend, "steering research priorities" (Nowotny *et al*., 2003:181), takes place at three different levels: at supranational level, national level and system level. Research priorities are increasingly being steered at various levels. At the supranational level, organisations such as the European Union (EU) have developed European Community (EC) framework programmes. These programmes are aimed at shaping the priorities of research to identified social or economic needs

(Nowotny *et al.*, 2003). At national level, governments and government departments are increasingly trying to create prescriptive research programmes that respond to short-term political agendas whilst contributing to increasing the capacity of long-term research (Nowotny *et al.*, 2003). This could have confusing or frustrating consequences as one government might spend years building a specific research agenda, only to have it overturned when an opposition party wins an election (Nowotny *et al.*, 2003).

The second trend identified by Nowotny *et al.* (2003) is the commercialisation of research. Public funding available for research has become inadequate to fund research. Researchers increasingly have to turn towards alternative sources of funding. The focus on the perceived reduction in public funding of research is overstated. The more important shift is that governments are starting to define their relationship with research funding in a quasi-commercial way. In addition, there is a focus on the exploitation of intellectual property (Arvanitidis & Petrakos, 2011; Powell & Snellman, 2004). This challenges the open nature of science. If universities are producing patents and research that are commercially sensitive, their research can no longer be shared freely in journals and the like. This both challenges the idea of science as a public good and removes the possibility of refutation by colleagues. If research processes are secret, the methodology cannot be challenged. In some instances, the results of research can even be kept secret as the information is valuable in the knowledge economy (Nowotny *et al.*, 2003).

Lastly, there has been a sharp increase in the demand for research to be able to prove its worth. Research has to be accountable to society. As part of this process, there is a strong focus on the evaluation of the effectiveness and quality of research. At national level, some examples include the Research Excellence Framework (REF) in the United Kingdom and the Standard Evaluation Protocol in the Netherlands (Bornmann, 2013; Grant *et al.*, 2009).

These national evaluation frameworks do not necessarily direct research, but define what is seen as a positive change, or which measurement criteria are used in determining the value of research (Research Councils UK, 2011). The use of these frameworks opens the system up to game playing. The rules that determine what is seen as excellence in research means that researchers start to aim at meeting these goals. Researchers begin to focus on the production of units of research and may show a preference to producing less controversial research as it is more likely to lead to predictable results and guaranteed research output. This process of auditing, evaluating and measuring has become part of all levels of research, be it with regard to research team members, university departments or government departments (Nowotny *et al.*, 2003).

According to Boaz, Fitzpatrick and Shaw (2009), organisations and individuals are increasingly considering research impact due to a range of reasons, including "accountability, performance, promotion of organisational achievements, learning and moderating between competing stakeholders/interests" (Boaz *et al.*, 2009:255). The push for increased accountability and understating of the SoIR is not driven just by aggressive external (non-research) stakeholder(s), but also by universities, funders and many members of the scientific community themselves who welcome and promote the process (Banzi *et al.*, 2011).

The new science–society contract requires an understanding of which research is undertaken in the most efficient manner (lowest cost) and produces the most effective results (highest societal impact). As Spaapen and Van Drooge (2011:3) summarise, scientific research today is seen as key in the drive to a sustainable, modern, efficient society. Science is "[n]ot only seen as a source of in-depth knowledge and innovation, but also as indispensable for the improvement of policymaking, education, social learning and […] quality of life" (Spaapen & Van Drooge, 2011:3).

Governments expect and are expected to illustrate clearly the benefits that derive from the research that they fund with public money. SoIR then becomes an important measure of the success of a government in addressing the needs of citizens (Rymer, 2011).

2.2.6 The influence of evaluation and new public management

Science–society contracts are ways of explaining the relationship between the scientific or research communities and governments. For much of the nineteenth and twentieth centuries, governments were the main funders of research. There existed an agreement that what was good for science was also good for society, as this would lead to benefits from future innovations. Governments also used science to drive projects that contributed, or were said to contribute, to national security and national interests. As the threat of the Cold War subsided, the processes driving the democratisation of science began to gain momentum.

Robinson-Garcia, Van Leeuwen and Rafols (2017:1) provide a good summary of what happened during this transition period in the 1980s:

> *As publicly funded institutions, universities and public research organisations are shaped by societal demands and challenges. Since the 1980s, they have been increasingly subjected to external pressures which have affected their governance. Among others, the massification of higher education, the increased scale of research and the globalisation of the higher education landscape have strongly shaped universities and research policies. Business-like and New Public*

Management practices have been incorporated to academia, introducing quantitative measures that aim to offer an 'objective and transparent' view on the performance of scientific organisations. These practices, which aim to improve research management and strategic planning have been largely based on publication and citation analysis focused on measuring scientific (rather than societal) impact.

There was a change in the relationship between science and society as governments and the societies they governed no longer accepted that what was good for science was automatically also good for everyone else. In addition, as described by Elzinga (1997), hybrid research communities influenced by external organisations and funders began to appear. Mode 1 (the paradigm of scientific discovery) decreased and Mode 2 (the paradigm of knowledge production) increased. In this changing world with external pressure and the need to show value, the fields of evaluation and of new public management took on new importance and provided frameworks on how to value science.

However, evaluation and new public management both predate the period of change in science, which has escalated from the end of the 1980s. The first evaluations date back to assessments of the 'great society' projects in the United States in the 1960s. Since then, numerous schools of thought or evaluation approaches have been developed. Evaluation has moved from what were widely (not universally) seen as definitive works, such as Campbell and Stanley's 1963, *Experimental and quasi-experiment designs for research*, to a plethora of approaches, including utilisation-focussed evaluation, realistic evaluation and meta-evaluation (Pawson & Tilley, 1997). The roots of NPM also date back to the early decades of the twentieth century with Max Weber's theory of the bureau as the main public sector 'instrument' (see Constas, 1958). This theory was further developed between the 1940s and 1960s through a focus on management and policy approaches (Lane, 2000:19–20). Thus, in the 1980s, when evaluation and new public management emerged in the assessment of research, both had already existed in other spheres.

Coincidently, the early 1990s (soon after the Cold War) was also the time during which evaluation and new public management truly entered the mainstream, becoming popular in government departments and various other international and national organisations. Between 1994 and 1995, evaluation societies were founded consecutively in the United Kingdom, Europe and Australia. It was also during the 1990s that many governments around the world began to engage in public sector reform, introducing some or all of the ideas associated with new public management. According to Lane (2000:6), these ideas included "decentralisation, privatisation, incorporation, deregulation and regulation, […] executive agencies, internal markets [‘purchaser-provider split’], [and] tendering/bidding schemes”.

The democratisation of science, the divergence of science–society interests, the multiplication of interests working in on science, the end of Cold War interests, the massification of higher education, the growth in the scale and cost of science, and the relative reduction in government funding – all created the demand for determining what the SoIR is. At the same time, the introduction of new public management policies meant that governments began to manage the public sector through contracts, including performance contracts. Evaluation, already used in some parts of the world to assess government projects since the 1960s, were deemed a logical method first to determine primarily the outcomes, and later, the quality of projects. When it came to the impact of research, the quality of research could (arguably) be evaluated through bibliometric indicators; however, the value or impact to society could not be measured through these citations and publications (Robinson-Garcia *et al.*, 2017). Having traced the growth in the importance of SoIR, section 2.3 looks at how to define the SoIR.

2.3 Defining societal impact of research

There is no accepted definition of SoIR and no standard best practice on how to assess it, even though there is a desire to develop reliable and meaningful ways of determining impact beyond academia (Bornmann & Bierman, 2012; Donovan, 2008; Kwan, Johnston, Fung, Chong, Collins & Lo, 2007). To take it one step further back, there are even different interpretations of what the SoIR is. For some (such as Spaapen *et al*, 2011; Economic and Social Research Council [ESRC] Evaluation Committee, 2011), research impact is part of a process during which later impacts are built, with research impact to a degree being the entire process of effecting these impacts. For others (see Samuel & Derrick, 2015), research impacts are final outcomes achieved as an end result of research. These differences point to varying ways of viewing or representing research impact. Research impact can in one view be effected in an orderly way, or it can be the result of a disorderly network. Additionally, there are different opinions on what ‘societal’ refers to with definitions of SoIR looking at the effects on individuals, all the way to the effect on entire societies (Stelzer, Wanner & Schäpke, 2015).

This section of the chapter provides a discussion on how to define SoIR. Firstly, the discussion is on the focus of different SoIR definitions. Secondly, the attention shifts to the linear view of SoIR, which values the final impacts achieved by research. Here the more traditional view of impact as a string of consecutive steps is elaborated. Although the current study viewed impact as something that takes place on a continuum with various feedback loops and not only as a linear process, the linear view of impact has academic value in that it allows studies to sketch narratives of how impact takes place coherently.

2.3.1 Different definitions of the societal impact of research

The measurement of research, as is shown below, remains controversial even in the more established areas of study. Generally, research output is counted by the number of publications produced (as most academics working at universities will know). Citations, for example, are again used as an imperfect proxy for short-term impacts (not necessarily quality) (Bloch *et al.*, 2014). With societal impact, there are however no general indicators (not even imperfect ones) that work between all disciplines. There are too many different ways in which impact can be effected to develop general indicators. A presentation by Kamenetzky, Hinrichs-Krapels, Wooding and Grant (2015:4) revealed 3 700 "unique pathways to impact" through which different academic fields have impacts on societal sectors (Kamenetzky *et al*., 2015:4). This, of course, does not mean that general indicators cannot be identified within specific fields. It does however show that the SoIR is an open term that has varying meanings to different people.

According to Bornmann (2013:217), there are at least six concepts that have been developed to explain the SoIR, namely:

- third-stream activities;
- societal benefits or societal quality;
- usefulness;
- public values;
- knowledge transfer; and
- societal relevance.

Third-stream activities for example focus on the 'additional' outcomes of university research that has an effect on decision-making in society at large (Molas-Gallart, Salter, Patel, Scott & Duran, 2002). Examples of third-stream activities include the commercialisation of university-produced technology or the undertaking of advisory contracts by academic staff (Bornmann, 2013). Public values or public value mapping, on the other hand, is defined as looking at the "non-scientific, non-economic goals – what we here term 'public values'", or public value impacts of research (Bozeman & Sarewitz, 2011:1).

According to Bornmann (2013), these are all related to the different types of benefits that derive from the products or ideas of research, be it in the social, cultural, environmental or economic realms. He argues that the assessment of SoIR can be done by looking at the effects of research results or products in these realms (Bornmann, 2013).

Different definitions of SoIR put the focus on different areas of society being influenced. According to the Research Excellence Framework (2011:26):

> *Impact is defined as an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia. […] Impacts on research or the advancement of academic knowledge within the higher education sector (whether in the UK or internationally) are excluded*.

SoIR comprises the social, cultural, environmental or economic realms (see Bornmann 2013), and expands the possible areas of impact with "public policy or services, health, the environment or quality of life" impacts (Research Excellence Framework, 2011:26). Importantly the definition states that these are impacts 'beyond academia'. 'Beyond academia' seems to exclude specifically knowledge production and the contribution of research to other research. Instead of just saying what the SoIR is, it also says what it is not – it is not scientific impact of research. According to Spaapen and Van Drooge (2011:212), the authors of the SIAMPI approach:

> *Social impact [is] a consequence of a process in which knowledge and expertise circulates to achieve certain goals that are deemed relevant for the development of society. Social impact can thus have multiple meanings depending on different social contexts*.

The use of the word 'social' in the above definition (referring specifically to 'social impact') should not cause concern. The generally accepted term in use today is 'societal'. In a report published in 2017, Spaapen himself had started using the word 'societal' (Van den Akker & Spaapen, 2017).

Other definitions provide their own lists of areas in which societal impact could have an effect. Wolf, Häring and Heß (2015:4), for example, see societal impacts as "practical [or] other 'real-world' impacts of research". A study by Joly *et al.* (2015) concluded that many different combinations of impact are used by studies to define societal impact. They identified the major sub-types of societal impact as economic impact, environmental impact, social impact, political impact, cultural impact, organisational impact and impact on health (Joly *et al*., 2015:6). Societal impact is the impact of research *outside* of academia in any sector of society (Moed, 2013).

In their study, Samuel and Derick (2015) interviewed 64 REF2014 evaluators regarding their views on societal impact (REF evaluations in the United Kingdom in 2014). The interviews were done prior to the REF2014 evaluation process. They found that the majority of interviewees thought of societal impact as an outcome (a change or a difference). Societal impact had taken place if something in society had already changed (Samuel & Derrick, 2015). In other words, it focussed on the 'benefit' of the use of research (Bornmann, 2013). They also found that the evaluators described societal impact in "more economic terms" (Samuel & Derrick, 2015:234). Benefit to the economy and the creation of jobs were some of the examples mentioned (Samuel & Derrick, 2015).

Societal impact could have an effect on different groups in society or it might only affect selected individuals (Wolf *et al.*, 2015). However, for societal impact to take place, it requires the conversion of research into useful products or services for society. Some examples of this would are new technologies, medicines or diagnostic tools (Bornmann, 2013).

Linked to this understanding of societal impact, Bornmann (2013) summarises three main definitions of societal impact that have emerged since the 1990s. These different definitions represent three different stages of the research process (i.e. of research having an impact) (De Jong *et al.*, 2014).

- Societal impact can be viewed as a *product*: The outputs or products of research are embodied in that which is produced by the research. It does not matter whether society uses the products; the product itself is the societal impact. Products may include information, methods or technologies among other 'products'.
- Societal impact is also the *use* of research: The use of knowledge includes any use of research results by a societal stakeholder (Bornmann, 2013). A 'societal stakeholder' refers to policymakers, professional users and end users. A policymaker mainly uses research for the drafting of policy. A professional user makes use of the research to develop products and services, while an end user refers to target groups of research, for example winegrowers (Spaapen *et al.*, 2007). The use of knowledge may be the result of interaction with a product of research or it can be the result of an interaction with a person (Bornmann, 2013; De Jong *et al.*, 2014).
- SoIR could also be the *benefits* derived from research: The use of knowledge could lead to someone benefitting from it. If research were used to write a policy, the existence of the policy would be a benefit of the research. Other benefits may be widespread, from changes in professional practice to improvements in a community. The benefits gained depend on the type of research (Bornmann, 2013; De Jong *et al.*, 2014)

SoIR is often described along the lines of a second impact definition, that of *use* (Bornmann, 2013). This is in contrast to standard programme evaluation where the products and use would be seen as outcomes leading to longer-term impacts (benefits). The SoIR is the *use* of research results outside of academia by any grouping of users – from individuals to a whole community. Research can be used in a number of ways with three prominent types of research utilisation discussed in the literature (four uses are presented below). These models were developed within the policy context but are also applicable in other domains (Boshoff, Esterhuyse, Wachira-Mbui, Owoaje, Nyandwi & Mutarindwa, 2018; Weiss, 1979).

- *Instrumental use*: This is what most people would probably have in mind when thinking about the use of knowledge (Weiss, 1979), and refers to a user of research seeking out research that would be able to address his or her needs. Instrumental use may include the use of research in policies or new farming techniques adopted by farmers based on research results (Boshoff *et al.*, 2018). Other types of instrumental use include the shaping of legislation or affecting the development of a practice (Johnson *et al*., 2013).
- *Symbolic use*: This is the use of research to prove an already held belief, or as support for a pre-formed argument. The contents of the research are important for the way in which they 'symbolically' support an argument or idea. Examples may include the use of research by politicians to support the views they already hold, or where a farmer might use research findings in tune with his or her beliefs (Boshoff *et al.*, 2018).
- *Conceptual use*: According to Boshoff (2014), conceptual use of research forms part of the enlightenment model of research (see Weiss, 1979). The enlightenment model is one of six models according to which research may come into use (Weiss, 1979). Conceptual use is the least conscious use of research, and is often the result of knowledge creep. The ideas of users of knowledge and policy writers for example, can be influenced by a number of research results to which they have been exposed. These results influence their views over time without one result being able to claim the change that takes place in their opinions over time (Boshoff, 2014a).

Some other definitions of societal impact include further ways in which research might be used. According to the ESRC Evaluation Committee (2011), the SoIR takes place along a continuum, which includes conceptual, instrumental and what they call capacity building impacts. According to the ESRC, capacity building impact refers to the transfer of skills and people between the researcher–user interface (ESRC Evaluation Committee, n.d.). Capacity building impact is however not included in most other authoritative sources on research utilisation, but just mentioned as an additional example (Estabrooks, 1999; Weiss, 1978; 1979; 1980).

Based on the above, the SoIR is thus the instrumental or conceptual use (possibly also symbolic or persuasive use) of or benefitting from research beyond academia by any grouping in society. Impacts may include but do not have to be limited to economic impacts, environmental impacts, social impacts and political impacts. Products of research can be societal impact in themselves; however, where use and benefit of research comprise interactions between research and society, a product as an output does not have to interact with society.

Based on the discussion above, SoIR is not one 'thing' or concept. Impact of research is any effect caused by research beyond academia that has value for someone, be it an individual or organisation. If someone is interested in the effect and the effect has importance to such person, the effect can most likely be seen as the SoIR. Although there is no accepted universal definition of the SoIR, some definitions such as the Research Excellence Framework definition (2011:26) with its focus on effects, changes or benefits have taken on some prominence.

In this study, societal impact was seen as taking place on a continuum. This view needs further explanation as it has an effect on when and how to assess societal impact. If impact is only something that takes place at the end of or long after a research project had been completed, the assessment can only be done *ex post*. However, if the SoIR is a continuum, it could potentially be monitored through process indicators of societal impact. The next section discusses the linearity of SoIR in more detail.

2.3.2 Societal impact of research as a linear and non-linear process

Research can create benefits for society, and those benefits are the result of a linear chain of events, where research generates outputs and products, which are then taken up and used by others to create those benefits. The view of societal impact as a conveyer belt of benefits probably has its roots in the same thinking as the Vannevar Bush science–society contract (Bush, 1945), which argued that the production of basic research as a public good will create the knowledge required to do applied research, which then translates into societal benefits. A similar idea was behind the deficit model of knowledge (science) (see Miller, 1983) used in science communication in the 1980s. It saw science in possession of useful facts that needed to be communicated to non-scientists (Ahteensuu, 2012). Empirical research showed that the deficit model of knowledge did not match the complexity of the real system, which led to the abandonment of the deficit model by science communication (Simis, Madden, Cacciatore & Yeo, 2016). This was however not the end of the view that science is almost by definition concerned with the production of valuable and useful knowledge and that societal impact entails having to share this with the world beyond.

The linear model of science, where science produces benefits to be distributed to society, has been proved to be inconsistent with the reality of how research is produced. The Research Councils UK (2007:35) already made it clear in 2007 that "[t]he inherent complexity of the innovation system means that many of the wider societal impacts arising from research are affected by a host of external, interacting factors (multipliers) beyond the control of the research base".

They went so far as to say that it is not realistic to expect that a research institute could cause "significant impact on society" by itself (Research Councils UK, 2007:35). Creating value from research or effecting impact is more than just producing research results that can then be transferred to beneficiaries at the end of research. It is also difficult to prove that a research project caused certain impacts. Effecting SoIR requires interaction and cooperation between a range of stakeholders (ones that are part of the research project or more distant) (Van Drooge, Vandeberg, Zuijdam, Mostert, Meulen & Bruins, 2011). Research is a social activity, and assessment of research has to take into account the larger process of innovation (Spaapen *et al.*, 2007).

As discussed in the focus of SoIR the 'continuum' nature of SoIR has been taken up by most current definitions. The three uses of societal impact (as a product, as knowledge use, and as societal benefits) take into account different stages of the research process (Bornmann, 2013). The ESRC definition, for example, also states, "the ESRC recognises that the nature of social science research impact lies on a broad continuum" (ESRC Evaluation Committee, 2011:5). In the SIAMPI approach and other impact mechanism–interaction approaches, it becomes possible to bring these uses closer to the researcher and identify 'impact' all along the research process (Spaapen & Van Drooge 2011b).

Approaches, such as SIAMPI, view research as a complex system with interactions between stakeholders from various different spheres (i.e. the academic sphere, funding and government). Within this system, the researcher cannot control the interactions that lead to innovation. SIAMPI focusses on productive interactions that are close in time and space to the researcher, and on how these interactions lead to contributions, potentially effecting societal impact (Costas, Prins, Van Leeuwen & Wouters, 2014). Academic research is not the only driving force of innovation but rather part of a wider process of innovation. The creation of SoIR is complex and non-linear and comprises inputs from various stakeholders from beyond academia that contribute their expertise along with the research produced (Jansen & Ruwaard, 2012; Spaapen & Van den Akker, 2017). The next section turns the attention to measuring societal impact.

2.4 How to measure societal impact

With no standard way of determining the SoIR, scientific impact at present is commonly assessed based on citations and the output of peer-reviewed journals. Citations show some form of recognition by a researcher's peers. The outputs of a researcher in peer-reviewed journals along with the rate at which the researcher is cited, can also be computed into an h-index (see Hirsch, 2005). At present, a researcher would measure his or her scientific impact by looking at citations and publications in 'high-impact journals'. These measures however do not assess the SoIR. At the most they show some form of impact on science by the specific researcher's research (Wolf *et al.*, 2015). As has been established by now, there is a growing demand for assessment methods that can appraise the SoIR. Section 2.3 has provided some insight into what is meant by 'SoIR'. This section provides an overview of the approaches taken to date to address this demand.

The section starts by considering the economically focussed beginning of SoIR assessments. Most of the first attempts to assess the SoIR focussed on cost–benefit and other ideas that emerged from the corporate environment. The second part of the section looks at an extension of this economic focus with a shift (in the academic literature) away from quantitative- to qualitative-focussed, or more precisely a mixture of both. The third part discusses the idea of a comprehensive evaluation along with *ex ante* and *ex post* research impact assessments of the SoIR. The comprehensive evaluation is presented first. *Ex ante* and *ex post* assessments are often presented as contrasting one another; yet, both has a place in a comprehensive evaluation. The final two parts of this section look at the payback framework, which is arguably the most commonly used impact assessment framework, and the emergence of new impact mechanism approaches, of which SIAMPI is an example. This section does not provide an overview of the numerous approaches that have been developed to measure the SoIR, but rather focusses on the main trends to which these approaches have been linked.

2.4.1 Moving from a purely economic focus in societal impact of research

The start of the new drive towards valuing science or research took place along with the rise of NPM. NPM is the introduction of business practices into the public sector. To date, most studies on the impact of research beyond academia have focussed on the economic impacts. These include input–output analysis and cost–benefit analysis (Bozeman & Youtie, 2017). In cost–benefit analysis, a comparison can be made between the cost of a programme or project, compared to the benefits that were created. If the benefits are more than the costs, it is possible to calculate an internal rate of return to arrive at the final benefits that were derived from a research project (Kilpatrick, 1998).

Economists working on economic growth and productivity were the first to try determining the value of research. They used economic models to estimate return rates on research for privately and publically funded research. These research projects on economic impacts were mainly commissioned by policymakers (Miettinen, Tuunainen & Esko, 2015).

There are however numerous problems with an economic focus for research impact or the SoIR. Although the idea (cost–benefit) behind these models is not complex, quantification of benefits remained rudimentary. It is very difficult to assign a value to human life or to health for example (Kilpatrick, 1998). It is possible to do it, but it can arguably enter less ethical ground where human lives are turned into monetary values. A pure focus on economic impacts from an academic or evaluation viewpoint also misses many non-economic impacts of research (Miettinen *et al.*, 2015). An additional danger of economically focussed assessments is that easily quantifiable and countable impacts can be over-reported, while harder to count impacts might be ignored due to the difficulty of collecting data. SoIR cannot be equated and limited to the economic impact of research alone (Milat, Bauman & Redman, 2015).

2.4.2 The use of quantitative and qualitative methods in the assessment of societal impact

The first attempts at assessing the SoIR were quantitative since they were based on economic principles and assumptions. The quantitative way of looking at the SoIR is linked to the linear idea of impact as it sees research as a valuable product that can be picked up and used (Miettinen *et al.*, 2015). An additional way of calculating the SoIR, not mentioned in the previous section, is social return on investment. Social return on investment (SROI) considers the economic, socio-economic and social returns produced by a project (Krlev, Münscher & Mülbert, 2013). Economic returns are financial returns such as revenues. Socio-economic returns are less direct and refer, for example, to a prevention of a loss of tax income, due to a project saving job opportunities. Social returns are the final type of effect, and this refers to all the non-financial impacts, such as increasing the knowledge base of a discipline or an increase in the self-esteem of a patient. SROI makes use of monetary, quantitative or qualitative evidence; however, the focus of the approach is on monetisation (Krlev, Münscher & Mülbert, 2013).

There are a number of limitations to this approach, which can, to some degree, be extended to other quantitative approaches. The pure use of metrics, or an overly strong focus on metrics could lead to inadequate reporting of qualitative impacts. There is a risk of placing too much emphasis on easily quantifiable indicators. There is also a risk of producing assessment systems that lead to projects attempting to 'tick boxes' rather than doing innovative research (which remains the desired 'return on investment'). Finally, the focus on monetisation could reduce the sophistication of analysis by focussing the metrics on the lowest common denominator to allow for the comparison of costs (Penfield *et al.*, 2014).

Most current approaches assessing the SoIR have moved towards a stronger qualitative focus (Bornmann & Bierman, 2012). The qualitative shift took place since it is near impossible to attribute changes in an open system to specific research projects. The use of in-depth case studies, interviews and impact narratives, which are all time- and resource-intensive, seem to be the best tools with which to assess SoIR (Bozeman & Youtie, 2017; De Jong *et al.*, 2014). The use of case studies to assess the SoIR, even for their limitations, are considered current best practice and have been adopted in some national research assessments, such as the REF in the United Kingdom (Bornmann & Bierman, 2012).

Case studies allow for more depth, and take into account the context around research (Donovan, 2008). It can also make use of qualitative and quantitative methods, and adapts data collection and the focus of the evaluations based on different perceptions gathered from stakeholders. Although the case study approach has been proved as a sophisticated and powerful tool, the unique aspects allowed for in each evaluation means that there is often no or little transferability of findings between studies or evaluations. In-depth case studies also require large investments of money and time, which has made it mostly unsuitable for adoption on a large scale (Donovan, 2008).

Along with case studies, evaluators or assessors of research make use of various other qualitative methods, including logic models and causal frameworks (theories of change). These frameworks and logic models are however linear, in contrast to the increasingly accepted notion of research impact as an iterative process (Dorp, Lowik & Weerd-nederhof, 2017). Case studies along with other qualitative (and quantitative) methods of SoIR assessment, also suffer from the general obstacles experienced in the assessment of SoIR. These are discussed in 2.6, and include the problems of attribution and temporality. One of the approaches that has emerged as a response is the SIAMPI approach with its focus on productive interactions (Dorp *et al.*, 2017).

The payback framework again is one model that makes use of logic models (see Donovan & Hanney, 2011a). It is likely the most used assessment model of SoIR (Stelzer *et al.*, 2015). The framework consists out of two elements. The first is a logic model, which provides an overview of the research. This is useful in SoIR assessments. The second element is a series of categories that list the expected paybacks or impacts of a research project (Donovan & Hanney, 2011a).

The payback framework is popular since it allows the representation of the research story. The framework also makes use of feedback loops, since it is understood that the research process is not (necessarily) linear (Donovan & Hanney, 2011a). The payback framework contains seven stages from 0 to 6. It starts with topic or issue identification in stage one, continues to inputs into research, the research 'process', primary outputs all the way to adoption of results and final outcomes (Donovan & Hanney, 2011:182). The framework presents the importance of intermediaries and beneficiaries in the effecting of research impact through a dissemination and adoption phase (Matt, Colinet, Gaunand & Joly, 2017).

In summary, qualitative approaches provide the depth and scope required to assess the SoIR. These approaches are however time- and cost-intensive and suffer from the general pitfalls related to assessing SoIR. Quantitative approaches again provide an air of trust and allow for easy comparisons to be made between different projects. The nature of SoIR however means that SROI and cost–benefit analysis (as examples of quantitative approaches) must rely on monetising aspects that cannot truly be monetised (for example human lives), leaving their calculations rudimentary. These approaches also create the illusion of a closed system and attribution of research impacts to projects, which can mostly not be supported through evidence.

2.4.3 *Ex ante* and *ex post* assessment of the societal impact of research

Other than how to assess the SoIR, there are also options regarding when to assess a project. *Ex ante* assessments look at possible future impacts, and *ex post* assessments look at completed projects. *Ex ante* and *ex post* assessments are complementary and both are part of a comprehensive evaluation (Kelley, Ryan & Gregersen, 2008).

An *ex ante* impact assessment would be the first step in a comprehensive evaluation. It can be used for priority setting to determine which likely future impacts of research best fit with the research portfolio of a funder. Monitoring of a project again takes place after a project has already started. It includes reporting on the progress of goals. An *ex post* impact assessment is the final type, and looks at changes in specific indicators related to the goals of a project (Kelley, Ryan & Gregersen, 2008).

Ex ante assessment of SoIR mainly focusses on pathways to impact statements (Samuel & Derrick, 2015). *Ex ante* assessments help with the setting of goal against which the future success of a project can be measured. As an exercise, it also helps to flesh out the logic of a project, ensuring that it has been thought through (Maredia, Shankar, Kelley & Stevenson, 2014). *Ex ante* assessments generate hypotheses on projected impacts. These projections can be used to monitor the progress of a project or to structure a future *ex post* assessment (Kelley *et al.*, 2008).

Ex post assessments of SoIR that take place after the research had been completed. In essence then, because it takes place after completion, the focus is on the achievement of the economic, social or other kinds of impact of the project (Maredia *et al.*, 2014). *Ex post* assessments can also look at indicators and compare the achievement of goals to what the indicators would have been if the research was never implemented. This is referred to as “the counterfactual situation or ‘control’” (Kelley *et al.*, 2008:203).

Since impacts can take time to form, *ex post* assessments might only be feasible a number of years after completion of the research. Other than the normal problems of temporality and increasing difficulty in determining attribution, this also means that *ex post* assessments are not appropriate for quick feedback (Kelley *et al.*, 2008). The slower feedback could mean that the results are no longer relevant by the time the assessment is done.

2.5 Developments in the assessment of the impact of agricultural research

Research impact assessment and the SoIR of agricultural research have developed along similar lines as non-agriculture-focussed research assessment and evaluation. With agricultural research, there is however still a very strong focus on economic impacts. Funding agencies that fund agricultural research and projects are, similar to other research funders, increasingly looking for evidence of the impacts of their investments (Andoseh, Bahn & Gu, 2014). These organisations are under pressure to show that they are using the available resources in an optimal way, which effectively generates technology and knowledge. They have to show an economic, social (societal) and environmental impact of their projects (Bennett, Kelley & Maredia, 2012; Kelley *et al.*, 2008; Springer-Heinze, Hartwich, Simon Henderson, Horton & Minde, 2003).

Unsurprisingly, the pressure on donors and the projects they fund, have led to an increase in interest in the assessment of agricultural research. This has sparked an international trend towards accountability, which requires the development of impact evaluation methods that could account for the benefits originating from agricultural research funding (Bennett *et al.*, 2012; Weißhuhn *et al.*, 2017). It has also been found (see Midmore, 2017) that agricultural research often delivers a higher societal return (impact) on average when compared to other research, making it a priority to measure for funders who seek to show the success of their funded projects. A study by Midmore (2017:614) reported that agricultural research consistently delivered the highest dollar-for-dollar impact out of all public investments made into agricultural production: "[s]uch returns are considerably above what might normally be acceptable for commercial ventures, and an order of magnitude greater than costs of public borrowing that are reflected in generally accepted levels of social discount rate."

To date, the problem with agricultural research impact assessments has however been that assessments at times mainly focus on success stories. Research funders commission studies of successful projects to demonstrate certain (wanted) outcomes, in the process possibly missing important information on why research fails (Weißhuhn *et al.*, 2017).

Additionally, agricultural research impact assessment mainly looks at the economic impacts of research, for example calculating rates of return for major food groups and commodities resulting from research (Springer-Heinze *et al.*, 2003). This focus has not changed much since 2003. Recent studies have found that research impact assessment is present at "all evaluation levels of agricultural research" (Weißhuhn *et al.*, 2017:40); yet, there remains a "major interest in economic impacts of new agricultural technologies" (Weißhuhn *et al.*, 2017:41). Although the economic impact of research is often a focus in SoIR, it is especially the case for agricultural research (Matt *et al.*, 2017).

One of the favoured economic approaches in agricultural research impact assessment is cost–benefit analysis for *ex ante* impact assessments (Andoseh *et al.*, 2014). Cost–benefit analysis is seen as useful since it can show the potential cost-effectiveness of funded research compared to other funded projects. It allows for inter-project comparisons (Bennett *et al.*, 2012). Other than economic or financial impacts, agricultural research impact assessments include social impact, such as food security and poverty reduction (Weißhuhn *et al.*, 2017). These are however mainly presented in monetary terms.

The assessment of the societal impact of agricultural research mainly makes use of three categories of impact studies: *ex ante* impact assessments, monitoring and evaluation (M&E), and *ex post* outcome attribution (Andoseh *et al.*, 2014). *Ex ante* evaluations look at the potential impact of research projects. They make use of detailed information on the current state of affairs (for example disease and pest burdens), and on expected impacts of new products and technologies (such as the profit benefits of the introduction of new crop varieties). Impact evaluations (part of a comprehensive evaluation) are used to consider the effectiveness of programmes. Finally, *ex post* impact assessments try to calculate the economic and social impacts that were effected by a research project after the completion of the project (Maredia *et al.*, 2014).

Gaunand *et al.* (2015) argue that agricultural research impact assessment can thus be divided into two camps, that of economic impacts and that of broader impacts. From the overview above, it is clear that the focus of agricultural research impact is mainly on economic impacts. However, similar to the SoIR, there is a realisation that economic impacts do not capture all the contributions made by agricultural research. The payback framework and SIAMPI are highlighted by Gaunand *et al.* (2015), along with impact pathways as approaches that could capture the different stages of the research process, "from the basic research inputs to the final impacts, including the different research outputs and outcomes for different types of users" (Gaunand *et al.*, 2015:851). This allows for the assessment of various types of impact, including economic and social impacts.

Section 2.6 considers the general obstacles that hinder the development of SoIR assessment approaches.

2.6 Obstacles in measuring the societal impact of research

With too little understanding of the mechanisms involved in effecting the SoIR, there is no consensus on how societal relevance and impact are produced (De Jong, Van Arensbergen, Daemen, Van der Meulen & Van den Besselaar, 2011). The search for research evaluation methods and approaches that assess the SoIR continues to be a priority for various organisations – from research funders, to governments and universities (Wolf, Lindenthal, Szerencsits, Holbrook, Heß, Szerencsits, Holbrook & Hess, 2013). There is a growing expectation that research should contribute to socio-economic impacts (Joly *et al.*, 2015). Research evaluation approaches mostly focus on scientific impact measured through impact proxies (indicators), such as the number of publications and citations (Wolf *et al.*, 2013). These indicators are however not useful in evaluating SoIR. Since there is no single definition of what SoIR is (the development of a working definition in 2.3 does not make it a universally accepted definition), it is near impossible to standardise indicators for SoIR (Robinson-Garcia *et al.*, 2017).

Although there are many other challenges in addition to those discussed below, there are three main obstacles encountered by most – if not all – SoIR approaches. These are the challenges of attribution, temporality, and inadequate data and expertise.

- *The challenge of attribution*: The issue of attribution is one of the most common obstacles encountered in any impact evaluation (Spaapen *et al.,* 2011). This is also true in research impact assessment. When looking at a target population, the number of factors that might influence their behaviours or ideas is near infinite. Since research works with ideas and the ways in which research might have affected an individual's ideas, this becomes a complex issue. How does one determine what gave rise to someone's thoughts and perceptions? Even if we look at an 'easy' example such as policy – easy because it is probably based on some theoretical debate or logic – we can see that a range of processes, individuals, research and other influences might have contributed to its formulation. Policies build on a culmination of findings originating from larger bodies of research and not from a single easily identifiable project. A policy might be adopted after a new research report has been released, but even in that case, the report probably cannot take full credit for the new policy. The officials writing the policy might have been influenced by other reports they had read in the past, something they saw on television, or their own personal background (beliefs). It is not possible to say, or rather, to prove with certainty, that one report was the single origin of an entire decision (Banzi, Moja, Pistotti, Facchini & Liberati, 2011:8; Bell, Shaw & Boaz, 2011:234; Bornmann & Bierman, 2012:674; Spaapen & Van Drooge, 2011:213). The problem of attribution gets more complicated over time as the number of factors that could potentially have had in impact increases (Dorp *et al.*, 2017). This becomes a compounded problem with the challenge of temporality.
- *The challenge of temporality:* In some cases, research has an impact soon after publication, while other research takes decades before any impact beyond science becomes visible. Impacts in agricultural research can regularly take up to 19 years to appear (INRA, 2017). This makes it difficult to determine when exactly to 'expect' impact to occur. An impact evaluation should only take place after it has been assumed (or planned) that impact must have taken place. It is important to understand when impact is expected, as an evaluation done too soon or too long after completion of a project might not show impact at all (Banzi *et al*. 2011; Spaapen & Van Drooge 2011a). A report by Research Councils UK (2007) found, "research impacts […] cannot be measured during the duration of research projects, and arguably should not be assessed before the 5 - 10 year time scale" (Research Councils UK, 2007:36). At the same time, impact might change over time. Impact might be visible directly after research is completed, but might have little persistence. The lack of persistence might

be intended, and evaluation must be done accordingly (Bell *et al.*, 2011). A strict standard for when impact must be measured will create a bias and not be relevant to all evaluations (Bornmann & Bierman 2012). Research is thus different to a social programme. In a 'normal' programme, the programme theory will set out when certain outcomes and impacts are expected. For research, including agricultural research, there are no similar timelines (INRA, 2017). It is also not possible to develop these timelines because the data and expertise needed for such an exercise do not exist or are not part of the average researcher's skillset. Additionally, as mentioned the complexity of attribution increases over time, creating a problem of latency where it becomes extremely difficult to determine what would be the best time to do an SoIR evaluation (Dorp *et al.*, 2017).

- *The challenge of inadequate data and expertise:* Data on the SoIR is not readily available. Bibliometric research could draw on datasets such as the WoS (Bornmann & Bierman, 2012). With societal impact, there are no comparable sets of data. This means that researchers must rely on programme staff and stakeholders for data. The reliability of information on societal impact gathered from stakeholders might, however, often be seen as suspect. This is not due to a lack of honesty but to a lack of expertise (Bell *et al.*, 2011). Assessing and understanding societal impact may make demands on scientists or researchers and stakeholders beyond their disciplinary expertise. An expert scientist might be a lay person in understanding societal impact (Bornmann & Bierman 2012). The challenge of expertise complicates the challenge of temporality and attribution as it is not possible to rely on stakeholders alone when deciding on time frames and project theory.

2.7 Conclusion

This chapter has laid out the history of how the SoIR has taken on such an important position in contemporary society. It is part of a long history of science and society engagement. In democracies, there is pressure from the democratisation of science, the need for informing the voting public what scientific consensuses are, and the hungry knowledge−based economies needing educated labour. With the desire to measure the SoIR on society, questions arise such as 'exactly what is SoIR', and 'how does one go about measuring it?' This chapter has shown how SoIR can be a number of different things for different stakeholders in the research process, and how the concept of the research process itself has moved from a linear understanding to a more complex understanding with numerous actors involved. Along with the shift in how the research process is viewed, opinions on the assessment of SoIR have changed. Mainly quantitative approaches were replaced by assessment methods that make use of both qualitative and quantitative techniques.

The next chapter considers the context within which the current research was undertaken, namely the field of agricultural research in South Africa and the two commodity companies that provided the case studies for the research, Winetech and Hortgro.

Chapter 3

An overview of the history of agricultural research in South Africa

3.1 Introduction

This chapter traces the history of agricultural research in South Africa over the last two centuries, covering the nineteenth and twentieth centuries until the present. The focus at first is mainly on the National Department of Agriculture (in its various forms) of the erstwhile Union (and later Republic) of South Africa and then shifts to the two commodity organisations, Hortgro and Winetech, from where the case study research projects were selected for the current study. The first part of the chapter provides a historical overview of how the agricultural research environment in the country developed over more than two centuries. The overview mostly lies at the national level focussing on changes in the policies and structures of the South African Department of Agriculture, but also includes a discussion of developments in agricultural research during the colonial era. It is important to look at the history of how agricultural research developed in South Africa as it shows the wider context of current issues facing the industries in the agricultural sector.

One of the main themes is the political disenfranchisement of the majority of the South African population. The disenfranchisement of black South Africans before the advent of an inclusive democracy in 1994, has led to calls for land reform in the current dispensation, including calls for the expropriation of land (mainly agricultural land) by the state without compensation. Aspects that seem unrelated to racial tensions, for example labour issues, could accordingly take on racial undertones. Landowners are often white, and the labourers are predominantly black. This means that topics such as mechanisation in the agricultural industry are very sensitive and could become racially loaded through the perception that it will destroy the livelihoods of the previously disenfranchised (black) poor. The reasons why South African agriculture is confronted by these realities emerge from an overview of the historical context.

Another aspect to keep in mind when reading the historical overview is the use of regulation by the South African (SA) government (after unification). The government increasingly took control of or exerted influence over all aspects of the agricultural industry, including research. The government further took control of training colleges, legislated against a free export market, and built a system in which only designated semi-government organisations could export agricultural products, such as fruit and wine.

The second part of the chapter follows the development of the two commodity companies, which provided the four case studies used in the current research. It looks at how these developed into their current forms out of the context discussed in the historical overview.

3.2 Agricultural research in South Africa from the colonial era to the present

The last two centuries in South Africa represent the formation of different states or political entities in the territory that would later become the Union of South Africa, following unification in 1910, and the Republic of South Africa in 1961. The period before 1910 includes developments in two British colonies and two Boer Republics. The years after 1910 and especially after 1948 again saw the implementation of racial segregation and so-called 'separate development', which would later be termed 'apartheid'. Apartheid (Afrikaans for 'separateness') meant that development was supposed to take place differently for different race groups. Apartheid led to the creation of ten 'homelands' for black citizens in South Africa. This meant that by the 1980s, South Africa had a total of 13 different Departments of Agriculture at the same time (Roseboom, Pardey, Von Bach and Van Zyl, 1994).

Although the disenfranchisement of non-white inhabitants of South Africa can be traced back to the two British colonies and the former Boer Republics, it was the Natives Land Act (No. 27 of 1913) (Changuion & Steenkamp, 2012) that institutionalised segregation in the newly created Union of South Africa. According to the Natives Land Act, black citizens could only purchase, hire or acquire land in specific areas designated by government. In effect, black citizens were limited to usage of first 7.3 per cent and later 8.3 per cent of the total area of the Union of South Africa (Changuion & Steenkamp, 2012:134).

The process of undoing the injustice of the Natives Land Act, was officially started with the proclamation of the Abolition of Racially Based Land Measures Act (No. 108 of 1991) (Changuion & Steenkamp, 2012) and the Upgrading of Land Tenure Rights Act (No. 112 of 1991) (Changuion & Steenkamp, 2012). This was followed by the Restitution of Land Rights Act (No. 22 of 1994) (Changuion & Steenkamp, 2012). This was one of the first laws to be passed by the first democratic government of South Africa. The Restitution of Land Rights Act (No. 22 of 1994) (Changuion & Steenkamp, 2012) began the process of land restitution (with a claim cut-off of 1913) (Changuion & Steenkamp, 2012:272–273).

According to Roseboom *et al.* (1994), the history of agricultural research in South Africa can best be captured through an analysis of the history of the SA Department of Agriculture (in all its different forms). They propose four periods for such an historical account: 1910–1958, 1959–1984, 1985–1992 and from 1993 onwards (Roseboom *et al.* 1994). The current study followed the same historical periods but with two modifications: a new last period (from 2013 until the present) as well as a new starting period (from 1806 to 1910). The reason for the new starting period is because 1806 was the start of the second British colonial occupation of the Cape and 1910 was the year in which South Africa became a union. This period saw the institutionalisation of higher education (as discussed in 3.2.1) and consequently research in the Cape province, but also in the Boer Republics that grew in the interior of the territories that would become the Union of South Africa (the precursor to the current Republic of South Africa) (Roseboom *et al.* 1994).

The periods as defined by Roseboom *et al.* (1994) are used for three reasons. Firstly, agricultural research and development during the 1900s was funded primarily through public sector financing. Although there were other research organisations that operated beyond direct government control, state-related research centres (directly run by the state or funded by the state) were arguably the most influential research institutions over the last century (1910–1994) (Liebenberg & Kirsten, 2006). Secondly, this study focussed on agricultural research in South Africa. It was only after the formation of the union in 1910 that ‘South Africa’ could truly be said to exist. The overview of the time before unionisation is important for context, but the focus is on the institutions related to the state. Thirdly, the modern history of South Africa has been dominated by Apartheid (especially after 1948). During the economic boom years of the 1960s, most of the wealth created flowed into institutions that benefitted and were owned by white South Africans. With the Apartheid state came strong government control, which also extended to the agricultural department(s) and their research. All research in South Africa, including agricultural research, was under the sway of a ‘pro-white’ national government in Pretoria. This government’s Department of Agriculture is thus a logical place of departure when undertaking an analysis on the history of agricultural research in South Africa. The relevant reporting periods are listed below. The theme for each period or relevant agricultural departments are indicated between brackets.

- the second British colonial period: 1806–1910 (institutionalisation of higher education and research);
- 1910–1958 (Department of Agriculture);
- 1958–1992 (Department of Agricultural Technical Services);

- 1993–2012 (Department of Agricultural Development and the first democratic Department of Agriculture); and
- since 2013 (introduction of the Integrated Growth and Development Plan for Agriculture, Fisheries and Forestry in 2012).

3.2.1 1806–1910: The second British colonial period

In the nineteenth century, European states engaged in the scramble for Africa. Nearly the entire African continent was colonised and subdivided. The focus of this expansion was the extraction of resources, such as gold, iron and copper, but also agricultural or plant-derived products such as rubber, coffee and other cash crops. Botanical gardens, experiment stations and test farms were founded in almost all British and French colonies in Africa, starting a new era of experiment-based agricultural research on the continent (Pardey, Roseboom & Anderson, 1991).

South African modern research history also dates back to colonial times. Under the two Dutch occupations of the Cape (the first from 1652 to 1795, and the second from 1803 to 1806) and the first British occupation of the Cape (1795 to 1802), settlers and the colonial authorities tested and experimented with the introduction of different crops. Cape Town itself has the *Kompanjiestuin* (Company's Garden) where fruits and vegetables (and today mainly garden plants) have been grown since 1652. Some of the first settlers, such as Simon van der Stel (the first governor of the Cape), were also known to have experimented with different types of fruit trees. This experimentation was not institutionalised. Higher education was essential in creating a home-grown skills base that could engage in research with academic rigour, but this was missing. From the beginning of colonisation in 1652 under the Dutch *Vereenigde Oostindische Compagnie* (VOC), until the end of the first British occupation of the Cape in 1802 with the Peace of Amiens, there had been almost no development in higher education in the SA territories apart from a few private secondary schools ('Latin schools'). Skilled or educated labour was supplied by the colonial 'motherlands' (Boucher, 1973:1).

Progress in developing higher education and research capacity only started after the second British occupation of the Cape in 1806 (Boucher, 1973). It took another twenty years, until 1829, for the founding of the first academic societies, the South African Institution and the South African Literary Society, in the Cape Colony. These two organisations were combined into the South African Literary and Scientific Institution in 1832 (Liebenberg, Pardey & Kahn, 2010). It then took another decade before the first governmental education department in the Cape was set up, in 1839, under the leadership of James Rose Innes, a Scottish born teacher (Boucher, 1973). The South African

Philosophical Society (later the Royal Society of South Africa) was founded in 1877 (Liebenberg *et al.*, 2010) and in 1903, the newly formed South African Association for the Advancement of Science started publishing the *South African Journal of Science* (Liebenberg *et al.*, 2010:10). The original name was the *Proceedings of the Annual Meetings of the South African Association for the Advancement of Science*, and it is still one of the leading science publications in South Africa today (The South African Journal of Science, n.d.).

The first attempts at establishing research or academic institutions in the Cape met with staunch government resistance. The South African Literary Society (SALS) was 're-founded' in 1829 after the first had been disbanded in the early 1820s after only a few months of operation. The first SALS was disbanded on the orders of the governor of the Cape, Lord Charles Somerset. In the British Empire at the time, science was seen as political. In the 1820s, debates in London called for the replacement of the "'aristocracy of wealth and power' [to] be replaced by 'the prouder aristocracy of science'" (Carruthers, 2010:8). Lord Charles Somerset would not allow any challenge to his aristocratic authority (Royal Society of South Africa, n.d.).

After Lord Somerset's term ended in 1829, the new governor (Sir Galbraith Lowry Cole) followed a more relaxed policy (Carruthers, 2010). He allowed the establishment of the South African Institution and the South African Literary Society, as well as freedom of the press, the establishment of a museum, an astronomical observatory, library and botanical gardens (Royal Society of South Africa, n.d.).

One of the main proponents of the call for an "aristocracy of science", Sir John Herschel, arrived in the Cape in 1834 (Carruthers, 2010:8). As a leading astronomer, he was elected president of the South African Literary and Scientific Institution the same year. According to Carruthers (2010:8), he "generally avoided the conservative elite set surrounding Government House". Even with a more lenient governor, science and politics did not see eye to eye. By 1857, the earlier momentum that started in 1829 had begun to slow down on its own accord, and the South African Literary and Scientific Institution went into a period of decline. It would only begin to recover in 1877 when the South African Philosophical Society was founded (Royal Society of South Africa, n.d.).

In the Cape Colony, *The Cape Monthly Magazine* became the publication of choice for scientific discoveries in this interim period (1857–1877). Different societies published in the 'journal', including reports from the Horticultural Society and the Albany Natural History Society. However, in time, the focus of the journal polarised towards articles on the arts and literature, losing some of its broader appeal. The South African Philosophical Society (1877) stepped into this gap focussing on original research in "natural history, physical condition, history, geography, statistics, industrial resources, languages and traditions of South Africa" (Royal Society of South Africa, n.d.). The Philosophical Society, in contrast to the confrontations with the colonial government in the past, invited the then governor of the Cape Colony, Sir Bartle Frere, to take up the position as president of the society (Royal Society of South Africa, n.d.).

The first publically funded organisation for academic and industrial research in South Africa, the Industries Advisory Board, would only be founded in 1916 after unification. However, before this date, both the colonial governments of the Cape and Natal, and the Boer Republics of Transvaal and the Orange Free State provided support for publically funded research. One of the examples from this time is the *Cape Agricultural Journal* of 1889 onwards (Lounsbury, 1940). The journal was published by the Department of Agriculture of the Cape Colony. Articles published in the journal included private research, but also research undertaken by the department itself. The department provided the journal to farmers at no cost. Farmers could submit written queries, which the government then referred to experts. A museum entomologist, L. Peringuey, was for example called a "government entomologist" in an 1891 issue of the journal (Lounsbury, 1940:9). He undertook research on mass die-offs of citrus trees. In another example, in 1904 (after the South African War, during which British control had been extended to the whole of the later South Africa), the Department of Agriculture imported camels to South Africa and tested them "on the most disease-ridden pastures, […] those in the Nelspruit district" (Smith & Schalkwyk, 2002:247). The glowing results were afterwards reported in the *Cape Agricultural Journal* (Smith & Schalkwyk, 2002).

In another part of the SA territories, the Transvaal Department of Agriculture founded a Veterinary Bacteriology Laboratory in 1897. There are also reports of research being undertaken in the Transvaal republic on rinderpest (cattle plague) during the 1890s (Liebenberg, 2013).

The 1870s to 1910, especially the 1890s and first decade of the 1900s, were also academically exciting times in South Africa. Not only was there an expansion of research activities and the first steps in building government research and scientific capacity, but university education was also expanding. The University of the Cape of Good Hope received the Royal Charter from Queen Victoria in August 1877, placing degrees it bestowed on par with degrees from British universities. English was chosen as the only academic language, being preferred over indigenous languages by the colonial government. The University of Cape Town at the time oversaw the criteria for both the matriculation and bachelor exams (Boucher, 1973). According to the examination rules of the University of the Cape of Good Hope, Dutch, at that time the language of the "Afrikaner group" in

Cape Society, was “treated as a foreign accomplishment and was made an optional subject, together with French and German in Matriculation and B.A.” (Boucher 1973:36–37). Indigenous languages such as Xhosa and “Sesuto” (Sesotho) were classified as “alternative modern languages” and only available at matriculation level (Grade 12) (Boucher 1973:36–37).

Local training in agricultural studies was advanced greatly in 1898 with the founding of the Stellenbosch College of Agriculture (Stellenbosch University, n.d.). The college formed part of the Arts Department at Victoria College (later Stellenbosch University) and was run by a professor of Chemistry and Experimental Physics. One of the first noteworthy projects launched through the college was a study on stem rust resistance in 378 wheat varieties (Stellenbosch University, n.d.). The project was run by Dr E.A. Nobbs through the Elsenburg and Robertson (agricultural) Experimental Stations (Stellenbosch University, n.d.). Cedara College was the second agricultural college in South Africa, and was founded in 1905 in what is now KwaZulu-Natal (KwaZulu-Natal Department: Agriculture and Rural Development, n.d.).

With the creation of the Union of South Africa in 1910, a new chapter in Southern African and SA history began. The new union was made up of the Boer Republics of the interior (Transvaal and the Orange Free State) and the British colonies of the Cape and Natal. Although agricultural research was already taking place before the founding of the union, it was only after 1910 that agricultural research truly began to take off (Roseboom *et al.*, 1994).

3.2.2 1910–1958: A new Department of Agriculture for the Union of South Africa

The Department of Agriculture of the Union of South Africa was formed in 1911 under the first prime minister, Louis Botha (Liebenberg *et al.*, 2010). At its inception, the national department comprised 18 divisions, including research-focussed divisions such as the Veterinary Research Division. The department took over the research programmes of preceding departments through continued funding to government-owned agricultural projects, such as the experimental farms in the Boer Republics. The research interests of the department also extended to a number of government-funded research programmes apart from the funding of experimental farms and agricultural colleges. According to Liebenberg (2010), the Department funded independent studies such as a cause and control study on East Coast Fever by Professor Nuttall of Cambridge University in 1911. The Department of Agriculture also provided Grants-in-Aid to various research-related institutions for example to veterinary laboratories and research-related divisions. The five agricultural colleges continued to conduct research through the experimental farms attached to them (Liebenberg *et al.*, 2010).

In 1913, the Department of Agriculture was given control of the four agricultural colleges previously administered by the Department of Education. These colleges comprised Elsenburg (outside Stellenbosch), Cedara (near Howick), Potchefstroom (in Potchefstroom), and Grootfontein (near Middelburg in the Eastern Cape). A fifth, Glen (in Mangaung outside Bloemfontein) was added in 1919 (Liebenberg, 2013).

The Elsenburg College of Agriculture was founded on 15 May 1912 on the farm Elsenburg, replacing the Stellenbosch College of Agriculture. The farm had been bought by the Cape Government in 1898 (Stellenbosch University, n.d.). After the founding of this agricultural college, the Victoria College Council however made representation to government and requested that they be allowed to establish a Faculty of Agriculture with the ability to grant university degrees as they had now 'lost out' on this opportunity to Elsenburg College. The Council succeeded, which led to the creation of their own Faculty of Agriculture on 13 September 1917 (Stellenbosch University, n.d.).

The founding of agricultural colleges throughout South Africa often involved government funds. Cedara College was built on land bought by the Natal Government in 1902 (KwaZulu-Natal Department: Agriculture and Rural Development, n.d.). The Grootfontein Agricultural Development Institute was established on land purchased by the Minister of Agriculture of the Cape Colony from the British Government prior to unification. The land included the farm Grootfontein and a number of buildings that earlier had been used as training facilities for British soldiers. On 7 February 1911, the buildings and farm were officially converted into the new agricultural college, then named the Grootfontein College of Agriculture, with a school and experimental station (Grootfontein Agricultural Development Institute, n.d.).

The reach of the national Department of Agriculture was extended further in 1920 when it took over the administrative responsibilities for the Faculty of Agriculture at Stellenbosch University in addition to the agricultural college (Roseboom *et al.*, 1994). The agricultural college would now report to the department and no longer to university management. In time, the national Department of Agriculture would also take control of the administrative responsibilities of the faculties of agriculture at the Universities of Pretoria (1940) and Natal (1948) (Roseboom *et al.*, 1994). At the same time (1920), extension services were made the responsibility of the agricultural colleges (Liebenberg *et al.*, 2010).

The Faculty of Agriculture at Stellenbosch University was one of the four original faculties that formed part of the university when it was officially founded on 2 April 1918, changing its name from Victoria College to Stellenbosch University. The university was established according to the University Act (No. 12 of 1916) (Stellenbosch University, n.d.). The Faculty of Agriculture was founded in 1917. The farm Welgevallen (in the Stellenbosch area) was purchased in the same year (1917) to provide an experimental farm within walking distance of the university campus. Originally, the farm was 278 ha of which 120 ha is still used by the faculty today (Stellenbosch University, n.d.).

The developments in South Africa during the so-called 'inter-war years' (1918–1939) and the years immediately after World War II were in stark contrast to those in most other countries in sub-Saharan Africa. The main reason for the difference was that, unlike South Africa, the rest of the continent was still mainly under direct or indirect colonial rule. The British and French colonies remained under European control, and research was coordinated from Europe. By as late as 1960, agricultural research in French colonies was still being coordinated through eight institutes that had their headquarters in France (Pardey *et al*., 1991).

In South Africa, agricultural research was directed by the government and mostly undertaken through department-based research institutes (DBRIs). In 1924, the Department of Agriculture decided that the agricultural colleges should focus on research related to the areas in which they were located. Elsenburg, for example, began to focus on winter grains, while Potchefstroom focussed on summer grains (Roseboom *et al.*, 1994). The DBRIs were distributed across the country in the various climatic zones. According to Liebenberg *et al*. (2010), the DBRIs worked closely with university researchers and publically funded extension agents (Liebenberg *et al.*, 2010).

In 1925, the Department of Agriculture established the Division of Extension. The division was tasked with providing a link between the specialists of the department and farmers or producers, and was organised by regions. It was at this time that the department started making use of cooperative demonstrations (Liebenberg, 2015). Fertilisers or crops would be tested in specific environments and then used in demonstration trials for farmers to see the benefits for themselves. Initially, government extension services functioned mainly in an advisory capacity; however, with the drought of 1933 (Liebenberg, 2015), the government began collecting regulatory duties to finance the expansion of these services. The duties, imposed through acts of parliament such as the Weeds Act (No. 42 of 1937) (Liebenberg, 2015) and the Soil Conservation Act (No. 45 of 1946) (Liebenberg, 2015), provided the funds needed to engage with farmers on a large scale (Liebenberg, 2015).

Scientific agricultural research was focussed on the needs or priorities set by the Department of Agriculture. In time, the various extension services increased internal cooperation as it was realised that a holistic approach to farming was needed. This process resulted in the use of "planned whole-farm" demonstrations from 1942 onwards (Liebenberg, 2015:2). The whole-farm approach in time resulted in the decentralisation of extension services, which in turn led to the establishment of eight regional offices. A whole-farm approach looks at the entire farm, as the name suggests, but it includes short- and long-term goal setting. A whole-farm approach can be used by a new farmer as it helps with the current needs of starting out, but also ensures that the development of the farm takes place according to long-term economic and environmental sustainable principles. Decentralisation resulted from the understanding that farmers need expertise on general farming practices, and this had to be established in a local context (which requires decentralised local knowledge) (Liebenberg, 2015:2).

In 1952, the agricultural Technical Services of the Department of Agriculture was reorganised so that it could fit in with a new regional focus of extension services (Liebenberg, 2015). The new Technical Services was split into three main branches and was mostly responsible for research by the department. Technical Services was overseen by a director (Roseboom *et al.*, 1994). The new arrangement reflected the regional structure of the Division of Extension and comprised of national divisions, special institutes, and agro-ecological entities. By 1961 (after some additions had been made), the service was extended to include 11 divisions, four special institutes and seven agro-ecological Regional Development Centres (RDCs). The RDCs would later be renamed the Agricultural Development Institutes (ADIs) (Liebenberg, 2015).

3.2.3 1958–1984: Establishment of the Department of Agricultural Technical Services

The ADIs were concerned with agricultural economics and other farming- and development-related issues. The ADI structure was used until around 1971 when university faculties of agriculture were systematically transferred to the National Department of Education. Following this transfer, a number of commodity institutes (or companies) were created between 1979 and 1988 (Liebenberg, 2015).

The Department of Agriculture split into two new full departments in 1958: the Department of Agricultural Technical Services (DATS) and the Department of Agricultural Economies and Marketing (DAEM). DATS focussed on research, education, regulation and control, while DAEM was responsible for economic policy, product marketing, and setting government controlled prices. DATS was again split into two directorates in 1962: the Directorate of Agricultural Research (DAR) and the Directorate of Agricultural Field Services (DAFS). DAR focussed on managing research at the national level. The country had been divided into seven agricultural regions, serviced by the agricultural experiment stations and colleges (the ADIs). These focussed on the regional research topics. Researchers were 'posted out' between the national and regional divisions to ensure that there was cooperation between the different levels, for example between the national research institutes and the regional experiment stations. The national research institutes and the regional experiment stations were the two most important groups of agricultural research organisations in the country because they did most of the research (between them, 90 per cent of publically funded agricultural research). Universities were much less important, accounting for the remaining 10 per cent of publically funded agricultural research (Liebenberg, 2013:179). The DAR controlled 10 research institutes, and the DAFS controlled three service divisions. The three service divisions were Veterinary Field Services, Plant and Seed Control, and Agricultural Engineering Services. Plant and Seed control was split into two new divisions in 1966, the Plant Pest Control Division and the Seed Control Division (Roseboom *et al*., 1994:4).

In 1967, the DAEM, established alongside the DATS in 1958, underwent restructuring. The existing DAEM Division of Economics and Markets was divided into two new divisions: the Division of Agricultural Production Economics and the Division of Agricultural Market Research. Agricultural Marketing Research focussed its research on production and consumption of agricultural commodities outside of government control. The Division of Agricultural Production Economics took over the responsibility for research on farm problems and enterprise studies (Roseboom *et al.*, 1994).

In the early 1970s, the administrative responsibility for the different faculties of agriculture and veterinary services at universities were transferred from the DATS to the Ministry of Education. Roseboom *et al*. (1994) note that the DATS however continued to fund research and a number of research positions at the different faculties.

In 1980, all the different government agricultural departments were combined into a single department, the Department of Agriculture and Fisheries (this included DATS, DAEM and the Department of Agricultural Credit and Lands). This was done as part of a government process that tried to streamline and rationalise the public service. In 1982, after a number of restructuring changes, the Department of Agriculture and Fisheries was renamed the Department of Agriculture and Water Supply (DAWS). This 'new' department would again be changed after the adoption of the tricameral dispensation of 1984 (see 3.2.4). However, regardless of the number of changes and restructurings, the different 'departments of agriculture' were driven by a policy of "optimal agricultural development" between 1968 and 1983 (Liebenberg, Pardey & Kahn, 2011:11). According to this policy, government was directly involved in price stabilisation and ensuring the productive optimal use of the country's agricultural resources (Roseboom *et al.*, 1994). This strategy was crucial in the attempts by government to mitigate the effects of international sanctions imposed on South Africa due to the policy of Apartheid, which government refused to abandon.

3.2.4 1985–1992: Towards the end of minority rule in South Africa

The introduction of the tricameral dispensation in 1984 was the separation of the SA parliament into three different elected chambers: the House of Assembly (white citizens, 178 members), the House of Representatives (coloured citizens, 85 members) and the House of Delegates (Indian citizens, 45 members) (Reynolds, 2005:305). There was no chamber for the black population since it was claimed that they had representation within the different 'homelands'. The chambers each had power over what was termed 'own affairs', for topics related to their specific racial group. Own affairs included areas such as education, welfare and local government. 'General affairs' (defence, commerce and topics of international importance) had to be approved by all three chambers (Roseboom *et al.*, 1994).

The turn towards a tricameral, racially denominated parliament meant that the DAWS was split into two departments, an 'own affairs' and a 'general affairs' department. In addition, the House of Assembly and House of Representatives also formed two 'own affairs' departments. Each of the ten homelands likewise had their own departments of agriculture. Although there was close cooperation between the SA government and the 'independent' homelands (their independence was not recognised outside of South Africa), these were officially seen as foreign governments by the then SA government (Roseboom *et al.*, 1994).

The DAWS also had an 'own affairs department', which was called the Department of Agricultural Development (DAD). It was a separate department to DAWS. The DAD took over the main functions of the DAWS (DAWS was still the general affairs department) including its research activities with its "11 research institutes, […] seven regional organisations, and all eight directorates of which some conducted research" (Roseboom *et al.*, 1994:6). This meant that the other 13 departments of agriculture (non-white 'own affairs' departments, the DAWS and the homeland departments) had very little or no research capacity and, as a result, did not produce or support any research activities. Agricultural research in South Africa at this time was almost exclusively focussed on supporting white commercial agriculture because it was coordinated by the white 'own affairs' agricultural department (Roseboom *et al.*, 1994). Between 1979 and 1988, the extension services provided by the government changed from an individual farmer approach to exclusively focussing on farmer study groups (Liebenberg, 2015:2).

There was however growing unhappiness with the level of expertise provided by the government via DAD, even with the near exclusive white farmer focus. By 1988, nearly 40 per cent of the extension service positions of the department were vacant. According to Liebenberg (2015), it was this unhappiness that led to the creation of own advisory services by the "private input supply companies, farmer co-operatives and certain producer/commodity organisations" (Liebenberg, 2015:2). Extension services had been hard hit by budget cuts since 1975 when the government began cutting non-security expenditures to allow for increased military spending. By 1975, university-related agricultural research had reached a cap of around US$40.3 million (Liebenberg, 2013; Liebenberg *et al.*, 2010).

By 1992, the political landscape had changed, and South Africa was turning into a non-racial constitutional democracy. In April 1992, most of the DAD's agricultural research activities were transferred to the newly formed Agricultural Research Council (ARC). The ARC was formed in 1990 through the Agricultural Research Act (No. 86 of 1990 (as amended by Agricultural Research Amendment Act 27 of 2001) (ARC, 2016). The creation of the ARC was part of a process of deregulation at the end of Apartheid. Regional agricultural research activities were consolidated into seven ADIs. The ARC not only ushered in a new era of deregulation but also encouraged a user-pay funding model for research where those who benefit should contribute to the cost of research (Roseboom *et al*., 1994:6).

3.2.5 1993–2012: A democratic Department of Agriculture

After the first inclusive democratic elections in 1994, SA state structures underwent extensive restructuring. Instead of the previous four provinces, South Africa was divided into nine provinces. The ADIs, renamed from the RDCs established in 1961, were used to form the new departments of agriculture in the new provinces. The new constitution placed agriculture under both national and provincial government jurisdiction. The various agricultural departments of the previous homelands were also incorporated into the new provincial departments (Liebenberg, 2015).

The transition era was inaugurated by the full democratisation of South Africa and the end of Apartheid. After various policy adjustments, this process culminated in the drafting of the Strategic Plan for South African Agriculture (SPSAA) in 2001. The SPSAA demarcates the end of the transition era during which the need for social impact of agricultural research became a critical component for government research funding. The need to address the racial inequalities of the Apartheid era was turned into government policy and laws. The SPSAA is also the policy document that directly precedes the currently used Agriculture, Fisheries and Forestry: Integrated Growth and Development Plan 2012 (IGDP, 2012). The IGDP 2012 is the long-term strategy used by the Department of Agriculture, Fisheries and Forestry (DAFF) (which replaced the Department of Agriculture in 2009).

The ARC, an organisation that can be seen to sit between a parastatal and a public entity, took over the responsibility for all agricultural research funding from DAD in April 1992 (Liebenberg & Kirsten, 2006). The ARC was initially funded through a system introduced in 1986 under which it reported to parliament and was funded through a baseline formula. In 1997, funding structures were changed to include a parliamentary grant for core funding and a competitive bidding system from a national fund to direct research to adhere to national priorities (Liebenberg & Kirsten, 2006).

The ARC struggled to adapt to the new system in which broad-based growth was required, and was criticised by its line department, the Department of Agriculture, for mainly focussing on the needs of commercial farmers (Liebenberg & Kirsten, 2006). The majority of commercial farmers were white, and the Department of Agriculture had a mandate to improve racial equality in the agricultural sector. The criticism pushed the ARC to consult with various stakeholders, including provincial departments of agriculture and representative bodies of organised agriculture about its shortcomings. The result of the consultation process was a separate programme that focussed on sustainable livelihoods for poor farmers, in addition to a new focus on the commercialisation of research outputs (Liebenberg & Kirsten, 2006).

The dual focus (on subsistence farmers and commercial farmers) represented the neo-liberal approach of the government at the end of the Mandela-era (1997–1999), which also characterised the term of President Thabo Mbeki (1999–2008). The focus on the poor was to assist them in making use of the legal and economic opportunities the government provided for growth. The focus on commercial farmers was intended to stimulate growth that could reduce unemployment and increase tax income through their contribution to gross domestic product (GDP) growth, the muchdebated 'trickle-down' effect (see Barrell, 2010:88-90). To date, inequality between rich and poor in South Africa remains stubbornly high.

Between 1975 and 1993, research funding by universities for agricultural research stalled at R157 million (rounded) (US$40.3 million). This was followed by a "relatively drastic decline" (Liebenberg, 2013:162) after 1994 and the establishment of the ARC. From 1994 to 2003, university agricultural research as a value would only show a marginal increase with accelerated growth after 2003. By 2010, university agricultural research stood at US$51.3 million (which inflation-adjusted is equal to agricultural research spending during the 1980s)[1] (Liebenberg, 2013).

The funding structure for agricultural research that emerged in the transition period is, broadly speaking, still the same today. The 'transition period' refers to the democratisation of South Africa, but in this instance, specifically to the period between the ARC taking over the funding responsibilities of the DAD in April 1992 and the end of the Mandela presidency in 1999. Funding was mostly derived from government, private sector enterprises and commodity-based organisations that introduced levies. The importance of commodity-based organisations as funders of research increased after the Marketing of Agricultural Products Act (No. 47 of 1996) had been promulgated (Liebenberg & Kirsten, 2006). The new law meant that agricultural produce could be marketed and exported in a free market. The immediate negative effects were severe on many farmers, and some producers made significant losses or went bankrupt. However, in the long term, the deregulation of the SA agricultural export industries had a positive effect on the productivity and competitiveness of the affected industries (Liebenberg & Kirsten, 2006). Deregulation is discussed in more detail in the following paragraphs.

Following the end of Apartheid and the first democratic election in 1994, South Africa adopted a new constitution and bill of rights, which came into effect on 4 February 1997. According to the Bill of Rights, "Every citizen has the right to choose their trade, occupation or profession freely. [Only] the practice of a trade, occupation or profession may be regulated by law." (The Bill of Rights of the Constitution of the Republic of South African, 1996). Through this law, government committed itself to a free market, and undertook to evaluate economic industries with the aim of deregulation. The entire fruit industry was accordingly deregulated in September 1997 by the Marketing Act (No. 47 of 1996) after 60 years of regulation. It was hoped that deregulation together with an open market

[1] Dollar values here are based on the source data and the exchange rate at the given dates. The exchange rate is thus different from the R15.75/€1 used in the rest of the dissertation.

would be more beneficial to smaller entrepreneurs entering the market, allowing for the creation of social equality (Sinclair, 2003).

Before deregulation, the industry had been regulated by the Agricultural Marketing Act (No. 59 of 1968). In terms of fruit exports, regulation meant that only the Deciduous Fruit Board and Citrus Board (in the citrus industry), for example, were allowed to control the export of deciduous and citrus fruits from South Africa. Unifruco was the deciduous export company, and Outspan the citrus export company (Sinclair, 2003). The KWV (*Koöperatieve Wijnbouwers Vereniging van Suid-Afrika*) was the designated exporter for wine (grapes were exported by Unifruco) (KWV, n.d.). Outspan controlled fruit exports from the country through Unifruco. These organisations appointed importers in overseas markets that were certified as the only distributors authorised to receive SA fruit exports. Deciduous and citrus fruit producers worked with the government-sanctioned exporters only and had no experience in international trade. The sole focus of a fruit farmer, for example, was on producing fruit, not on marketing or selling it (Sinclair, 2003).

According to Vink, Williams and Kirsten (2004), the deregulation of the agricultural sector in South Africa was the result of 20 years of change starting in the late 1970s, through the 1980s, until the middle 1990s. Changes in the monetary policy and fiscal strategies over that time “undermined the complex structure of protection, price support and cross-subsidies on which the system of agricultural support was founded” (Vink *et al*., 2004:227). The final move to deregulation took place along with a range of other changes in the agricultural sector that were implemented after the National Party withdrew from the Government of National Unity in 1996. The reforms were far-reaching, ranging from land reform to increased rights for workers and labour tenants, the liberalisation of international trade and the introduction of a new rural development policy, amongst others (Vink *et al.*, 2004:227–228).

Much confusion followed the deregulation of the fruit market in 1997. Many new exporters entered the market and a number of farmers lost substantial amounts of money trusting exporters who did not have the expertise or the necessary professionalism to support the produce. The previously government-sanctioned exporters also needed to transform, reshaping themselves into private commodity-based agricultural support organisations. Unifruco was renamed the Deciduous Fruit Producers’ Trust in 1997 and ultimately, Hortgro in 2013 (Hortgro, n.d.). Winetech was also born during the general confusion of the mid-1990s. Winetech was founded in 1996 through an initiative by Stellenbosch University under the leadership of Professor Sakkie Pretorius (Boshoff, 2012).

3.2.6 2013-current: The Integrated Growth and Development Plan

The focus of the current publically funded agricultural development system (and extension services that include research) is largely determined by the Agriculture, Fisheries and Forestry: Integrated Growth and Development Plan 2012 (IGDP 2012). The IGDP 2012 replaced the Strategic Plan for South African Agriculture of 2001 and originated from the creation of DAFF in 2009. The IGDP 2012 brought the focus of the department back to village and local level, specifically focussing on the deployment of trained development workers at a so-called 'low level' (Worth, 2012).

According to Liebenberg (2015) the focus of the IGDP 2012 has remained on training and infrastructure development, including "physical and curricular" upgrades at the 11 colleges of agriculture (Liebenberg, 2015:11). The IGDP seems to be the first strategy that integrated the three different industries (agriculture, fisheries and forestry) under the DAFF. As it is conceived, the IGDP 2012 is in many ways a continuation of the Comprehensive Agricultural Support Programme (CASP) of the Department of Agriculture (which preceded the DAFF). CASP was used by the DAFF to assist new landowners who had benefitted from land reform or who have become landowners through private means (Liebenberg, 2013). CASP supports smallholder farmers through conditional grants (Department of Government Communication and Information Systems [DCIS], 2016).

For the DAFF, the focus of the IGDP 2012 and agricultural research is on improving food security and safety, and agricultural economic output both in terms of quality and quantity. Agricultural productivity and the improvement of the trade and regulatory environment are mentioned and meant to improve the state of the agricultural economy and, in doing so, increase rural employment by contributing to development and economic growth (Liebenberg, 2015). In this way, there is still, even with the "village focus" (Liebenberg, 2015), an awareness of the importance of redressing the inequalities of the past through support to small-scale mostly black farmers, in addition to the support that all commercial farmers need to be competitive internationally. The DAFF's key strategies for the agricultural sector reflect this focus, namely to:

- support new and existing producers;
- provide and ease access to markets; and
- provide and facilitate access to resources (Liebenberg, 2015:11).

According to DAFF (2012:49), the department has also set a number of objectives for all the sectors under its jurisdiction. These objectives are:

- economic growth (and development);

- job creation;
- rural development;
- sustainable use of natural resources;
- maintenance of biodiversity and ecosystems;
- sustainable livelihoods; and
- food security.

Overall, the IGDP 2012 is an attempt at correcting the inequalities in the SA society that emerged from the historical context. The IGDP 2012 is aimed at reducing the "constraints experienced in the areas of input supply, production and marketing" (DAFF, 2012:49–50). The focus on transformation is further visible in the four sector goals drafted by DAFF in the IGDP:

- Sector goal 1: A transformed and equitable sector;
- Sector goal 2: Equitable growth and competitiveness;
- Sector goal 3: Improved sustainable natural resource management; and
- Sector goal 4: Effective and efficient governance systems (DAFF, 2012:50).

Agricultural extension services are seen as very important in terms of reaching intended beneficiaries of agricultural research, especially in terms of small farmers at village level who cannot afford consultants and do not belong to commodity organisations. It is crucial that the new landowners receive adequate support to assist them in farming their land successfully and crucially also begin to expand their economic interests (this is mainly in the case of new commercial farmers). The task of providing extension services was taken up by more organisations than just government. In a report produced for the DAFF, Worth (2012), identified various players in agricultural extension services in the country including state-funded agencies, organised agriculture, and SA universities (Worth, 2012). Liebenberg (2015) further identified commodity organisations as additional private sector extension services that provide support to government (Liebenberg, 2015).

Worth (2012) also identified three government-funded extension services: the ARC, Agri-TV and Agri-Business Development Agency (KwaZulu-Natal). Of these three, the ARC is by far the most important, as it works on a national level in all provinces. The ARC coordinates research undertaken by 11 research institutes. The ARC is currently also responsible for training programmes that aim to address the gap between information (research and development) and end-users. Officially, the ARC also facilitates "partnerships and coordinate and integrate technology transfer processes to deliver tangible products and services into the market place for the benefit of the society", further expanding on their role of connecting research and end-users (Worth, 2012:82).

'Organised agriculture' referred to above, refers to agencies that represent farmers and agricultural stakeholders (DAFF, 2012). The two main agencies are Agri SA (Agri South Africa) and the National Agricultural Farmers Union (NAFU). These agencies are generally concerned with promoting the views of their members and bringing problems with which their members are confronted, to national attention. The agencies also engage in some training and research practices. NAFU, for example, seeks to empower young people and women to enable them to engage actively with farming practices (DAFF, 2012).

In addition to the state-funded agencies and organised agriculture, a number of private extension services have been established. These are often formed around a commodity. The different organisations on which the case study research projects utilised in the current study focussed, fell within this category.

According to Worth (2012:70):

> *One of the implicit behaviours among farmers is that when they reach a state of what can be termed self-reliance or a state where their knowledge and skills in their particular field outstrip those available from the State […] they [become] willing to fund research and extension specific to their primary production focus.*

Unlike in the 1980s, where inadequate expertise and understaffed government extension services led to the creation of commodity organisations, the commodity organisations of today formed after the withdrawal of state involvement (with the disbanding of the industry boards) in the 1990s during and after deregulation (Liebenberg & Kirsten, 2006). There are a large number of commodity-based agricultural support organisations in the country that focus mostly on providing information, research and extension to members with the aim of supporting economic development.

There are currently around 33 agricultural commodity-based organisations in South Africa. These organisations are mostly funded through levies (on products sold), trust funds and membership fees (Liebenberg, 2015). The research undertaken by these organisations is funded (in part) by private funds, which leads to a demand for the funding to produce research that has a clear and visible effect.

South Africa's agricultural research was first mainly undertaken in department-based research institutes with links to university researchers and extension agents (Liebenberg, 2013). In time, three sets of main publicly funded institutions with or of agricultural research emerged: regional institutes, national institutes and universities. Out of these, regional research institutes did the lion's share of research (48 per cent), followed by national research institutes (42 per cent) and universities (10 per cent) (Liebenberg, 2013:179). By 2010, regional institutes' share had fallen to 27 per cent, with national institutes at 52 per cent and universities still last at 20 per cent (Liebenberg, 2013:179). Out of the 12 agricultural colleges in South Africa, nine offer higher education diplomas. These colleges are managed by provincial departments of agriculture (Liebenberg, 2015). The next section looks at agriculture in South Africa more generally.

3.3 The agricultural industry in South Africa: Facts and figures

This section provides an overview of the current state of the agricultural sector in South Africa. Over the last half century (1965 to 2009) (based on data till 2012), the SA agricultural sector declined in relative importance as its share of contribution to gross domestic product declined due to economic diversification (DAFF, 2012:1). According to DAFF (2012), food inflation and global economic instability have contributed to fears of rising and volatile food prices (food security or insecurity). These global trends have also had an effect on South Africa where the role of the agricultural sector is being re-evaluated. It is in this context that the IGDP 2012 discussed in the previous section contributes to food security, growth and development of agriculture and rural economic development (DAFF, 2012).

3.3.1 Agricultural producers

South Africa is unique in terms of the profile of its agricultural sector. According to the DAFF (2012), there are three "distinct types of producers" in the country (DAFF, 2012:3–4).

Commercial farmers

There are nearly 40 000 commercial farmers in South Africa, or more correctly 40 000 farming units, that produce around 95 per cent of the country's formal marketed agricultural output. Farming units are one or more farms in a province that are farmed together as an entity. One farming unit can be farmed by more than one farmer and one farmer can farm more than one farming unit (Van Wyk, 2014).

Since the 1950s, the country has seen an increase in the concentration of commercial farming units. Most of the commercial agriculture is owned by white farmers; however there has been a significant increase in black ownership. Media reports and parliamentary debates have controversially stated that by 2014, "40 000 whites [still] own[ed] 80 percent of South Africa", which would indicate a severe failure on the part of government to fulfil its mandate for creating racial economic equality

(Van Wyk, 2014). However, according to a study by the Institute for Poverty, Land and Agrarian Studies (PLAAS) the 80 per cent figure is an unfair picture of government's efforts. The real percentage for "white commercial agricultural land" is closer to 67 per cent. Of the remainder, 15 per cent of land is in "black communal ownership", 10 per cent is owned by the state and 8 per cent is under urban development (Walker & Dubb, 2013:1). Currently, 40 000 farming units control 67 per cent of SA land, with 13 per cent of this total being arable and around 33 per cent being in the Northern Cape. The Northern Cape is a semi-desert region with 2 per cent of the SA population. In addition, although most of the farmers in the 40 000 farming units are white according to PLAAS, there is no record of the private purchasing of land by black farmers since 1994 (Walker & Dubb, 2013:1-2). In other words, since land can be freely bought and sold, but race statistics are not kept on the sales, it seems probable that a large minority of the 40 000 units of "white commercial agricultural land" is black owned (Walker & Dubb, 2013:1-2). Even though the analysis by PLAAS 'softens' the picture in terms of racial inequality, it is still correct to state that commercial farmland is disproportionately white owned. This paints a very unequal distribution of land, which has led to calls for the expropriation of farmland under the politically loaded term of 'land reform'. Under the current presidency of President Cyril Ramaphosa, land reform has become a key government policy. According to President Cyril Ramaphosa, "[f]or South Africa to grow faster and build a more transformed economy, land reform is necessary and urgent. We will advance the three elements of redistribution, restitution and security of tenure through inclusive dialogue" (The Presidency Republic of South Africa, 2018)

According to DAFF (2012), the concentration of units (referring to the concentration of farming units since the 1950s) is the result of a decline in the value of agriculture in terms of its contribution to the GDP. With a career in agriculture being unattractive, farmers have no one to bequeath farms to, resulting in other farmers purchasing farms or the concentration of family holdings into the hands of a single willing heir. The agricultural sector is mainly run as family businesses, with a recent trend of corporatisation in some subsectors (DAFF, 2012).

The number of commercial farms fell from 58 000 in the mid-1990s to 45 800 in 2002. Between 2002 and 2007, there was an additional decline of 13 per cent to 39 900. According to Kuschke and Geyer (2016), the vast majority of these farms (22 500) had an annual turnover of less than R500 000 (when looking at available data, which is only available for 2007). As Table 3.1 shows, farming in South Africa is mostly not economically lucrative.

Table 3.1 Number of farming units per annual turnover (2007)

	Number	Percentage	Turnover
1	22 500	56%	< R500 000 (< €31 750)
2	12 300	31%	R500 000–R3 million (€37 500–€190 500)
3	2200	6%	R3 million–R5 million (€190 500–€317 500)
4	2900	7%	> R5 million (> €317 500)

Source: Kuschke and Geyer (2016:16)

Even though the number of farming units is on the decline, the country has been able to increase production and produce a trade surplus for agricultural commodities. South Africa however relies on the import of processed foods (DAFF, 2012). The production areas for maize, wheat and dairy have all decreased over a 20-year period (until 2007), although production has remained steady. This trend can be attributed to the use of synthetic fertilisers and better or increased irrigation methods (Kuschke & Geyer, 2016).

Smallholder farmers

According to SA government estimates, there are around 225 000 smallholder farmers in South Africa (DAFF, 2012). Smallholder farmers are mostly black and live in areas that fell under the previous homelands. According to DAFF (2012), the areas in which smallholder farmers are found present different challenges since, although the areas are poor and underdeveloped, they also provide opportunities through large tracts of quality underutilised arable land. This means that smallholder farmers have growth potential if the impediments to growth are addressed (DAFF, 2012).

Subsistence producers

There were approximately 2.8 million subsistence producer households in South Africa in 2012 (DAFF, 2012). Subsistence farmers grow crops or raise livestock to supplement their income or improve nutrition. Very few of these households produce agricultural products with the aim of full self-sufficiency (DAFF, 2012). Subsistence farmers mostly contribute to the informal economy, but are still an important focus for knowledge transfer as their welfare is a concern for the South Africa state.

3.3.2 Agricultural production, employment, and government support

Livestock and livestock products form the largest agricultural sector in South Africa (by income). One of the reasons for this is the type of farmland available to farmers. Roughly three quarters of farmland is more suitable for livestock since large tracts of South Africa are semi-arid. Horticultural produce is nonetheless still important and has shown an increase in its economic contribution. Currently, the country is producing at below domestic consumption criteria in basic food commodities, such as red meat and wheat. In total, the SA agricultural sector contributed R58.2 billion (€3.7 billion), equal to 2 per cent of GDP, to the SA economy in 2012 (Kuschke & Geyer, 2016:15).

Table 3.2 Top ten agricultural commodities by production value (2012)

Product	Production value (million US$)	Tonnes produced
Meat indigenous, cattle	2.1	0.8
Meat indigenous, chicken	2.1	1.5
Maize	1.1	11.8
Grapes	1.1	1.8
Milk, whole fresh cow	0.9	3.4
Sugar cane	0.6	17.3
Eggs, hen, in shell	0.4	n/a
Meat indigenous, sheep	0.4	n/a
Apples	0.3	0.8
Potatoes	0.3	2.3

Source: Kuschke and Geyer (2016:16) [US$ is used based on source data]

The most important export commodities are fruit (35 per cent), wine (13 per cent) and sugar (13 per cent) (1997–2013) (Liebenberg, 2013). These rankings are based on the value per export commodity. Before the arrival of the free marketing era, before 1997, commodities such as wool and maize were the dominant agricultural exports (Liebenberg, 2013).

The agricultural sector has shown an absolute decline in the number of people employed on commercial farms over the last two decades (1993 to 2012), mainly due to mechanisation. The commercial farming sector has also seen a casualisation where the number of regular jobs in the sector has declined faster than the number of casual jobs. According to the DAFF (2012), employment in the agricultural sector declined by 27 per cent between 1993 and 2007, and by 18 per cent between 2008 and 2012 (DAFF, 2012:6). In 2013, the agricultural sector employed 7 per cent of individuals classified as 'formally employed' in South Africa. The agricultural sector is an important employer of unskilled labour since 77 per cent of workers in the sector were classified as elementary workers with 22 per cent of these being unskilled (Kuschke & Geyer, 2016:15).

In its own policy documents, the SA government acknowledges that some of the competitiveness of the SA agricultural sector is undermined by the lack of government support when compared to competitors in countries to which South Africa exports. South Africa provides the same level of support (producer support estimate based on Organisation for Economic Co-operation and Development [OECD] calculations) as other developing countries (for example Brazil and Chile); however, these countries are currently trying to increase their support to their agricultural sectors. In South Africa, the cost of support as a percentage of GDP has declined "from 1 percent between 1995 and 1997, to 0,6 percent between 2005 and 2007". The OECD advises a level of at least 1 per cent of GDP (DAFF, 2012:7).

The lack of government support affects all the different types of farmers in the SA agricultural sector, from commercial to subsistence. Historically, South Africa's intensity of agricultural research and development was higher than that of the United States and Australia until the 1970s; however, since 1980 the country has fallen behind the United States (DAFF, 2012).

With the democratic government elected in 1994, the support provided to farmers was shifted to favour the smaller producers (smallholders and subsistence farmers) away from the commercial farmers. The problem however is that the large number of these smaller producers has meant that the support provided has been inadequate due to a lack of a large enough extension corps (DAFF, 2012).

Having traced the developments of SA agricultural research and the sector in general, the focus will now shift to the two industries where the commodity companies whose research projects formed the focus of this study, are based. In each case, a summary will be provided for the industry (deciduous fruit and wine) to provide background of the context in which the commodity companies were operating at the time of this research. Finally, a historical overview of the development of the companies will be given.

3.4 The SA deciduous fruit industry

The first attempts at organising the deciduous fruit industry can be traced back to the founding of the SA Co-operative Deciduous Fruit Exchange Ltd (Vrugtekwekers Koöperatiewe Beurs van Suid-Afrika Beperk) in 1922 (De Beer, Paterson & Olivier, 2003:15; The South African Fresh Produce Online Magazine, 2010). The organisation underwent a number of changes over the years, through the creation of the Deciduous Fruit Board in 1939,[2] the Universal Frutrade Co-operative in 1987, the Deciduous Fruit Producer's Trust in 1997, and finally Hortgro in 2013 (De Beer *et al.*, 2003; Hortgro Science, n.d.), with Hortgro Science as its research arm.

3.4.1 Historical overview of industry organisation and development

The earliest roots of the deciduous fruit industry in South Africa date back over 350 years to 1652 when a Dutch citizen, Jan van Riebeeck, arrived in the Cape of Good Hope and planted the first fruit trees in 1654 (De Beer *et al.*, 2003; Hortgro Science, n.d.). The first trees planted were apple trees imported from St Helena (The South African Fresh Produce Online Magazine, 2010). The first known successful export of deciduous fruit was in 1892 when the ship, *Drummond Castle*, delivered a consignment of peaches to the United Kingdom (De Beer *et al.*, 2003; The South African Fresh Produce Online Magazine, 2010). With limited knowledge on the preservation of fruit on long sea voyages, the Cape Colonial government recommended that the best fruit for export were dark-coloured grapes with tough skins, peaches, apricots, plums, pears and apples (De Beer *et al.*, 2003).

In 1893, as demand for Western Cape produce grew in Paris, Brussels and Berlin, the export of fruit increased to 15 000 cases, including 2 400 cases of peaches and 11 000 cases of grapes. At that stage, peaches were the main fruit grown in the Western Cape. The first apple orchards in Elgin (today a famous apple-producing region in South Africa) were planted in 1899. Fruit production also began to spread to the interior of the country, and in 1901, the Cape Orchard Company built its first inland cold store in the Hex River Valley. Today, the Hex River Valley is one of the best-known table grape-producing regions of the world. As a result of the growth in the sector, fresh fruit made up 5.3 per cent of all agricultural exports from South Africa by 1920 (De Beer *et al.*, 2003).

The SA Co-operative Deciduous Fruit Exchange Ltd was founded in 1922. It represented the first attempt at coordinated marketing of SA deciduous fruit (The South African Fresh Produce Online Magazine, 2010). By 1927, the Deciduous Fruit Exchange was shipping 1.5 million cases of fruit, and by 1928, its membership had reached 1 200 registered growers. In the same year, 87 per cent of all exports were from members represented by the Exchange (De Beer *et al.*, 2003). However, the Exchange was hindered in its operations by the fact that producers could still distribute their fruit themselves. The Exchange also lacked an effective sales organisation to assist in exporting fruit (The South African Fresh Produce Online Magazine, 2010).

[2] Hortgro (n.d.) puts this date as 1947.

The outbreak of World War II was instrumental in the centralisation of control over the deciduous fruit industry. With the threat of a ban on exports and a collapsing global market, stakeholders agreed to establish the Deciduous Fruit Board (De Beer *et al.*, 2003; The South African Fresh Produce Online Magazine, 2010). The Deciduous Fruit Board was established on 4 October 1939 under the Deciduous Fruit Regulatory Scheme by Proclamation No. 230 of 1939 (The South African Fresh Produce Online Magazine, 2010). Under the Board, a single channel for the export of deciduous fruit was created. The Board did away with the practice of each producer having their own brand and all deciduous fruit were now to be exported under the 'brand' "South African Fruit – Deciduous Fruit Board". The overseas representative of the Board received all overseas consignments (De Beer *et al.*, 2003). In 1954, South Africa set a national record with the export of 727 metric tons (153 000 cases) of apricots (De Beer *et al.*, 2003).

The Deciduous Fruit Board also introduced a statutory single-channel export scheme (Greenberg, 2016). After 1966, all deciduous fruit was exported under the Cape brand (De Beer *et al.*, 2003).

As a statutory body, the Deciduous Fruit Board had the following powers:

- As the sole purchaser of all deciduous fruit produce, the Board regulated the distribution of produce.
- The board could do anything with the produce after it had been bought in terms of what it felt was needed within the industry.
- It could create prohibitive regulations, which related to specific production regions or marketing areas to regulate distribution and supply.
- The board was allowed to impose a levy on producers and had the power to prevent the export of fruit by any other body (The South African Fresh Produce Online Magazine, 2010).

The Universal Frutrade Co-operative (Unifruco) took over the single-channel monopoly in 1988 (Greenberg, 2016). Unifruco continued to apply stringent export controls to the fruit under its mandate. Only Class I fruit qualified for export, but any grower who was able to achieve the quality demanded could gain entry into the export market. Unifruco was obligated to accept all Class I fruit (World Bank, 1994:73). Under Unifruco and its predecessors, SA fruit gained an international reputation for premium quality. The reason was mainly that only top quality fruit qualified for export with restrictions on exports preventing producers who had fruit of lower quality from exporting their fruit themselves.

Unifruco earned income through a 2.5 per cent commission levied on gross sales (data for 1990). Unifruco sold the fruit on behalf of its members and deducted all the market-related costs before paying the residual to members. Although Unifruco operated on a break-even principle it was still able to make a profit from fixed and liquid assets (World Bank, 1994:73).

In the 1990s, the fruit industry continued to grow, and in 1990, the 1954 apricot export record was at last surpassed with the export of 228 000 cartons of apricots. The industry was still expanding geographically and new trees were being planted, especially in the Klein Karoo and along the Berg River.

The deregulation of the fruit industry in 1997 caused much chaos (De Beer *et al.*, 2003). This confusion however did not last and today the industry has fully recovered. By 2011, South Africa was the 8th largest apricot exporter in the world (down to 12th in 2014) (DAFF, 2014a; 2016). Although South Africa is not a significant producer of deciduous fruit internationally (based on size), the industry has a strong export focus with exported fruit earning a higher return than locally sold fruit (DAFF, 2014b).

At present, South Africa's multi-million rand deciduous fruit industry produces a wide range of fruit such as apples, pears, apricots, nectarines, peaches, plums, grapes, olives, figs and cherries. Total production of deciduous fruit reached 1 813 717 tonnes in 2013, contributing R13 151 million (€835 million) in gross value production (DCIS, 2016).

3.4.2 Hortgro Science

With the confusion and uncertainty that emerged with deregulation in 1997, the single-channel monopoly of Unifruco became outdated as the market was opened to all (De Beer *et al.*, 2003). However, the deciduous fruit producers decided to reorganise themselves into a new producer organisation, the Deciduous Fruit Producers' Trust (DFPT). The DFPT would not have the old statutory powers that Unifruco had, but would be its successor in many other ways (De Beer *et al.*, 2003). The current deciduous fruit commodity organisation, Hortgro, traces its origins in a continuous line from the Deciduous Fruit Exchange (1926), to the Deciduous Fruit Board (1939), the Universal Frutrade Co-operative (Unifruco) (1987), and the Deciduous Fruit Producers' Trust (1997) and up to Hortgro (2013) (De Beer *et al.*, 2003; Hortgro, n.d.).

The DFPT was founded with the understanding that it would assist growers and the industry with:

- market protection and communication that assists in increased market share;
- the creation of long-term relationships;

- lobbying government and relative authorities;
- creating awareness of deciduous fruit to relevant audiences;
- lowering input costs and enhancing export value chain efficiency; and
- establishing and improving the sustained viability of the industry (Greef & Kotze, 2007).

In 2013, the DFPT was renamed Hortgro, an organisation that has taken on the role of a national communication platform for fruit producer organisations. Under Hortgro, growers have structured their control and industry participation into different producer organisations based on fruit type. The South African Stone Fruit Producers' Association (SASPA), recently renamed Hortgro Stone, is for example the main association for the apricot, peach, nectarine and plum industry. Hortgro is the umbrella organisation for all the associations under Hortgro Stone and also Hortgro Pome (renamed from the South African Apple and Pear Producers' Association [SAAPPA]). Each of the different associations have their "own deed, constitution, board, members, priorities and funds" (DAFF, 2014a:50).

Hortgro Science undertakes research for the both Hortgro Stone and Hortgro Pome and focusses on "production, research and technology, markets, and transformation within the deciduous fruit industry" (Hortgro Science, n.d.). Hortgro Science seeks to improve the competitiveness of their producers globally to become the preferred suppliers "anywhere in the world" (Hortgro Science, n.d.). According to Hortgro Science, it tries to bring together the needs of the growers and academia. It tries to do this by building human capital and engaging in projects that provide return on investment for growers. Hortgro Science also promotes sustainable agriculture and supports the notion of "farming for the future" (Hortgro Science, 2015:iv). Hortgro Science (2015:iii) summarises their purpose as aiming:

> *To generate and transfer the knowledge, technology and practices required to mitigate, avoid or overcome threats/risks, and to exploit opportunities, that impact the on-going economic sustainability of South African pome and stone producers while ensuring the development and retention of skills.*

The research undertaken by Hortgro Science is driven by the needs of the industry, from the origins of the fruit in the orchard to the final consumer (Hortgro Science, 2015). It is also very important for Hortgro Science to identify and mitigate risks to the industry including areas such as water scarcity, fruit quality, climate change and market access. To ensure that the research undertaken is in line with what the industry needs, Hortgro Science engages with grower groups and individual growers in both formal and more informal ways to gather their inputs on what is needed in the industry (Hortgro Science, 2015:3).

Hortgro Science makes use of more than 200 experts in the deciduous fruit industry who assist with aspects such as technical advice and peer reviewing (of research proposals), but who also engage in research processes (Hortgro Science, 2015:3). For each research process (under which different research projects are undertaken), a process manager, or sometimes managers, are identified. There are currently five of these research processes, namely:

- genetic optimisation (breeding);
- sustainable farming (with a crop production and crop protection component);
- (post-harvest) product integrity;
- market alignment and a sustainable supply chain; and
- a communications programme (Hortgro Science, 2015:4).

In the period 2016/2017, Hortgro Science supported 116 projects, as shown in Figure 3.1

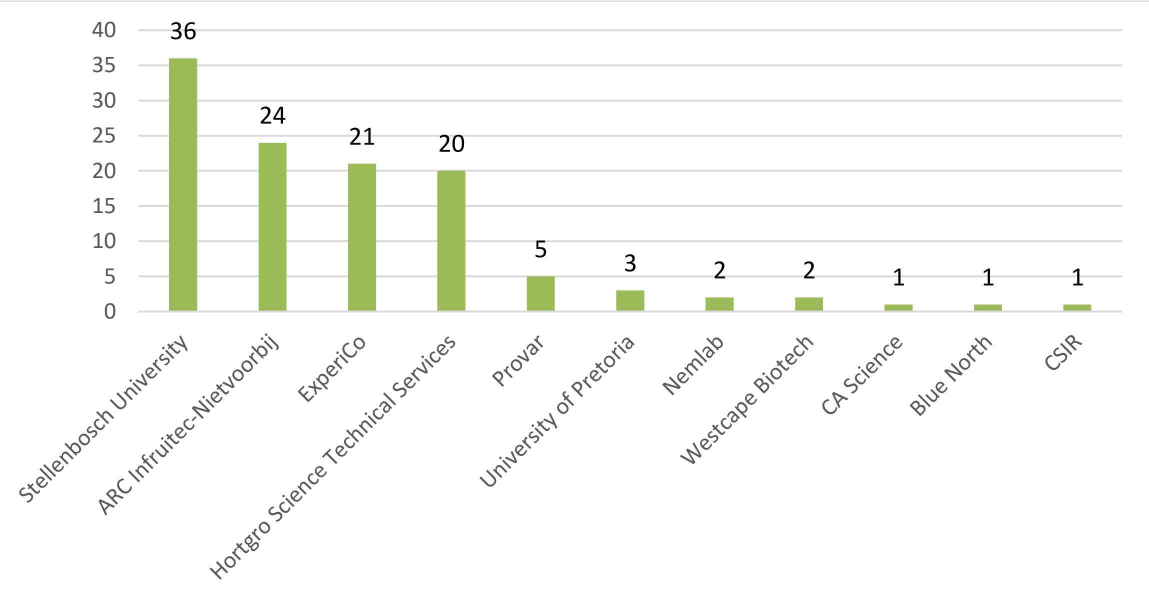

Figure 3.1 Number of Hortgro Science projects per research institute 2015/2016 (N=116)

Source: Hortgro Science (2018:89)

Between 2010 and 2015, the average cost per project was R142 953.50 (€9076) (Hortgro Science, 2015:7). The projects were mainly housed within research institutions in the Stellenbosch area followed by three other major organisations in terms of number of projects, the ARC (Infruitec-Nietvoorbij specifically), ExperiCo (a private research company) and Hortgro itself. Projects of Hortgro Science, as can be expected, focus on pome fruit and stone fruit. Hortgro's spending profile is shown in Figure 3.2 below. It shows the importance of post-harvest spending in both the pome and stone fruit industries.

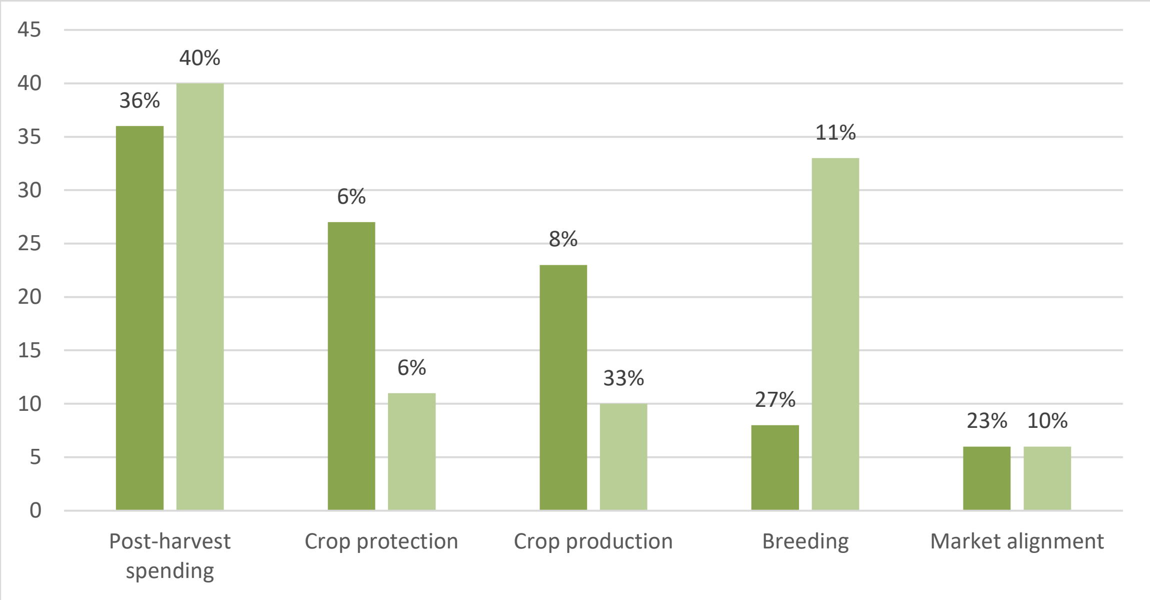

Figure 3.2 Hortgro Science percentage spending profiles of pome and stone fruit for 2016/2017

Source: Hortgro Science (2018:86–87)

Hortgro Science has a staff and management team of eleven people, and an additional two seconded staff members, one chair researcher and two contracted researchers. The office staff component comprises the:

- general manager
- assistant general manager and crop production programme manager
- research and technology manager and post-harvest programme manager
- crop protection programme manager
- regional fruit production researcher
- applied researcher in crop protection positioned at Stellenbosch University
- crop protection technical assistant positioned at Stellenbosch University
- research administrator
- science communications specialist
- events coordinator
- group communications manager (Hortgro Science, 2018:17)

The staff seconded to Stellenbosch University are two doctoral-level researchers in the Department of Conservation Ecology and Entomology and a 5/8 doctoral researcher in the Department of

Horticulture Science. There is also a chair in Applied Pre-harvest Deciduous Fruit Research. Finally, there are two contract positions, which are funded through research projects, namely one doctoral-level researcher in the Department of Conservation Ecology and Entomology and a researcher that forms part of the "Dormancy Projects" (although it is unclear under which department this last position falls) (Hortgro Science, 2015:4).

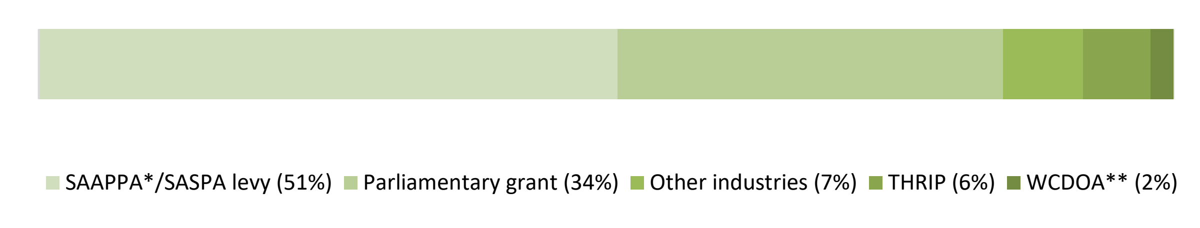

Figure 3.3 Percentage breakdown of Hortgro Science income, 2016–2017

*SAAPPA = South African Apple and Pear Producers' Association; **WCDOA = Western Cape Department of Agriculture

Source: Author's compilation from Hortgro Science (2018:84)

For 2014–2015, Hortgro Science generated 51 per cent of its income from the Hortgro Stone and Hortgro Pome growers levy. Currently, 54 per cent of the standard levy for pome fruit and 45 per cent of the stone fruit levy is used for research and development (Hortgro Science, 2015:5).

3.5 The SA wine industry

The SA wine industry, similar to the deciduous fruit industry, was greatly influenced by state regulation between 1924 and 1997. The wine industry was regulated by the Wine and Brandy Control Act (No. 5 of 1924) and the Marketing Acts of 1937 (No. 26 of 1937) and 1968 (No. 59 of 1968). The wine industry's board was however under the control of the industry and not under the control of the state as with many of the boards in other industries. During the Apartheid years, the industry was granted protection by the state through price support and import protection, creating a monopoly in the national market (Vink *et al.*, 2004).

3.5.1 Historical overview of industry organisation and development

The first vines in the Cape were planted in the mid-seventeenth century. The wine industry reached maturity in the first half of the 1800s, before and after the Napoleonic Wars. Between 1808 and 1825, the number of planted vines increased from 15 million to 32 million. Around the same time, (1810–1820) wine became the largest export commodity from the Cape, benefiting from imperial preference duties of the British Empire. Under the Empire's policies, levies on Cape wines were only around a third of that levied on Iberian wines. In 1825, the Empire however abolished imperial preference, which resulted in a 75 per cent decline in exports and depression in the market. The poor quality of Cape wines was the constant main problem that stifled growth in exports. There were however some examples of exceptional wines, such as the famous wines of Groot Constantia, which were enjoyed by the Emperor Napoleon during his exile on St Helena, made an appearance in Jane Austin's *Sense and Sensibility* and was a favourite of King Louis Philippe of France. During the second half of the 1800s, the industry continued to face numerous problems: low quality, a new trade agreement between France (a large wine producer) and Britain, and the spread of odium disease and phylloxera (Vink *et al.*, 2004).

After the many setbacks in the 1800s, the winegrowers in the Cape Colony made numerous attempts to organise the industry and to cooperate to face the challenges collectively. However, none of the attempts lasted for more than a few years. One of the main problems facing the industry remained the poor quality of the wine produced. According to Vink *et al.* (2004:229), it was reported in 1905 that producers and merchants were sitting on large volumes of stock that could not be sold or which could only be sold below cost. After many attempts at solving the problems of the industry, such as the creation of nine cooperative cellars through government loans under the Companies Act, the KWV was initiated in 1916 and registered as a company in 1918 (KWV, n.d.). The KWV collected a 10 per cent levy on wine sales. Each year, the KWV would announce the official level of surplus in wine production for the year and remove (purchase) the surplus from the market (Boshoff, 2012).

The KWV however struggled to control the market from inception and faced strong opposition from the Constantia and Stellenbosch farmers who wanted control over their 'good wine'. These were some of the few areas (including the Paarl region) in the country where winemakers concentrated on the production of quality drinking wine. The Constantia farmers won a court case, which allowed them not to pay a "surplus contribution" for "good wine" to the KWV (Vink *et al*., 2004: 230–231). By 1923, merchants who had cooperated with the KWV withdrew their cooperation as they could buy wine directly from farmers. Farmers received more for their wine than they would from the KWV and merchants paid less than they would have to pay the KWV (Vink *et al*., 2004: 230–231).

As a result of the KWV's inability to take control of the market, the SA government decided to override criticism and invest the KWV with statutory powers. With statutory powers, granted through the Wine and Spirits Control Act (No. 5 of 1924), the KWV could charge artificially higher prices for wine and protect its members from oversupply. With the artificial profit, they could pay farmers for the unneeded excess wine. By means of the Act of 1924, the KWV would shape the SA wine industry for the next 73 years (Vink *et al.*, 2004). The system in essence meant that farmers were provided with surplus protection even when they produced poor-quality wine.

Between 1919 and 1924, Imperial preference was re-established, and South Africa regained entry to the UK market. Exports of wine increased to the United Kingdom and brandy exports to Canada and New Zealand also increased. Domestic demand and exports could however not keep up with production. Between 1926 and 1939, only 51 per cent of wine that was produced for export was actually exported. The problem was still linked to surplus protection, which incentivised quantity over quality. This problem would plague the SA market until the 1990s and the arrival of deregulation (World Bank, 1994).

The Wine and Spirits Control Act (No. 23 of 1940) gave the KWV the power to set the price of wine (KWV, n.d.). In a strange turn, this law was introduced after complaints from the industry that the KWV had too much power in the industry. The Minister of Agriculture appointed a Wine Commission in 1935, which agreed that the system was stimulating the production of low-quality wine; however, its solution was to provide the KWV with more powers to regulate the market better. According to Boshoff (2012:21), in the decades following, the KWV would be able to set the prices for good wine and distilling wines unilaterally.

> *Every year the KWV set a minimum price for good wine, which was then submitted to the Minister of Agriculture for approval. In the case of distilling wine, the KWV estimated at the start of every year what portion of the crop would be declared as surplus. If, for instance, the surplus was declared at 24 percent, then the producer had to provide 24 percent of the entire crop to the KWV without any compensation. The remainder of the crop the producer could sell to merchants but for no less than the minimum price for distilling wine, which was also fixed by the KWV.*

The grip the KWV had on the industry was only broken with deregulation in the 1990s. In 1996, the KWV applied to the Cape Division of the Supreme Court to change from a cooperative to a company (Boshoff, 2012). The government determined (through a ministerial investigation) that the state did not have a right to the assets of the KWV. As part of the KWV's change into a company it was obliged to provide R200 million (€12.5 million) over ten years to the South Africa Wine Industry Trust (SAWIT). It also had to provide services to SAWIT to the value of R227 million (€14.5 million). SAWIT established two committees, the Business Committee (Busco) and the Development Committee (Devco). Busco provided funding to industry organisations, namely:

- Wines of South Africa (exporters association);
- Winetech (research arm of the industry); and

- VinPro (industry extension service) (Vink *et al*. 2004:239).

Devco, on the other hand, focussed on the issues of development, such as land reform, removing racial barriers and assisting new farmers in entering the market (Vink *et al.*, 2004). In 2003, Winetech was incorporated into the South African Wine and Brandy Company (SAWB), established in 2002 with the support of the two largest producing wholesalers. SAWB was created as a representative for the entire wine industry. The SAWB was renamed the South African Wine Industry Council (SAWIC) in 2006. SAWIC disbanded in 2008 at which time Winetech resigned from SAWIC. According to Boshoff (2012), the disbanding of SAWIC created a situation where "the wine industry […] experience[ed] a leadership vacuum, without any clear indication as to who should be guiding the industry and in what direction" (Boshoff 2012:28).

Today, the wine industry is of particular importance to the Western Cape. Excluding tourism, the wine industry supported over 200 000 jobs in 2008 and contributed R14.214 billion (€900 million) to the Western Cape economy (for the year) (DAFF, 2013:5). Also in 2008 (the year for which data has been released by the SA government), the wine industry contributed R26.223 billion (€1.66 billion) to the economy, or 1.95 per cent of the national GDP (DAFF, 2013:5).

Although some wine production takes place in the Northern Cape and KwaZulu-Natal, the largest wine-producing region is the Western Cape at around 34° south. The Western Cape with its mild Mediterranean climate is seen as ideal for wine production (DAFF, 2013:6).

Since 2000, the production of red wine has seen a sharp increase. In 1996, red wine varieties only accounted for 18 per cent of planting. However, by 2008, this had increased to 44 per cent. The increased production however overshot local demand, leading to a reduction in price. This lack of demand has necessitated a much more aggressive focus on export markets. In 1999, only 21 per cent of SA wine was being exported. By 2008, this had increased to 54 per cent (DAFF, 2013).

South Africa has seen a sharp spike in terms of harvest (litres per year), total planted area and yield per hectare. In addition, there has been an increase in the gap between input production costs and revenue per hectare. This increased gap shows that profitability is increasing. The total area planted under wine grape vineyards increased from 96 000 ha in 2002 to 102 000 ha in 2006 and 100 568 ha in 2011 (excluding sultanas) (DAFF, 2013:13). Drinking wine production increased from 8 973 395 litre in 2009 to 11 679 697 litre in 2013. In 2009, drinking wine was 79.1 per cent of the harvest and by 2013, this had increased to 81.5 per cent. Distilling wine production decreased from 815 496 litre in 2009 to 7 474 846 litre, or from 7.2 per cent to 5.2 per cent. This clearly illustrates the change in the SA wine market after deregulation. The industry is now geared towards producing drinking wine or "quality wine" (PricewaterhouseCoopers [PwC], 2014:21).

As mentioned above, the average yield per hectare also increased. For red varieties, there was an increase from 11 tons per hectare to over 12 tons per hectare between 2009 and 2013. White varieties increased from 16 tons close to 19 tons over the same period (2009 to 2013) (PwC, 2014:22). Along with increased yields, there was an increase in profitability. The average cost of production per hectare in 2009 was just below R27 000 (€1700). This increased to over R35 000 (€2200) in 2013. However, the revenue per hectare for red varieties increased from just over R27 000 in 2009 to more than R39 000 (€2470) in 2013. White varieties saw an even bigger increase, going from around R30 000 per hectare in 2009 to around R42 000 (€2600) in 2013 (PwC, 2014:27). The industry as a whole is however struggling from a lack of profitability. In 2017, VinPro reported that 80 per cent of local wine volumes were being sold at less than R26 per litre (€1.65) (reporting on the year 2016). It also reported that 40 per cent of producers made a loss in the same year with only 13 per cent producing at a sustainable income level. Of the producers, 44 per cent were reportedly breaking even. The low level of profitability meant that return on investment fell to below 1 per cent in 2016 (Loots, 2017).

3.5.2 Winetech

The origins of Winetech can be traced back to the early 1990s. After the end of Apartheid, SA wine producers were able to access international wine markets. The problem was however that after decades of focussing on quantity over quality the international demand for quality SA wine was far more than the supply. Action was needed to fill the gap in knowledge and research on quality wine production. The near total lack of expertise is clearly illustrated by the fact that by 1995, the Stellenbosch University's Department of Oenology had only ever produced one PhD student. The head of the oenology department again was a retired professor who had been reappointed for three years since he was the only professor of oenology in the whole of South Africa (Boshoff, 2005:21–22).

As a response to the shortage of expertise, Stellenbosch University approached an up-and-coming academic, Professor Pretorius, at the beginning of the 1990s and offered him the position of professor in oenology. As a microbiologist, he declined but agreed to assist the university in establishing oenology and viticulture at both undergraduate and postgraduate level. It was under Prof. Pretorius' recommendations that the Institute for Wine Biotechnology (IWBM) was founded on

1 October 1995. He would hold the position of director of the IWBM for the next seven years. Professor Pretorius only accepted the request by the University and the wine industry that he head up the IWMB on condition that the IWBM would be aligned with the needs of the industry. Winetech was founded as a result (Boshoff, 2005).

According to Boshoff (2005), who interviewed Professor Pretorius, Winetech was born out of the need to establish mutual research goals for the wine industry. If mutual goals were not determined, the industry's priorities would change from year to year and lead to a fragmented research agenda. With mutual goals, a single vision could be formulated (Boshoff, 2005:26). Winetech was created as the virtual organisation with the aim of materialising the industry's growth objectives. Winetech was founded with no personnel except for an executive manager and technical assistant (at present there are four permanent staff members and two contracted staff members, discussed below) (Boshoff, 2005; 2012).

Winetech's mission is to "provide the South African Wine Industry with a sustainable basis of forefront technology and human resources in order to strengthen both local and international competitiveness and profitability" (Winetech, n.d.).

According to Winetech's constitution it has six objectives:

- to support the wine industry with expertise;
- to support the training and education of individuals for the industry;
- to establish a culture of technological innovation;
- to facilitate the development of resource-poor and previously disadvantaged producers;
- to establish world leadership in selected niche areas of the wine industry; and
- to commission relevant and thoroughly planned research, technology development and technology transfer (Winetech, n.d.).

Winetech's stated primary interest is "to build a strong and healthy South African wine industry through co-operative (participative) research and development initiatives" (Winetech, n.d.). The strategy according to which it does this is called the "Research and technology innovation and transfer" strategy (Winetech, n.d.). In alignment with this strategy, Winetech has two core functions.

- to create a space in which to coordinate research, development and technical innovation within the wine industry; and
- to transfer the results of the research, development and innovation to the industry (Winetech, n.d.).

Winetech currently represents the wine industry in a number of different representation bodies namely the:

- ARC
- Vine Improvement Association
- Wine and Spirit Board
- Wine Industry Information Committee
- Commissions I (Viticulture), II (Oenology), III (Law and Economy) and Scientific and Technical Committee of the International Wine Office
- National Agricultural Research Forum
- South African Society for Enology and Viticulture Board
- Fruit and Wine Confronting Climate Change initiative; Advisory Committee for Agricultural Programmes of Cape Peninsula University of Technology
- Western Cape Agricultural Research Forum
- Extension & Advisory Services Work Group
- Cape Agency for Sustainable Integrated Development in Rural Areas
- Department of Science and Technology/Sector Innovation Fund Wine Industry Steering Committee
- Research, Development Innovation Workgroup of the Wine Industry Value Chain Round Table (Winetech, 2015:27).

Winetech's membership mainly comprises all the members of the South African Liquor Brand owners Association, the Cape Wine Producers Association, National African Famers Union and the Black Association of the Agricultural Sector (Winetech, 2015).

Figure 3.4 below provides a breakdown of the number of projects Winetech has funded in various fields over 15 years (2000 – 2015). Production technology/microbiology maintains its importance over this time. Brandy and distilling seems to lose importance, while the number of technology transfer projects increase sharply.

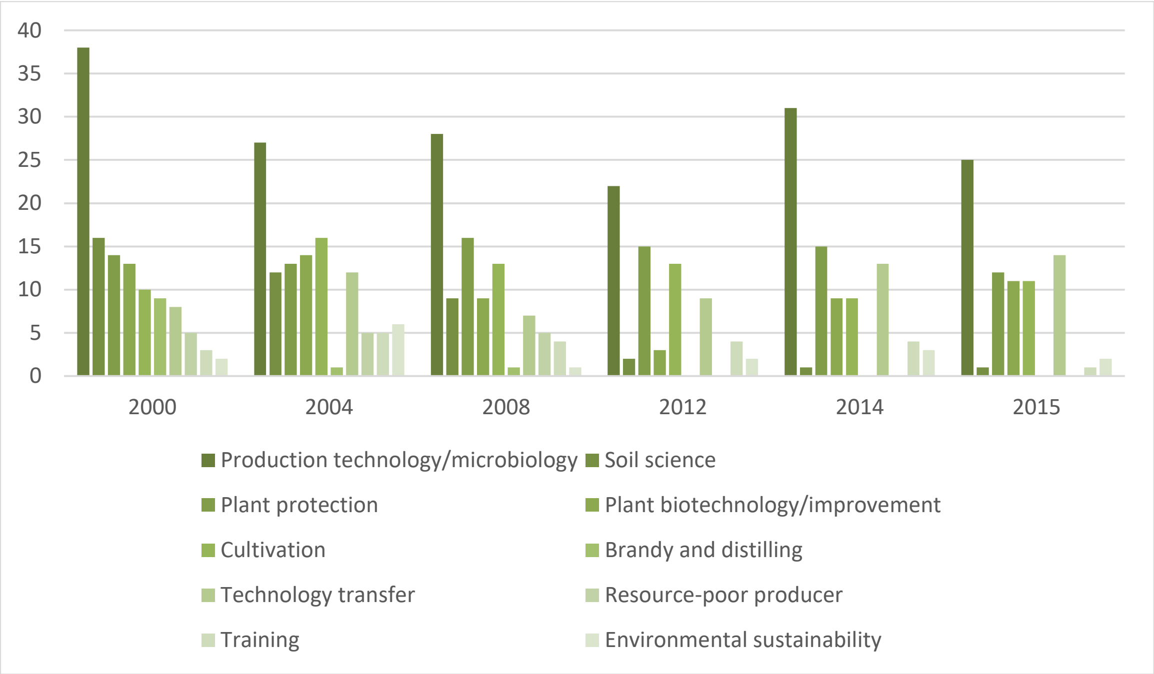

Figure 3.4 Breakdown of Winetech-funded projects per field of focus, 2000 to 2015

Source: Winetech (2015:5)

Winetech has four permanent employees: an executive manager, a manager, an administrative officer and a research and development manager. In addition there are two part-time employees, a technical advisor and a technology transfer coordinator: oenology (Winetech, 2017). Winetech's council is jointly responsible with the Winetech management for the management and operational functioning of the organisation. The Winetech Executive Committee acts as the remuneration committee. A committee system is also used for evaluating, identifying and prioritising research, training, development and transfer of technology (Winetech, 2017).

To ensure that more specialised tasks are undertaken with the right skillsets available, Winetech makes use of specialist sub-committees allowing informed opinions to be heard on all subject fields related to the wine industry. Members of these sub-committees operate without remuneration. Winetech's financial and human resource services are managed by the South African Wine Industry Information and Systems (SAWIS). For auditing purposes, Winetech makes use of both the support of the Winetech Audit Committee and an independent external auditor (Winetech, 2015:1).

As an organisation coordinating research, Winetech published 16 reports on successful projects in 2015 and accepted the launching of 22 new projects. Research is supported through the research and development levy that is leveraged on wine sales. In 2015, this amounted to R26.5 million (€1.68

million) (Winetech, 2015:40). Figure 3.5 shows a breakdown of Winetech's research spending in 2015, dominated by oenology and viticulture.

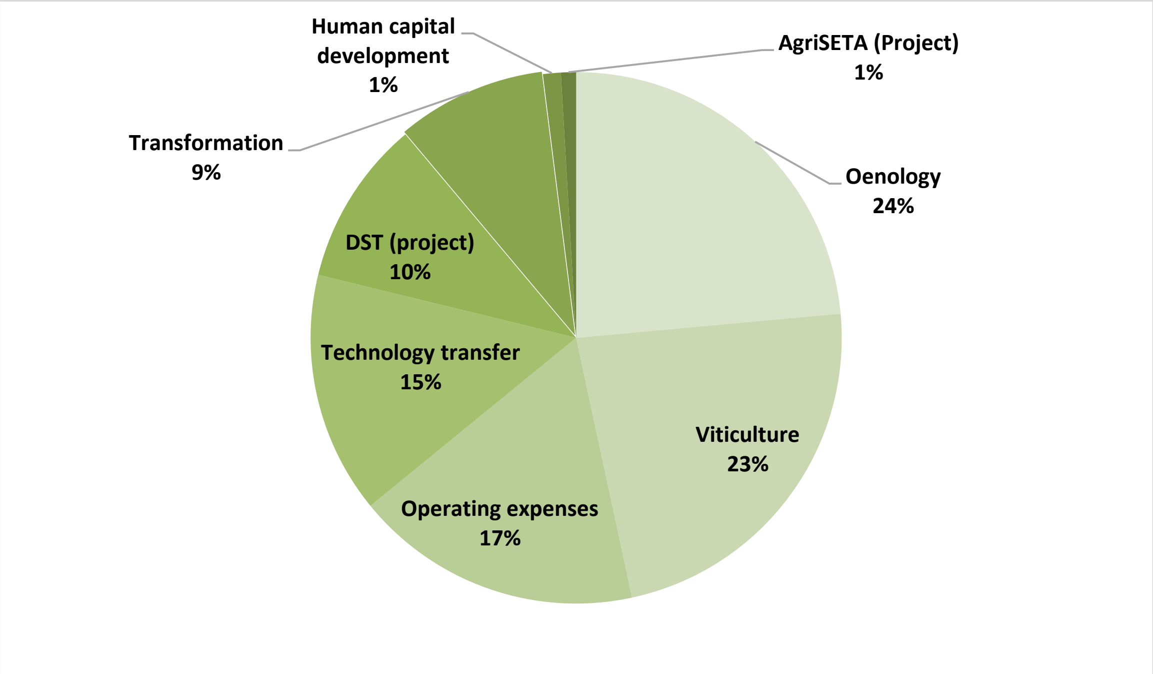

Figure 3.5 Winetech research expenses 2015 by field (N=R30 738 019/€1 951 620)

Source: Author's compilation from Winetech (2015:40)

Apart from research projects, 20 per cent of the funds from the research and development levy is spent on transformation (figure 3.5 includes additional income streams). Additional funds are invested in the technical training of farm and cellar workers (Winetech, 2015).

In 2015, Winetech's research partners included the ARC Infruitec/Nietvoorbij, ARC Plant Protection, the Institute for Wine Biotechnology, the Department of Viticulture and Oenology and the Universities of Stellenbosch, Cape Town and Pretoria. In total, during 2015, Winetech-funded 77 projects (Winetech, 2015:5). Table 3.3 Comparison between Hortgro Science and Winetech in terms of key dimensions (2016–2017) (on the following page, page 84) provides a comparison between Hortgro and Winetech in terms of key dimensions, for example their research focus and research budgets.

Table 3.3 Comparison between Hortgro Science and Winetech in terms of key dimensions (2016–2017)

	Hortgro Science (2016/2017)	**Winetech** (2016)
Industry	Pome fruit and stone fruit	Wine
Home base	Stellenbosch	Stellenbosch
Reach	National (South Africa)	National (South Africa)
Number of projects 2015	116	85
Research budget or expenses	R18 841 184[3] €1 196 265	R31 109 212 €1 975 188
Top recipients of funding (by number of projects)	Stellenbosch University 31% ARC 21% ExperiCo 18% (2016-2017)	Stellenbosch University 43% ARC 31% Other universities 15% (2016)
Sources of income	Industry levy (51%) (2016-2017) Other (49%) (2016-2017)	Industry levy (85%) (2016) Other (15%) (2016)
Focus of research	Post-harvest programme Crop protection Crop production Breeding Market alignment	Oenology Viticulture Technology transfer Human capital development

Source: Author's compilation from Winetech (2017) and Hortgro Science (2018)

3.6 Conclusion

The development of agricultural research in the territory that would later become South Africa emerged from the informal processes that predated colonialism and the founding of the republics in the interior. However, with the second occupation of the Cape Colony under the British and the founding of the Boer Republics, formal research and academic institutions began to emerge along with institutions of higher learning. It would be from these intuitions and the new agricultural colleges that South Africa's own 'home-grown' agricultural research would develop after the founding of the Union of South Africa. Although governmental agricultural development and agricultural research were focussed on SA problems and driven from within South Africa, the

[3] Estimate based on the average cost per project multiplied by the number of projects.

emphasis was mainly on upliftment and the benefit of the white population group. During the Apartheid years, agricultural industries were regulated and government controlled much of the research, but also economic aspects of these industries (sales, prices, exports) through the various industry boards.

With the arrival of the new democratic non-racial dispensation of 1994, the country entered a new era of deregulation which directly and indirectly resulted in the creation or expansion of commodity companies in the country. These commodity companies (including Hortgro and Winetech) were faced with a number of challenges, such as working towards demographic changes within their industries, providing support to farmers ranging from subsistence (on a lesser extent) to commercial farmers (the main focus) whilst also driving research.

Government changed its focus away from commercial agriculture to subsistence farmers. However, due to the vast number of these farmers compared to the available extension resources available it has been an uphill battle to provide meaningful support or stimulate the rise of new agricultural entrepreneurs at a time when farming units are consolidating. The consolidation is the result of weakening economic benefits deriving from agriculture and the need to produce on a large scale to be profitable.

The culmination of these factors has placed commodity companies in a difficult position. Today, these companies are expected to create value for the producers they represent, and at the same time, they are expected to assist the government in its efforts to drive economic transformation. This has meant that it is imperative for these companies to understand and be able to show how the research they fund and undertake affects society. The next chapter introduces the conceptual underpinning of the current research.

Chapter 4

Conceptual underpinnings: Productive interactions, realist evaluation, theories of change and impact literacy

4.1 Introduction

This chapter provides the conceptual underpinnings of the current research. The four main conceptual foundations are the SIAMPI approach with its focus on productive interactions (Spaapen & Van Drooge, 2011; Spaapen *et al.*, 2011), realist evaluation (Pawson & Tilley, 1997), theories of change (including participatory impact pathway analysis [PIPA]) (Douthwaite *et al.*, 2007; Marshall, Millstone & Van Zwanenberg, 2010; Spaapen & Van den Akker, 2017; Spaapen & Van Drooge, 2017), and impact literacy (Bayley & Phipps, 2017). A common theme that runs across the different conceptualisations are the insights into impact they provide, be it SoIR or programme impact.

SIAMPI provides a new lens for looking at and understanding SoIR through impact mechanisms (productive interactions), while potentially working around some of the traditional obstacles to the assessment of the SoIR, such as temporality. Realist evaluation brings a 'logic of inquiry' (way of thinking) based on realism into the realm of evaluation, adding the focus of impact mechanisms that operate in context (the CMOs) (Pawson & Tilley, 2004:10). Similar to SIAMPI's shift in focus to the space and time closer to the researcher, CMO inclusion by realist evaluation, help to expand the understanding of impact beyond summative judgements of failure or success (Pawson & Tilley, 2004). Both of these approaches take a process-oriented view of impact, where impact cannot be viewed in isolation from the mechanisms responsible for outcomes or from the context in which the mechanisms produce that outcome. While realist evaluation focusses on the steps of achieving the desired impact in social programmes, productive interactions trace the various connections, engagements and exchanges that are closely associated with the research process (Pawson & Tilley, 1997; Spaapen *et al.,* 2011).

Theories of change (as a tool) emerged from evaluations focussed on community initiatives where they were used to make explicit the process of how a programme worked through a theory of change (the approach) (Blamey & Mackenzie, 2007; Mountain, n.d.). As a result, theories of change are often used in realist evaluations. Even though realist evaluation is a method-neutral approach, theories of change (again the tool and not the approach) have become common practice or tools often used by many who follow the approach. In theory-based evaluation, of which realist evaluation is one example, theories of change can also be used to guide an evaluation (Stein & Valters, 2012). The focus on how a programme works also links to impact literacy (see Bayley & Phipps, 2017; also see 4.6) as the latter applies a novel lens to establishing what is important in understanding impact. The lens of impact literacy concerns three foci: 'how' impact is being effected, 'who' is involved in effecting it, and 'what' is being effected (Bayley & Phipps, 2017).

The different conceptual underpinnings are discussed in the order given above. The section on SIAMPI looks at productive interactions, the obstacles the approach might be able to overcome in SoIR assessment, how SIAMPI views impact, and what the ultimate aims and limitations of SIAMPI are. The second section of the chapter looks at realist evaluation. The section explores the concept of CMOs in realist evaluation. CMOs are, in essence, the construction of testable hypotheses on the effecting of impact that are refined through various evaluations, a central idea in realist evaluation (see Pawson & Tilley, 1997). The third section of the chapter presents research on theories of change with a specific focus on PIPA. PIPA originates from the field of development research, where it was used to assist M&E activities. Two cases of where theories of change were used in practice, reflecting on agricultural research, are discussed. The fourth section gives an overview of impact literacy and the 'who', 'what', and 'how' of impact (Bayley & Phipps, 2017). The chapter concludes with an overview of the logic of the current research, setting out how the different conceptual underpinnings were combined in the dissertation.

4.2 The SIAMPI approach

The social impact assessment methods through productive interactions (SIAMPI) approach is a relatively new approach for determining SoIR, which theoretically can overcome the most general issues experienced in evaluating SoIR. The approach was developed with two goals in mind: to explore how societal impact occurs, and to develop a method by which SoIR could be assessed and identified (Spaapen *et al.*, 2011). What makes SIAMPI different to other approaches is its focus on the process through which impact is created. The problem of attribution is potentially overcome because the emphasis is on interactions close to the research and not on 'final' impacts.

4.2.1 Productive interactions

Central to the SIAMPI approach is the idea of productive interactions. The latter interactions involve direct, indirect and financial (material) aspects. According to the authors of the SIAMPI report, these different aspects help to separate those interactions that form part of a researcher's 'normal' life from his or her role as a researcher (Spaapen *et al.*, 2011).

- *Direct interactions* are interactions on a personal level, such as meetings between people or contact through phone, email and the like.
- *Indirect interactions* are interactions that occur through another medium in a non-personal manner, for example through a research article or a YouTube video.
- *Financial (material) interactions* are interactions based on funding, including contracts, funds and in kind contributions to the research (Spaapen *et al.*, 2011).

Although SAIMPI presents three types of productive interactions, in effect there are only two types of interactions, as financial (material) interactions will have to be facilitated through a direct interaction. The nature of a financial (material) interaction, providing some type of support to the research, means that the underlying interactions will always be a direct interaction (De Jong *et al.*, 2014:90). Additionally, a later article by Van den Akker and Spaapen (2017) changed the last type or level of interaction to *material* interactions. By this understanding, a financial interaction is one form of material interaction. The current research followed Van den Akker and Spaapen's (2017) example and refer to material interactions instead of financial interactions from here on.

Below are examples of direct, indirect and material interactions:

- **direct**: "face-to-face meetings, double functions, other mobility arrangements, phone conferences, email, social media, videoconferencing, public debate, radio, tv [sic], internet" (Van den Akker & Spaapen, 2017:30);
- **indirect**: "academic journals, professional journals, non-academic journals, popular media, exhibitions, artefacts, models, films, master theses, graduate projects, standards, protocols, social media" (Van den Akker & Spaapen, 2017:30); and
- **material**: "research contracts, facility, instruments sharing, start-ups, contribution 'in kind' (people), intellectual property rights arrangements, patents, licenses, professional training, other stakeholder interest" (Van den Akker & Spaapen, 2017:30).

From the above examples, it should be clear that, for SIAMPI, interactions include a wide range of encounters that are not usually described as interactions. Instances of knowledge production as well as of the transfer of knowledge are also considered interactions. According to SIAMPI, an interaction becomes productive when a stakeholder makes use of or tries to use the results of research in any way (use of research was discussed in the Chapter 2, see 2.2.1) (Spaapen & Van Drooge, 2011:212).

SIAMPI sees impact as having occurred when research stakeholders have changed behaviour as a result of research outcomes. Behavioural change is any action based on the research taken by stakeholders to reach societally relevant goals (Spaapen *et al.*, 2011).

For SIAMPI, societal impact is change that can be observed as the result of a research effort. For societal impact to take place, there must be an interaction between researchers and non-academic stakeholders. The interaction is "productive when it leads to efforts by stakeholders to apply research results to social goals" (Spaapen *et al.*, 2011:2). When there is no observable attempt of using the results in any way, there was an interaction, but it was not productive (Molas-Gallart & Tang, 2011; Spaapen *et al.*, 2011).[4]

Research (or a research process) with productive interactions however does not necessarily lead to impact. Research can for example, recommend that a situation should remain as it is (that no changes are needed) (Molas-Gallart & Tang, 2011).

Further, SIAMPI views all actors "involved in the process that leads to societal impact" as stakeholders (De Jong *et al.*, 2014:92). "We use the concept of 'stakeholder' in a broad sense, that is, all those involved in achieving social impact: researchers, industry, public organizations, the government, the general public" (Spaapen & Van Drooge, 2011:212).

This broad view of stakeholders has a number of implications. It shows that SoIR is part of a larger process than just a research project. Knowledge and the expertise of possibly diverse stakeholders combine to realise goals that are relevant to different parts of society. This means that when the context of research changes, the societal impact created (or valued) in that context could change. What is viewed as a positive or negative outcome by one stakeholder might have no importance to another (Spaapen & Van Drooge, 2011:212).

4.2.2 Societal impact as understood by SIAMPI

This section expands on the concept of impact within SIAMPI, briefly touched on earlier in the previous section. The SIAMPI approach does not make use of the word 'societal' in its original texts (Spaapen & Van Drooge, 2011; Spaapen *et al.*, 2011); it rather refers to 'social' impact. The current research made use of the word 'societal' to describe the overarching type of impact that looks at the impact of research beyond academia – social impact in contrast is only one of the possible sub-types

[4] As will be discussed in 5.4.1, the research thus set out to identify first *potentially productive* interactions. These are referred to as 'research interactions'.

of impact which fall under the umbrella of societal impact along with, for instance, cultural, environmental and economic impact. Spaapen himself (who co-authored the SIAMPI report in 2011) has also started to make use of the term 'societal impact' (Van den Akker & Spaapen, 2017). Social, when used in the context of SIAMPI, should almost always be read as societal, except where logically not the case.

According to the SIAMPI approach:

> *Social impact of scientific research refers to measurable effects of the work of a research group or program or a research funding instrument in a relevant social domain. The effect regards the human wellbeing ('quality of life') and or the social relations between people or organizations* (Spaapen *et al.*, 2011:9).

The approach also provides clarity on the key terms in the definition. 'Social' relates to "human well-being and social relations between people and organisations". 'Measurable' means that the effects must be calculable through quantitative or qualitative methods. 'Effects' is defined as "changes in behaviour" of organisations or people or in the "use of" new instruments (Spaapen *et al.*, 2011:9).

SIAMPI's definition takes on a very wide view of impact through the explanation of 'social domain'. According to SIAMPI, 'domain' includes any relevant social environment, ranging from a narrow to a broad approach. The narrow approach would look at the impact on other researchers, and the broad approach would look at groups "in society" (beyond the research field) (Spaapen *et al.*, 2011:9).

Due to the problem of attribution, the SIAMPI approach does not view impact only as something on the end of a causal chain, but rather as a process that has traceable effects originating from "close to the primary research process" (Spaapen *et al.*, 2011:9). SIAMPI is not against linking research to larger societal goals; however, SIAMPI believes that it is more feasible to limit the scope. This allows SIAMPI to "trace impacts, indications for impact, much earlier than through the logical framework approach" (Spaapen *et al.*, 2011:10).

SIAMPI understands societal impact as something that can have different meanings depending on the context. For SIAMPI, the difference between societal impact and productive interactions is narrow since "the transition from interaction to impact is often gradual" (Spaapen & Van Drooge, 2011:212). There is no need to try and attribute long-term societal impact to research, but rather it is understood that impact is reached through a combination of interactions and their contributions and uptakes. The SIAMPI approach looks at the different steps contributing to the more intricate network that creates or leads to impact (De Jong *et al*. 2014; Spaapen & Van Drooge, 2011).

Impact and how it is viewed by SIAMPI are focussed on productive interactions as the basis of an impact assessment. By looking at the interactions, the assessment necessarily explores the processes through which research is made useful or productive. This is in contrast to the more traditional identification of impacts and assigning value to them (Molas-Gallart & Tang, 2011).

4.2.3 Overcoming evaluation obstacles

SIAMPI brings a number of aspects together in a unique way that allows it to possibly overcome some of the obstacles to the evaluation of the SoIR. SIAMPI bridges a contrast between programme evaluation practice and the literature on societal impact. Evaluation practice to date has mainly tried to evaluate SoIR through linear economic models while the literature on societal impact describes the process of how impact is achieved through network and interaction models (Spaapen *et al.*, 2011:7). SIAMPI uses a broad definition of stakeholders, and includes everyone in the network involved in achieving societal impact, namely "researchers, industry, public organisations, the government, [and] the general public" (Spaapen & Van Drooge, 2011:212).

SIAMPI also moves away from the earlier focus on *attribution*; instead it focusses on productive interactions where the emphasis is on the *contributions* of different actors, productive interactions and stakeholders (Spaapen & Van Drooge, 2011). Attribution aims to determine 'how much' an intervention or action has contributed to an impact or outcome (De Jong *et al.*, 2014). Research is however rarely consciously used to guide specific choices; instead, a large range of sources might influence individual choices, opinions and actions (Weiss 1980:403). It is hard or even impossible to prove that a specific piece of research caused something, such as a policy change. This means that the focus has moved away from attribution where an impact is ascribed to an action or report, to contribution on a smaller and observable scale (Joly *et al.*, 2015; Spaapen *et al.*, 2011). By being close to the activities of researchers through this shift, SIAMPI can identify contributions.

> *[Societal] impact is not only a faraway goal, but can be seen as a process in which each step is valuable, the beginning (a contact, an article, a public debate), the middle (a joint venture, a prototype, a new protocol or rule), and the end (a product, a service, a new organization)* (Spaapen & Van Drooge, 2011:216)

Spaapen *et al.* (2011) also highlight three aspects of SIAMPI that they believe make it unique when compared to previous approaches. According to them, SIAMPI is process-oriented, contextual and oriented towards learning and improving.

- **Process-oriented**: SIAMPI believes that societal impact, as a measurable effect, develops over time. Due to the long periods associated with SoIR, the final measurable effect is not the focus of the approach; it rather looks at the processes or productive interactions that are closer in time and space to the researcher. By focussing on the process of research impact-effecting, SIAMPI could partially overcome the issue of temporality.
- **Contextual**: SIAMPI looks at the different contributions and attempts of research uptake of researchers and stakeholders, and instances of use, which all add together to reach impact. Usually, this process suffers from the problem of time lag, but by focussing on the steps that form part of the process of societal impact generation this issue is overcome. This approach also has the potential to highlight shorter-term impacts that occur as part of the societal impact 'process', which would not otherwise have been noticed had the focus remained on end results or longer-term impacts. Productive interactions can trace the process of a research process and capture effects that, depending on the context, might be of importance to a particular stakeholder.
- **Oriented towards learning and improving**: Finally, SIAMPI is primarily oriented towards improving understanding rather than accounting or judging. The result of a SIAMPI assessment is envisioned as recommendations that will allow for the improvement of interactions between researchers and stakeholders to facilitate the achievement of societal impact (Spaapen & Van Drooge, 2011).

In summary then, SIAMPI looks at the networks, both formal and informal, that form around research, seeking to identify the productive interactions that take place in these (Van den Akker & Spaapen, 2017). The aim is to understand specific instances of impact better in terms of interactions between researchers and stakeholders with the hope of using this information in the development of methods and approaches that assess the SoIR (Spaapen *et al.*, 2011).

4.2.4 Collecting data on productive interactions

One of the challenges of SIAMPI is however that the data needed to undertake the assessment of productive interactions are not always freely available. The collection of data is complex as there are various actors and different types of interactions involved. SIAMPI proposes that the best way to collect data on direct and indirect interactions is through interviews and focus groups – admitting that the collection of financial and funding data might be more difficult to obtain due to it probably not being publically available (Spaapen *et al.*, 2011).

Interviews for stakeholders and beneficiaries, based on SIAMPI guidelines, are developed around four themes or objectives:

- "[Theme 1:] To identify the types of interactions between researchers and potential users and beneficiaries elsewhere in society
- [Theme 2:] To trace the efforts that these stakeholders have invested to apply research results to social goals (identify productive interactions)
- [Theme 3:] To identify, and if possible, measure, the social effects of these efforts (identify the results of productive interactions)
- [Theme 4:] To identify instances where the stakeholder may have played a role in the definition of academic research questions, or the analytical methodologies used by researchers (feed back into the research process)" (Spaapen *et al.*, 2011:24).

In their article, introducing SIAMPI, Spaapen and Van Drooge (2011) admit that the approach will probably create new obstacles since it introduces new complexities. Instead of looking at the research process as a single entity causing an impact, the focus is shifted to numerous interactions. Additionally, SIAMPI's broad definition of stakeholders increases the number of stakeholders compared to previous approaches. This means that there are more individuals and groups to consider as having had an impact or playing a role in the researcher process. As a result, a reviewer would have to include a wide range of stakeholders, making use of research tools beyond just quantitative measures since some aspects of societal impact can only be determined through more qualitative measures (Spaapen & Van Drooge, 2011:213). It is however possible to overcome most if not all these challenges. Techniques have, for example, been developed that allow for the discussion of complicated ideas and questions with groups of stakeholders, such as through the use of focus-groups that bring various stakeholders together (Spaapen & Van Drooge, 2011).

In sum, SIAMPI, with its focus on productive interactions, looks at the different steps in a research process, thereby exploring the process through which research is effected. Realist evaluation, which is discussed next, holds a similar process-oriented view of impact. The difference is that, in SIAMPI, productive interactions are considered impact mechanisms, whereas, in realist evaluation, the corresponding mechanisms are CMO configurations. This is because of the portrayal by realist evaluation of impact as an outcome or change in regularity that forms part of a CMO configuration.

4.3 Realist evaluation

Traditional methods of research impact assessment (including methods that incorporate citations and linear understandings of impact) are not suitable for the evaluation of SoIR. Approaches, such as the SIAMPI approach, discussed above, with its emphasis on interactions between researchers and stakeholders within different networks, seem to provide a promising new option for understanding the SoIR (Robinson-Garcia *et al.*, 2017).

Understanding can however only be taken so far before value needs to be added to allow for summative judgements in an assessment or evaluation context (Pawson & Tilley, 1997). Whereas both SIAMPI and realist evaluation focus on formative judgements, realist evaluation is also summative. 'Value' refers to a weight being attached to, for example, a productive interaction, which would allow an evaluator to understand which interactions are more important in a specific context. One school of evaluation that has been able to bring together both the need for understanding (formative) and the need for measuring impact (summative) is theory-based evaluation. Realist evaluation is a 'brand' of theory-based evaluation (Wildschut, 2014:58).

4.3.1 The theory-based origins of realist evaluation

Theory-based or theory-driven approaches, under which realist evaluation falls, look inside the black box of a social programme by applying logic to the design of the programme. Theory-based evaluation can be traced back to the 1930s when Ralph Tyler did work on testing programme theory for evaluation (see Madaus, 2004). Theory-based evaluation examines the logic of how a programme will move from its larger over-arching goal to achieving its different aims (Salter & Kothari, 2014). According to Weiss (1997), there are two reasons for evaluators to adopt the use of a theory-based approach in evaluation. The first is to operationalise a theory for a programme and to test that theory through evaluation. This is followed by a revision of the programme intervention. Another reason would be that the programme that is tested was consciously built based on a theory. In this case, the evaluator would "follow the tracks of theory in the evaluation" (Rogers, 2007:72).

Writing around the same time, Fitz-Gibbon and Morris (1996) provide a detailed and still relevant definition of theory-based evaluation. First, a theory-based programme is one where the features of the programme are selected based on an underlying theory on how the programme will achieve the required effects. According to Fitz-Gibbon and Morris (1996), a theory-based evaluation then is:

- an evaluation that explicitly makes use of the conceptualised theory of a programme to determine which features to evaluate;
- an evaluation based on a model, theory or philosophy that is supposed to represent the causal relationships or mechanisms of how a programme works;

- an evaluation where a theory, either that of the programme or another, is used to select the variables of what will be studied during the evaluation (Fitz-Gibbon & Morris, 1996); and
- an evaluation where the methods resemble an implementation evaluation.

However programme theory does not only look at whether a programme has been implemented as planned, but also at the mechanisms through which outcomes were achieved (Fitz-Gibbon & Morris, 1996; Weiss, 1997).

Revisiting Weiss' work from 1997, Rogers (2007) observes that between 1997 and 2007 programme theory widely increased in popularity. One of the reasons for its increase in popularity that has most likely also extended to the present (2018), is based on the "recognition of its value for planning and management, as well as for evaluation" (Rogers, 2007:64). The tools for theory-based programme evaluation are relatively accessible to a large public through the internet. It is possible to download guides and examples of logic models and access online forums and communities for support. Still, there are a number of issues related to theory-based evaluation that remain relevant (Rogers, 2007).

- Firstly, many evaluations claim that they are making use of programme theory, when they are in fact only specifying some activities with outcomes. When theory is used, the mechanisms that cause change should be specified, not only in a logic model list style, but also as part of an actual developed theory.
- A second problem is that practitioners make assumptions on how a programme will work, basing these assumptions on their own logic and reasoning. Although there can be value in these assumptions, assumptions alone cannot constitute theory. With only assumptions, the value of learning from evaluations is reduced due to the simplicity and lack of scientific rigour of the theories.
- Lastly, theory-based evaluations themselves can be simplistic, only detailing the logic through a logic model and then testing whether something happened or did not happen. Although this is surely part of what needs to be done, the theory of why something did or did not happen also needs to be developed (Rogers, 2007).

When undertaking a theory-based evaluation, there are a number of aspects that will determine whether an evaluator will be able to test a programme theory:

- The theory of a programme needs to be well defined, and there should be agreement on whether the theory as understood by the evaluator is indeed what the programme will be, what it is or on what it was based.

- In addition, it is important that the activities of the programme be based on the assumptions of the programme theory.
- Lastly, theory-based evaluations can be very time- and cost-intensive. When undertaking a theory-based evaluation it must be ensured that there is enough money and time available (Birckmayer & Weiss, 2000).

White (2009:7) summarises much of what has been discussed above in "the six key principles of a theory-based impact evaluation". According to White, a theory-based evaluation will:

- "Map out the causal chain (programme theory)
- Understand context
- Anticipate heterogeneity
- [Include] rigorous evaluation of impact using a credible counterfactual
- [Include] rigorous factual analysis
- Use mixed methods" (White, 2009:7).

The whole idea behind theory-based evaluation is very similar to the drive behind evaluation in general: to understand social programmes better with the aim of improving them based on cumulative knowledge of change processes (or causal mechanisms) (Birckmayer & Weiss, 2000). Theory-based evaluations could contribute to the improvement of policies because they answer the question of why (or why not) an impact was achieved (White, 2009).

4.3.2 Overview of realist evaluation

In 1997, Pawson and Tilly published *Realistic evaluation*, presenting a new realist evaluation approach to theory-based evaluation. The difference of realist evaluation,[5] compared to previous evaluation approaches, was that it took the traditional evaluation questions further than they had been taken before. Evaluation since the 1950s primarily focussed on whether programmes worked or not. Although this was not exclusively the case, the dominant focus of programme evaluation was on summative judgements of what worked and what did not work. According to Pawson and Tilly, this left a black box of *how* programmes worked. They proposed to extend the evaluation question of "what works" to, "what works, for whom, in what respects, to what extent, in what contexts, and how?" (Pawson, Greenhalgh, Harvey & Walshe. 2005:25).

---

[5] It was first called 'realistic evaluation' but Pawson and Tilley (1997) conceded later that most scholars refer to it as 'realist'.

The focus on these extended question(s) means that realist evaluators want to know exactly how a programme works. This is where realist evaluation distinguishes itself from other theory-based evaluation approaches. In realist evaluation, understanding how a programme works is done by testing CMO configurations. Realist evaluation is built on the concept of CMO configurations that are created, based on theory, and then tested, refined, and tested again. 'Theory' here refers to the ideas or understandings on which a programme (social intervention) was built. Realist evaluation tests these hypotheses on which programmes are built (Wildschut, 2014:58). A project that looks at anxiety in undergraduate students, for example, will probably propose changes or build a programme based on theories from psychology. The theory is the logic or reason behind why programme staff believe their programme will be able to have the desired effects. This logic can be derived from informed opinion, practical experience or systematic investigation (which seems to be in contrast to the need for theory-based evaluation to be built on more than just 'assumptions alone'). This means that the theory of a programme does not necessarily have to be based on academic literature or results (factual knowledge) (Pawson & Tilley, 1997). Other types of knowledge can be used to build informed programme theories, for example procedural knowledge. Factual knowledge is based on results that have been arrived at empirically. Procedural knowledge again can be derived through practice. Farmers or producers might not know why something works, but they know that it works, because they have been doing something in a certain way for years (implicit knowledge, or without conscious awareness). They might also understand why the process they use works (conscious) (Boshoff, 2014b). Although this knowledge is not necessarily based on scientific results, it is based on an informed opinion, not an assumption.

Realist evaluation is theory-based because the CMO configurations are built on pre-existing theory (derived at as described above). CMO configurations can themselves turn into theory by showing what works, for whom and in which context. Realist evaluation sets out to test what has caused a change in regularity. The process is understood as causal mechanisms effecting changes in regularity through the introduction of choices and capacity. These new mechanisms in CMO configurations do not only lead to change but are in fact the new regularity. New CMOs disrupt or replace previous CMO configurations. These changes in regularity can be tested through indicators developed for the outcomes and impact of a programme.

Realist evaluation is based on two 'axioms' and a statement that serves as an explanation of purpose. In their book, *Realistic evaluation*, Pawson and Tilley (1997:71) talk about "boxing" their main arguments to set out how they view theory-driven research and how this view, encapsulated in realist evaluation, makes a contribution to evaluation. By 'boxing', they literally mean that they highlight the importance of the ideas in their book by drawing a box around them. In full, the statement and two axioms read:

Boxed statement:

> *The basic task of the social inquiry is to explain interesting, puzzling, socially significant regularities (R). Explanation takes the form of positing some underlying mechanism (M) which generates the regularity and thus consist of propositions about how the interplay between structure and agency has constituted the regularity. Within realist investigation there is also investigation of how the workings of such mechanisms are contingent and conditional, and thus only fired in particular local, historical, or institutional contexts (C)* (Pawson & Tilley, 1997:71).

Based on the above understanding, they suggest that the following questions should be answered:

> **Axiom 1**: *Research has to answer the question: what are the mechanisms for change triggered by a program and how do they counteract the existing social processes?* (Pawson & Tilley, 1997:75)

> **Axiom 2**: *Research has to answer the question: what are the social and cultural conditions necessary for change mechanisms to operate and how are they distributed within and between program contexts?* (Pawson & Tilley, 1997:77)

A realist evaluator wants to know how a programme outcome was achieved with the introduction of an intervention in a certain context. This is presented as: mechanism + context = outcome (Pawson & Tilley, 1997). The use of CMO 'hypotheses' fits well with the traditional understanding on the logic of evaluation. According to Carol Weiss (2004), evaluation can be used to increase the theoretical understanding of social programmes systematically, which is, as mentioned above, the way in which CMOs are built on theory and theory constructed[6]:

> *As development of program theory progresses, it may well turn out that there are limited numbers of mechanisms (or families of assumptions) that underlie […] programs […]. It is probable that many program[me]s are based on the same explicit or implicit theories. With great fortune, we'll be able to figure out sets of positive or negative incentives that form the basis for societal program[me]s, and then we can go about the vital task of testing them* (Weiss, 2004:160)

[6] A CMO is built on theory, because it is hypothesised to work based on either informed opinion or research results. Once tested through an evaluation, the CMO can be improved, thus constructing theory.

CMO configurations as small hypotheses of impact creation, build understanding of impact, and explain how impact was achieved. Before looking more closely at CMO configurations, it is important to consider how realist evaluation views programmes. Its understanding of what a programme is, is important because that which is evaluated influences the tools, methods and approaches used to evaluate it. The section also explores how realist evaluations work.

4.3.3 Evaluating social programmes in realist evaluation

According to realist evaluation, programmes are 'theories' incarnate, they are 'embedded', they are 'active', and they are 'open systems' (similar in many ways to how SIAMPI views the research process) (Pawson & Tillye, 1997). Programmes are viewed as **theories** since the ideas of how they will work are formed in the minds of policy architects and practitioners. These ideas provide an understanding of how the world works or how programme beneficiaries will react. From this, it is already clear that programmes are thus also **embedded** in social systems (Pawson & Tillye, 1997). Realist evaluation takes into account the different layers of social reality that surround a programme. A programme can only introduce change if it takes into account the the way in which a system works, "it is through the workings of entire systems of social relationships that any changes in behaviours, events and social conditions are effected" (Pawson & Tilley, 2004:4). Thirdly, programmes are mostly **active**. They require the active participation of beneficiaries. Typically (although not always), the beneficiaries will have to do something to engage with the programme, be it attend classes or undergo a certain treatment. Lastly, programmes are **open systems** where any number of other sources or actors could influence the outcomes of a programme. It is near impossible to isolate the workings of a programme and it is expected that unanticipated events might influence outcomes (Pawson & Tilley, 2004:4–5).

According to Salter and Kothari (2014), a realist evaluation can be divided into four phases. These four phases essentially represent the creation, testing and redrafting of CMO configurations. This process of configuring CMOs involves the creation and refining of (impact) hypotheses.

Phase 1: Development of CMO and hypothesis

Phase 2: Data collection

Phase 3: Data analyses – testing of hypotheses

Phase 4: Refinement of original CMO configuration (Salter & Kothari, 2014).

During **phase 1**, the theories on which the programme is based are developed. These theories are built out of theories derived from pre-existing research and adapted based on, for example, interviews with experts in a field. After the theory has been established, CMO configurations are developed based on these theories. **Phase 2** involves data collection. For data collection, any methods that are appropriate to the CMOs can be used, and triangulation is recommended. In some cases, sources of data might not deliver on the requirements of the evaluation. With triangulation, it is possible to then rely on other sources. In cases where the data derived from sources are similar, it creates certainty that the data are correct. In **phase 3**, data that have been collected are analysed and the CMO configurations can be tested with the available data. Finally, **phase 4** makes use of the information from phase 3 to adjust the CMO configurations, which can then be used in future evaluations (Salter & Kothari, 2014).

In essence then, CMO configurations are 'if–then' propositions that are tested through evaluations with data collected from social programmes. In realist evaluations, the process begins and ends with CMO configurations (Pawson & Manzano-Santaella, 2012). Causation is constructed through CMO configurations. Pawson and Tilley (1997) provide definitions for each of the separate parts:

- **Context**: Is "the spatial and institutional locations of situations, together, crucially, with norms, values, and interrelationships found in them. […] Just as programs involve multiple mechanisms, they will, characteristically, also include multiple contexts" (Pawson & Tilly, 1997:216). 'Context' refers to the aspects about a specific case that have the potential to influence the workings of mechanisms. It forms part of the planning of interventions to understand at whom the programme will be aimed, and under which circumstances the programme will be able to function (Pawson & Tilley, 2004:7).
- **Mechanisms**: "Mechanisms describe what it is about programmes and interventions that bring about […] effects. Mechanisms are often hidden, rather as the workings of a clock cannot be seen but drive the patterned movements of the hands" (Pawson & Tilley, 2004:6). These are the "choices and capacities which lead to regular patterns in social behaviour […] and a key analytical task is to discover whether [these] have disabled or circumvented the mechanism responsible for the original problem" (Pawson & Tilly, 1997:216).
- **Outcomes**: "Outcome-patterns comprise the intended and unintended consequences of programmes, resulting from the activation of different mechanisms in different contexts. Realism does not rely on a single outcome measure to deliver a pass/fail verdict on a programme" (Pawson & Tilley, 2004:9). Instead, it is understood that programmes will not

work in every context or be equally successful when the context changes. Different subjects and situations will mean that mechanisms will 'fire' differently and have different effects depending on the context (Pawson & Tilly, 1997:217).

Each realist evaluation will test numerous CMO configurations. The same mechanism can be introduced in various contexts, or a different mechanism in a similar context. C + M = O, or when the mechanism is kept the same and the context changed we might have C1 + M1 = O1, or C2 + M1 = O2 and so on (Pawson & Manzano-Santaella, 2012:184). These different CMO configurations are constructed to enable the testing of impact mechanisms. A realist evaluation engages in both evaluation and research (the expansion of knowledge). The process by which CMO configurations are developed, tested, refined, and tested again can continue until the researcher or evaluator runs out of time and money (Pawson & Manzano-Santaella, 2012).

By looking at the three aspects of CMO, realist evaluation can help to shed light on how different layers of social reality react with the different aspects of a programme (Byng, 2005). Through realist evaluation, the three functions of evaluation can be addressed. Firstly, realist evaluation is formative, because it can assist in understanding how mechanisms work. Secondly, realist evaluation can be summative as it shows whether a programme worked or did not work, while also analysing why. Lastly, through its testing of different small hypotheses (CMO configurations), realist evaluation helps to expand the knowledge base on what works, for whom, in which circumstances and why (Mark, Henry & Julnes, 1998).

Realist evaluation techniques recognise that there are many interwoven variables operative at different levels in society; thus, the evaluation method suits complex social interventions, rather than traditional cause–effect, non-contextual methods of analysis. Realist evaluation acknowledges that interventions do not necessarily work for everyone, since people are different and are embedded in different contexts.

Realist evaluation allows for three things:

1. A level of certainty is established on which combinations of mechanisms are needed to achieve the success in programmes, and ways to optimise programmes. It is possible to determine how these mechanisms produce change.
2. Findings from realist evaluations can have transferability potential if they rely on solid theories, which can be or have been tested in an evaluation with clear links between CMO

configurations and theories. This allows for an understanding of which mechanisms are appropriate in which contexts.

3. The findings of a realist evaluation can inform future decisions on the construction of new programmes. It informs what can be expected as an outcome based on the context of a programme and the mechanisms involved (Pawson & Tilley, 2004; Pommier, Guével & Jourdan, 2010).

A realist evaluation sets out to test understandings of how active, embedded, theory-based programmes work. It develops CMO configurations that are empirically tested and explains what Pawson and Tilley (2004:11) call the “signature of outcomes”. The realist approach takes it for granted that a single intervention can have many different positive and negative results when rolled out on a large scale since mechanisms fire differently in different contexts. Pinpointing the nature and sources of the differences in the activation of mechanisms is important (Pawson & Tilley, 2004).

Although realist evaluation is method-neutral, in that it does not prescribe methods to be used, it is a “species of theory-driven evaluation” (Pawson & Tilley 2004:2). Realist evaluation regards programmes as originating from the human imagination that chart how an unwanted regularity can be changed. Programmes are built based on a vision of change, and evaluations done on such programmes will inevitably test underlying programme theories. In a realist evaluation, the questions of whether a programme worked as it was supposed to and whether the ideas on why it should have worked are ‘realistic’ and ‘logical’, can be explained by theory (Pawson & Tilley, 2004).

4.3.4 Impact as understood by realist evaluation

Impact is seen as an outcome or change in regularity that results from CMO configurations (Pawson & Tilley, 1997). Impact cannot be viewed in isolation from the mechanisms responsible for the change in regularity, which is embedded in a specific context (in which the relevant mechanisms produce a specific outcome). The mechanisms (CMO configurations) explain how the population targeted by a programme responds to the programme, leading to impact. These early impacts are often described as ‘outcomes’. This means that realist evaluation has a process-oriented view of impact (Pawson & Tilley, 1997). “The realist understands causality in terms of underlying causal mechanisms generating regularities. […] Realistic evaluation is […] concern[ed] […] with understanding causal mechanisms and the conditions under which they are activated to produce specific outcomes” (Tilley, 2000:4–5).

Pawson and Tilley (1997) relate the idea of an impact mechanism to the firing of a gun. A gun can be fired when certain conditions are met, for example, there should be gunpowder, the gunpowder should be under pressure and it has to be hit by a trigger. All these various elements need to be in place for the gun to fire. If there is not enough pressure or if the gunpowder has become wet, these small changes will result in the gun not firing. For realist evaluation, the same understanding can be applied to programmes and the mechanisms on which they are built. If we are able to look at what we perceive to be similar mechanisms, but in different contexts, we can begin to understand why mechanisms fire or do not fire. In this way, an understanding of impact mechanisms can be built up (Pawson & Tilley, 1997).

> *Realistic evaluators can then identify, modify, test and refine the CMO configurations. […] a mechanism is "not a variable but an account of the make-up, behaviour and interrelationships" of the processes which are responsible for the change, "a mechanism is thus a theory"* (Pommier, Guével & Jourdan 2010:2).

As discussed in the previous sections (4.3.2-4.3.3), CMO configurations are based on theories and are themselves small theories (Pommier *et al.*, 2010). In other words, doing evaluations is in part learning how CMO configurations work, or how impact is caused. According to Pawson and Tilley's (1997) understanding of mechanisms or CMO configurations, actors react (or do not react) to resources and opportunities that are introduced by an intervention or programme. Outcomes are caused by the actors' reactions or reasoning (Pawson & Tilly, 1997).

Pawson and Tilly (1997) view the status quo or social regularity as a 'balance' between current choices and capacities to which people have access. They make use of an example based on the suicide rate in an area. According to this understanding, the suicide rate is affected by choices (to commit suicide or not), and capacities (community support). To have an effect on the suicide rate, a programme will have to influence either choices or capacities. A suicide helpline can be established, providing a different capacity. The change we make to regularity (by changing choices or capacities) is however affected by the context in which it is taking place. The same programme but implemented at two different schools, for example, might have very different outcomes depending on the context (such as competence of teachers and motivation of the school's management) (Pawson & Tilley, 1997).

Change or impact is caused through CMO configurations that affect either the choices or the capacities of people (Pawson & Tilley, 1997). In summary then, realist evaluation views outcomes as the result of a mechanisms firing in a context (outcome = context + mechanism) (Tilley, 2000a). This means that programmes or interventions rely on the appropriate social and cultural conditions that determine whether a mechanism is activated or not (Pawson & Tilley, 1997). CMO configurations are models that show how changes in regularity (outcomes) are produced when mechanisms are activated in a programme (Pawson & Tilley, 2004; Tilley, 2000b).

4.4 Theories of change and impact pathways

Both research and social programmes are under pressure to show how they are having an effect on the welfare of society, be it in terms of social, cultural or environmental or other changes (Rogers, n.d.). Some methods or tools used in programme evaluation – in this case, theories of change – can contribute value by making sense of how different productive interactions come together in a research project.

4.4.1 Theories of change

Theories of change as an evaluation approach form part of theory-based evaluation, along with realist evaluation. The theory of change approach emerged in the United States during the early 1990s in the field of community initiatives (Coryn, Noakes, Westine & Schröter, 2011; Stein & Valters, 2012). Programme theory (as discussed in 4.3.1) makes explicit how a programme is expected to work, basing these expectations on either tested or on hypothesised theory of how the intended outcomes of a project will be achieved. Theory-based evaluation again uses programme theory to guide the evaluation (Stein & Valters, 2012). A theory of change (a tool in theory-based evaluation) is used to show how and why the activities of a programme will have certain outcomes, leading to the desired impact. The idea behind programme theory (made explicit in a theory of change) is that there is a logic to how programmes work, in other words, there is an underlying theory that can be captured (Blamey & Mackenzie, 2007). According to Carol Weiss (1995:70), "[t]he concept of grounding evaluation in theories of change takes for granted that social programs are based on explicit or implicit theories about how and why the program will work."

The theory of change approach focusses on gathering inputs from different stakeholders on how a programme will work. It views these stakeholders as experts on their field or in their area. Where realist evaluation is concerned with engaging stakeholders on how a programme will work for the design of CMOs (to be tested), the theory of change approach focusses on creating community involvement in the implementation and design of a programme. A realist evaluator does not necessarily seek general community involvement, but relies on targeted 'experts' or informed stakeholders to build CMOs. Realist evaluators focus on implementation theory as a means to build

CMO configurations. Theories of change, however, seek to build a sense of community programme ownership (Blamey & Mackenzie, 2007).

The current research did not make use of the theory of change approach, but of theories of change as a tool (Blamey & Mackenzie, 2007; Mountain, n.d.). A theory of change as a tool can be useful in evaluations for many different reasons, for example:

- A theory of change allows for better monitoring of shorter-term impacts and outcomes that are seen as forerunners of longer-term impacts. If you know what you should begin to observe at different stages of a programme, these might be early indicators of success or failure.
- If a programme is failing, a theory of change allows an evaluation to pinpoint what it is about the logic of a programme that is failing.
- Or, if a programme has been implemented as intended (determined through a process evaluation), it is possible to determine whether the underlying programme theory is to blame for failure.
- And, when a programme does have success, the theory of change allows an evaluation to understand which parts of a programme are working (Rogers, n.d.).

A theory of change can be presented as a flow chart (as seen in Figure 4.1), moving from problem, to goal, identification of target population, different activities and who are responsible for the activities, expected outcomes, and finally leading to impact and achievement of the goal. The problem is the regularity that needs to be changed by a programme. The goal is the overarching, almost idealistic, vision of what the programme strives to achieve. The population is the group in society that the programme will be targeting specifically (where the changes will take effect). Activities are actions undertaken by programme staff that have outputs and lead to outcomes.

Outcomes, as used in the below theory of change, are generally short-term impacts. One or more outcomes can then combine to lead to longer-term impacts. The final impacts should speak to the original goal that the programme was launched to address. Figure 4.1 displays a schematic example of a theory of change (used as a tool in the research). A theory of change shows how different activities take place and why they lead to outcomes and impact. A theory of change is accompanied by an impact narrative that describes this causative theory.

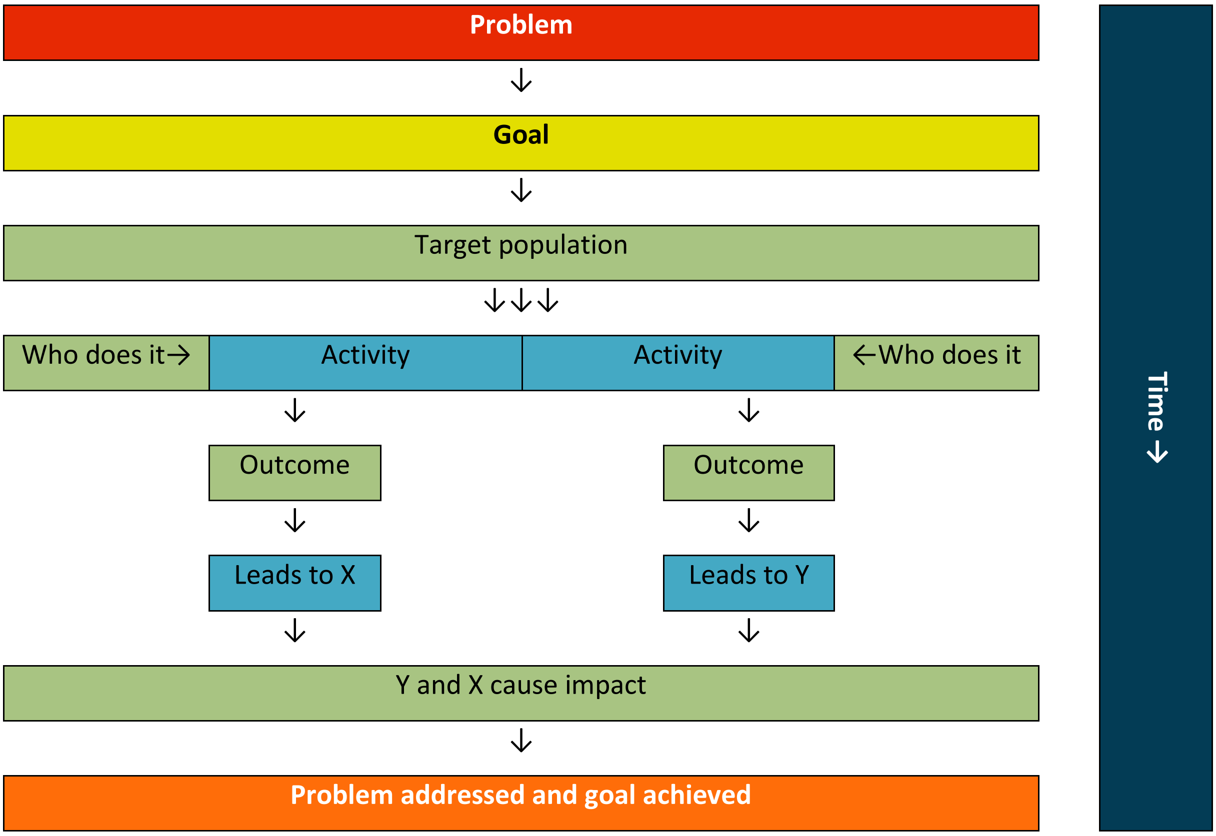

Figure 4.1 Simplified example of a theory of change

[Source: Developed by author. For information on theories of change see Thornton, Schuetz, Förch, Cramer, Abreu, Vermeulen and Campbell (2017)]

The current research made use of three elements that are seen as building on each other. The first element is productive interactions, the second is theories of change, and the third impact pathways. Productive interactions are small impact mechanisms that can potentially combine to form into impact pathways. An impact pathway is seen as an event trail, an impact narrative or story, which is built on productive interactions (in the case of the dissertation), and leads to a specific impact or outcome. Theories of change, however, can show the entire research process or the entire scope of a programme, within which different impact pathways are imbedded. Not all productive interactions in a theory of change for a research project will necessarily lead to a final impact. Some might have short-term (lower-level) outcomes that are of less importance to higher-level outcomes. Lower-level outcomes are those effects that take place closer in time and space to the researchers or research team in a project. Higher-level impacts, on the other hand, affect individuals, groups and organisations that are not related to a project. Low-level impacts are often within the control of a research team, while high-level impacts occur beyond their control.

4.4.2 Participatory impact pathway analysis (PIPA)

In a recent article, Van Drooge and Spaapen (2017), the co-developers of SIAMPI, identify a theory of change approach, PIPA, as of particular interest to the field of research evaluation (specifically SoIR assessment). They describe this relevance in the context of transdisciplinary collaborations (between researchers and stakeholders that cooperate to solve societal challenges) (Van Drooge & Spaapen, 2017:31):

> *[PIPA] is a relatively young and experimental approach that draws from programme theory evaluation, social network analysis and research to understand and foster innovation. It is designed to help the people involved in a project, programme or organisation to make their theories of change explicit, in other words how they see themselves achieving their goals and having impact*.

PIPA was originally developed by the Consultative Group for International Agricultural Research (CGIAR) for application in development research (see Alvarez, Thiele, Mackay, Córdoba & Tehelen, 2010). The PIPA method promotes the joint drafting of programme theory, from the start of a programme, involving all programme stakeholders, including personnel and intended beneficiaries. The stakeholders jointly develop a theory of change during workshops, from which they can then develop a logic model that assists in future M&E by identifying relevant indicators (Van Drooge & Spaapen, 2017).

PIPA includes planning for future networks through which impact can be achieved. Workshops are held at the start of the project, but can also be held during and after the project, to ensure that the vision captured by the theory of change remains relevant. In the case of research, where the societal impacts are not always clear from the start, it allows for adjustments during the run of the project. The awareness of possible impact and the use of a theory of change ensures that data are captured (for example on interactions between stakeholders) that are useful in later evaluations, or in the case of this study, in the identification of productive interactions (Alvarez *et al.*, 2010).

PIPA, if applied in the context of research, moves the focus from the researcher as the sole or main authority on the potential impact of their research, to all stakeholders. Instead of the researcher, who is an expert in his or her own field and not necessarily on impact, having to develop ideas on how impact will work, the researcher becomes an actor in a network, with many other stakeholders. Input on impact could come from potential users of research (if these are clear), from funders, suppliers of technologies (products) and any other stakeholders in the research environment (Alvarez *et al.*, 2010).

The PIPA method can have a number of benefits in research evaluation and planning for research impact, including:

- clarifying the process through which research will potentially have an impact;
- raising awareness, through a wide range of stakeholders, of how the research might 'collaborate' on a problem with other research projects;
- creating awareness of the ways in which impact might come about, both through scaling up and out (discussed below); and
- creating a framework that will help with future M&E (Alvarez *et al.*, 2010).

PIPA is especially useful in the context of funder-driven research, such as in the case of agricultural extension and commodity companies. What was of interest for the current research, was however less focus on community involvement (as mentioned, realist evaluation is concerned more with targeted stakeholders than with full community engagement) than on network constructions at different times of the research process.

4.4.3 Importance of networks in PIPA

Stakeholders, or actors that play a role in the effecting of research impact, are important in the PIPA method (Alvarez *et al.*, 2010; Spaapen & Van den Akker, 2017). Research impact is an interactive process with multiple stages, which do not necessarily (or at all) work in a linear way, from researcher to beneficiary. Research use takes place in an intricate network of actors. These actors can be called different names, but generally include (among others), researchers, funders and translators (changing research to suit their needs or industry). The importance is that research utilisation is not just about publishing research and hoping for impact. Beyond publishing, there is also engagement with research by stakeholders through uptake (reading and becoming aware of research), use (acting on research in any manner for example by suggesting it to someone else) and impact (change due to the research from ideas to practice) (Morton, 2015).

Development (or change in a particular agricultural industry) does not necessarily follow a linear process, but rather moves through a system of involved stakeholders (Douthwaite *et al.*, 2007). There are chains of impact-generating mechanisms that create links between researchers (where scientific knowledge is produced) and problems that need to be addressed. These mechanisms transform scientific knowledge into knowledge that is useable in the applicable field or industry. At the same time, the process is not one of a knowledge deficit, with knowledge flowing from researcher to end-user, but rather two-directional, with knowledge moving and being translated both ways, for example from problem to researcher (Matt *et al.*, 2017; Van den Akker & Spaapen, 2017).

Networks serve a very important role in keeping a project active after the original researchers involved had moved to other topics. Impact of research often requires a continued push to have an effect, for example through knowledge creep (see Weiss, 1980). Someone must be doing something with the research for it to have an impact. However, if a researcher leaves a project and there is no network to support continued awareness of findings, impact might never be effected. PIPA holds that planning these future network(s) (including a future network in a theory of change) is essential. Although PIPA was developed in the context of developmental research, it holds true for most other types of research projects (Douthwaite *et al.*, 2007). In PIPA, future networks and their development are planned. The same stakeholders do not have to be part of every step of the process. Rather, PIPA includes the steps of how a network or networks will be formed, moving from one phase to the next.

PIPA also focusses on what it calls 'scaling up' and 'scaling out'. 'Scaling out' means the impact takes place within the same community or target group, for example adoption from farm to farm. 'Scaling up' is the adoption of research results from localised (the farmer), to local (the funder), and to national level (policy) (Alvarez *et al.*, 2010). Scaling up is important because impact through scaling out might be affected by impact having scaled up (Alvarez *et al.*, 2010). When research influences policy for example, this can have an effect on the adoption at farm level (Douthwaite *et al.*, 2007). Scaling up and scaling out should be taken into account and included when developing a PIPA theory of change (Alvarez *et al.*, 2010).

With PIPA, four elements come together: the normative element of logic models, the causative element of programme theory, the participation of numerous stakeholders, and the construction of future networks for effecting impact (Douthwaite *et al.*, 2007; Van Drooge & Spaapen, 2017). The next two subsections present examples of SoIR assessment methods that use theories of change.

4.4.4 Practical application – ImpresS

IMPact of RESearch in the South (ImpresS) is a research impact evaluation method and approach developed by the French Agricultural Research Centre for International Development (CIRAD) (CIRAD, 2015a). CIRAD works within the developmental sphere, and publishes research and technical advice on agriculture, focussing on sustainable development. Since their research involves communities and local stakeholders, it was important to develop an understanding of how their research was having an impact in the societies where they work. It was from this need that ImpresS was developed. The ImpresS method, as inspired by PIPA, tries to include the different stakeholders who participate or who will foreseeably participate in the research process (Barret *et al.*, 2018).

ImpresS includes both an *ex post* method and an *ex ante* approach.[7] The *ex post* method “uses a range of participatory tools, applied to understand the innovation process after it has reached maturity”, while the *ex ante* approach helps to “formulate a common vision and plausible impact pathway of an intervention” (CIRAD, 2015a).

The ImpresS *ex ante* approach is useful in developing a common vision of what an intervention or research project should achieve. During this process, stakeholders develop what they see as plausible pathways to impact (for the intervention). Focus for the approach then shifts from how to achieve outputs or outcomes by actors, to monitoring and potentially adjusting the impact pathways as needed to achieve the desired impacts (CIRAD, 2015b).

The ImpresS *ex ante* approach consists of six phases that rely on three principles, supported by three main tools. The six phases are:

- construction of a “first hypothetical impact pathway” (CIRAD, 2015c) that is based on a needs assessment;
- outcome mapping;
- consideration of public policies in the region where the intervention will be active;
- assisting stakeholders to strengthen their capacities where needed;
- development of a suggested impact pathway along with a number of alternative scenarios; and
- the “design [of] a participatory monitoring, evaluation and learning (MEL) system” (CIRAD, 2015c).

The three main tools used by the ImpresS *ex ante* approach are an innovation narrative, outcome mapping and crucially, an impact pathway. The innovation narrative helps to organise the intervention so that stakeholders can agree on what the most feasible process is to follow, to achieve the desired goals (CIRAD, 2015c). In outcome mapping, the possible outcomes are hypothesised based on how outputs and stakeholders (or actors) are to come together, leading to the aforementioned outcomes.

[7] CIRAD makes use of the two different terms ‘method’ and ‘approach’, in the opinion of the research, both can however arguably be called ‘methods’.

The impact pathway is used to illustrate the way in which the narrative and outcomes map combine. There are five elements to the ImpresS *ex ante* approach impact pathway: inputs, outputs, outcomes, primary impacts, secondary impacts (CIRAD, 2018). The inclusion of primary and secondary impacts relates to the creation by PIPA of future networks that drive impact further beyond the direct involvement of the research team (CIRAD, 2018).

The ImpresS *ex post* method is used to look back at a completed intervention to determine how different parts of the intervention led to impact. The core elements of this method are its participatory nature and enhancement of mutual learning. Firstly, the most important stakeholders are all involved in assessing the impacts of the intervention, and secondly, the different stakeholders (such as farmers, commodity companies and researchers) engage with each other directly, building capacity and understanding (CIRAD, 2015b).

The ImpresS *ex post* method has five phases, namely preparation, dialogue, construction, measurement and validation.

- During the **preparation phase***,* the evaluation team looking at an intervention define the limits of the study, create a stakeholder map, hypothesise certain impacts (expected or observed), and they write an impact narrative (CIRAD, 2015d).
- The **dialogue phase** mainly entails refining everything developed in the preparation phase, but now include the different stakeholders who formed part of the project (CIRAD, 2015d).
- The **construction phase** identifies moments of interaction between the intervention and society, and systematically “document[s] and [characterises] the impact pathway elements” (CIRAD, 2015d).
- In the **measurement phase***,* data are collected on the different impact pathways through various methods, such as surveys and focus groups. The aim is to strengthen the data through the triangulation of sources (CIRAD, 2015d).
- The final phase is the **validation phase**. During this phase, the results of the evaluation are presented to the different stakeholders who are able to validate the impacts identified, or provide further recommendations and insight (CIRAD, 2015d).

The current research made use of theories of change (similar to the *ex ante* method discussed above) followed by the identification of impact pathways based on these theories of change (similar to the *ex post* approach above). In other words, the dissertation follows the logic of building theories of change from which impact pathways can be identified. The difference is that in the case of the dissertation, the theories of change are not developed based on focus groups or *ex ante* deliberation between stakeholders, but through the identification of research interactions in completed research projects that are then organised into theories of change (where these become productive interactions – this is discussed in detail at the end of the chapter and in Chapter 5). According to the current study and as reported in this dissertation, a theory of change is a comprehensive overview of all the different interactions that took place during a research process (in a research project). Not all of these interactions necessarily link directly to final impacts. Instead, the theories of change are used to identify impact pathways, or groups of interactions within the theories of change, that directly speak to a specific outcome or impact.

4.4.5 Practical application – ASIRPA

The Socio-economic analysis of the impacts of public agricultural research project (ASIRPA) by the French National Agricultural Research Institute (INRA), which was launched in 2011, made use of productive interactions, actor network theory, *ex post* case methodology and systematic codification of variables in standardised case studies and knowledge value concepts, to assess the contributions of INRA in agricultural research impact. INRA constructed impact pathways, as proposed by the CGIAR, to develop ideal impact pathway types (Joly *et al.*, 2015).

The theory of change of ASIRPA is in fact a theory of innovation (Joly *et al.*, 2015). INRA built their theory of innovation (how it sees the innovation process) on actor network theory (ANT). According to ANT, research impact takes place through translation in four stages:

- problematisation = agreement and definition of problem;
- *intéressment* (participation) = building a preliminary actor network (getting actors involved);
- enrolment = establishing roles for the different actors; and
- mobilisation = taking impact beyond the immediately involved actors (Joly *et al*., 2015:445).

Various scholars maintain that innovation takes place along a non-linear process of knowledge translation by actors who translate or transform knowledge (Ahteensuu, 2012; Evans & Durant, 1995; Pohl *et al.*, 2010; Simis *et al.*, 2016; Wynne, 1991). Knowledge, as understood by ASIRPA, is made actionable through this process by turning it into "products, processes, and ways of doing or governing things" (Joly *et al*., 2015:441). Through productive interactions, the ASIRPA approach identifies not only inputs and outputs of research, but, more importantly, also the chain of translation of research. ASIRPA includes the ideas of SIAMPI, substituting attribution with contribution, and moving the focus to the productive interactions close to the researcher. ASIRPA identifies impact-generating mechanisms in the innovation process, incorporating all the actors involved in the innovation process (Joly *et al.*, 2015; Matt *et al.*, 2017).

ASIRPA does not see productive interactions as a proxy of impact and include measures to assess impact endpoints (Joly *et al.*, 2015). This is in contrast to the view of SIAMPI of productive interactions being near indistinguishable from impact at times. As mentioned, for SIAMPI the difference between societal impact and productive interactions is narrow since "the transition from interaction to impact is often gradual" (Spaapen & Van Drooge, 2011:212).

The *ex post* case study methodology of ASIRPA allows for the standardisation of case studies and systematic codification of variables. The approach was successfully followed by INRA and was able to identify four ideal-type impact pathways through which INRA, as a public research organisation, had an impact on the creation of agricultural research impact generation. The ideal types are "characterised by specific translation mechanisms, critical points, research and adoption networks, research outputs, and impacts" (Matt *et al.*, 2017:207).

In ASIRPA, knowledge gains value through actors, called 'knowledge value collective' (KVC) actors, who use and transmit (transform, translate) scientific research. The KVC originates from the work of Bozeman (2003:6-7), who explains how what he calls growth, fecundity and "science and technology human capital", have an impact on the KVC to effect social impact by translating research knowledge that has been produced (Bozeman, 2003). The context in which research is produced and transmitted is important, including the characteristics of knowledge, interactions between potential users of research and knowledge producers, the political context and also the legal context (the limitations that are attached to the publication of research) (Joly *et al.*, 2015). ASIRPA makes use of an *ex post* case study methodology. It focusses on impact-generating mechanisms, and it views stakeholders as crucial in research impact generation. Similar to SIAMPI, it also agrees that research and innovation take place in networks, and combines both quantitative and qualitative indicators (Van den Akker & Spaapen, 2017).

Based on the theories and approaches described above,[8] ASIRPA developed a "fictive impact pathway" (an example of the framework can be found in Joly *et al*., 2015:447). The impact pathway is built around a context that spans the project, as well as inputs, outputs, intermediaries, impacts 1

[8] The theories and approaches are: SIAMPI (productive interactions), ANT, *ex post* case methodology and systematic codification of variables in standardised case studies, and knowledge value concepts.

and impacts 2. This ‘fictive impact pathway’ “[makes] apparent the characteristics of the research (or inputs), its products (outputs), the intermediaries involved, the primary impacts (impacts 1), and the secondary impacts (impacts 2)” (Joly *et al*., 2015:447).

ASIRPA was able to develop four ideal type impact pathways successfully:

“Type 1: Intense transformation drawing on existing networks” (Matt *et al.*, 2017:213) and also called “strong structuration of the partnership from research to impact” (Joly *et al*., 2015:449). Type 1 was identified based on cases of research projects where INRA and external actors had had a long and stable relationship leading to research outputs and impact (Matt *et al.*, 2017).

“Type 2: Strong public/private collaboration in long-term research programmes” (Joly *et al.*, 2015:449; Matt *et al.*, 2017:214). This type is based on cases where the INRA infrastructure and experimental units have made long-term research collaboration possible. These projects are led by INRA and focus on basic research (Matt *et al.*, 2017). The smooth cooperation between INRA and the academic and external socio-economic partners allows for creation of large impacts (Joly *et al.*, 2015:449).

“Type 3: Market for technologies” (Joly *et al.*, 2015:449) is based on cases where technology transfer took place between public organisations who produce basic research, and private companies who develop and then distribute these technologies (Matt *et al.*, 2017). In the case of INRA, this entails the production of research that is transferred to external partners who further develop the research outputs (Joly *et al.*, 2015).

“Type 4: Public research as key initiator of intensive transformation” (Matt *et al.*, 2017:215) and als ocaled “alternatives to the dominant model in a context unfavourable to its diffusion” (Joly *et al.*, 2015:449). In these cases, new networks were often built to facilitate transformations, for example in technological trajectories or regulatory decisions with economic consequences (Matt *et al.*, 2017). The new research provides alternatives to the dominant model (the way a system, for example, is functioning at present). These ready-to-use outputs with potential impact however remain unused due to structural or economic obstacles (Joly *et al.*, 2015).

From the ASIRPA project, INRA concludes that the research produced useful results in that the typologies allow for a better understanding of types of impact. It also creates understanding on the problems faced, and what the critical points were (translation of knowledge in the actor networks). The results showed that it does not only depend on agricultural researchers or research institutions (funders) what the impact of research will be, but the socio-economic environment is also important for success. The results proved the value of productive interactions over just the use of realised impacts and allowed INRA to understand the mechanisms and critical conditions needed for research impact in its own environment (Joly *et al.*, 2015).

These examples have shown the application of theories of change in some 'real-world' examples. The data available to construct these theories of change have an impact on the theory that can be built.

In the current research, there was also a need to find a way of looking at research impact, as possibly captured through research interactions (productive interactions) and the theories of change built from these (explained in Chapter 5) that could provide some indication as to which aspects of research impact had been captured. The concept of impact literacy provided the research with a way of looking at research impact.

4.6 Impact literacy

In both the SIAMPI approach and realist evaluation, there is a strong focus on understanding how impact is achieved and not only whether it has been achieved. Theories of change can give a visual representation of the process through which impact is achieved. A focus on research impact literacy, on the other hand, provides a further reflection on societal impact and its measurement, given that a discussion of impact literacy necessarily involves an exploration of the 'essential elements' of impact (Bayley & Phipps, 2017).

The literature on impact literacy is, for all intents and purposes, limited to a single academic article, "Building the concept of research impact literacy", by Julie Bayley and David Phipps (2017). The concept does however draw on current literature to arrive at its conclusions. The driving force behind this new way of looking at impact was sparked by the problems faced by assessment processes of the SoIR.

Measurement-centric approaches that have often been used to date to assess the SoIR (also in agricultural research as discussed in section 2.5) lead to short-termism. These assessment methods also cannot comprehend the larger context involved in effecting research impact (specifically SoIR). Non-prescriptive routes to impact have their own problems (Bayley & Phipps, 2017). With little to guide them, researchers are left to their own expertise to find ways of effecting impact or showing that impact has been effected. When a researcher is expected to use a measurement-centric system, the tendency to work towards addressing these narrow measurements can become the prime target of the research (Bayley & Phipps, 2017).

Defining the SoIR is hard or impossible since there are countless different ways in which various research projects can have an impact in different disciplines. Bayley and Phipps (2017) refer to an study by Kings College London (Kings College London and Digital Science, 2015), which found 3 709 unique impact pathways out of 6 647 impact cases analysed (this number has been adapted to 6 679 in updated versions of the same report) (Kings College London and Digital Science, 2015:38). These results have also been mentioned in the Chapter 2 (under 2.3.1 Different definitions of the SoIR). The way in which research has an impact is extremely varied and does not follow the trajectories of traditional economic models. The conclusion, according to Bayley and Phipps, is that there is no 'one-size-fits-all' template for research impact, with the next realisation (they argue) that this creates a need to improve the way in which the research and innovation community understands impact. The authors' response is the concept of 'impact literacy', which they claim has the potential address these challenges at individual and institutional levels (Bayley & Phipps, 2017).

The aim of impact literacy is to empower practitioners of research impact (this group comprises any group or individual who takes part in the process of knowledge translation) to understand the networks and processes around research impact better. In impact literacy, impact is seen as the dependent variable with knowledge mobilisation and knowledge production as the independent variables (Bayley & Phipps, 2017:4).

Impact literacy is the understanding of research impact in terms of a crossing or junction of three essential elements, 'how', 'what' and 'who'. When all the elements overlap, there is impact literacy. The 'how' of impact literacy refers to understanding how impact is created, for example, the different interactions that were part of the research process. The 'what' looks at the "identification, assessment, evidencing and articulation of impact endpoints" (Bayley & Phipps, 2017:3). These can be traditional final impacts, or shorter-term impacts or effects that take place during the research. The 'who' focusses on which actors need to be integrated (in a network) to effect research impact successfully (Bayley & Phipps, 2017).

When all three elements are present, an individual or organisation is impact literate (Bayley & Phipps, 2017). However, when one element is missing, different issues emerge. For example:

- The absence of 'what' leads to a lack of understanding exactly what the indicators required for assessing impact are since it is unclear what was supposed to be effected.

- A lack of 'how' causes a breakdown in the process of effecting impact and theory, or in other words, understanding what the process is of achieving the desired impacts (theory here, is used in a similar way as in a theory of impact, or as in realist evaluation).
- The absence of 'who' could cause inefficient impact strategies that are not supported by the right actors (Bayley & Phipps, 2017).

Impact literacy is not a zero-sum scenario; rather, 'literacy' can be seen as a spectrum, as opposed to seeing the opposite of literate as illiterate. 'Literacy' in this context is mostly synonymous with 'consciousness'. When research funders and researchers understand how impact is effected, who the different role players are, but also crucially what is understood by research impact, research with societal impact can be produced (Bowen & Graham, 2013). For this to happen, impact literacy needs to be built. The next section provides an overview of how the different conceptual underpinnings discussed in this chapter were combined in the current research.

4.7 Logic of the research

The premise of the current research was that the SoIR is something valuable that is worth determining. The nature of research however makes this endeavour arguably more complicated than assessing impact in traditional programme evaluations (or assessing the scientific impact of research through citations). The section below provides a recapitulation of the logic behind the current research, combining insights from Chapter 2 on SoIR with the conceptualisations presented in the preceding sections of this chapter.

The research was undertaken from the view that the effecting of SoIR is something that takes place through an interactive process and not so much through a linear model where the only aspects that really matter are the final impacts. It is therefore important to understand how the research process effected impact. This means that the theory of how impact works is important. Realist evaluation – which originated in programme evaluation – is one of the most widely used theory-based evaluation approaches (Blamey & Mackenzie, 2007; Green *et al.*, 2015). Realist evaluation has a number of characteristics, in addition to its theory-based nature, which makes it compatible with the study of research impact:

- *It looks at the context*: Similar to research taking place in a larger context and not just in the enclosed space of academia from where 'valuable' research is shared (the linear model of research production), realist evaluation believes that the outcomes of programmes are affected by the broader contexts in which they are implemented (Jagosh *et al*., 2015; Jagosh, Tilley & Stern, 2016; Pawson & Tilley, 2004).

- *It is process-oriented with impact mechanisms (CMO configurations)*: Research impact is not something that happens at the end of the linear line building up to impact (only), but rather, smaller impacts and effects that can be identified along the entire process. According to realist evaluation with CMO configurations, there are multiple impact mechanisms (similar to the SIAMPI productive interactions) that combine to form later impacts (Marchal *et al.*, 2012:203; Salter & Kothari, 2014:5).
- *It can produce summative judgements*: It remains important to know, also in research, what worked and what did not – the summative conclusion. At the same time, a finding that only states whether a programme worked is not enough when the desire is to understand programmes with the aim of improving them (Marchal *et al.*, 2012:203; Salter & Kothari, 2014:5).
- *It can produce formative judgements*: Realist evaluation is mainly geared towards understanding how programmes work – the formative conclusion (Pawson & Tilley, 2004). Research funders often have long-term relationships with the researchers with whom they work. Researchers might even be part of some of their committees. In agricultural research, there is also the possibility that there are a very limited number of experts per field. It is often better to help researchers improve their impact (formative judgement) than cancel funding due to a perceived lack of impact from their research (summative judgement).
- *It is specifically aimed at being useful for decision-makers*: By looking at how programmes work, a body of knowledge can be built up on theory of which programmes or programme components work and in which context. This allows policymakers (or funders of research) to understand whether a programme that worked in a certain context will work in a next, or how to produce a similar result (Marchal *et al.*, 2012; Pawson & Tilley, 1997).

The question that emerges then is why not make use of realist evaluation to assess the SoIR? Realist evaluation as discussed in Chapter 4 is built on the concept of creating CMO configurations that constitute small hypotheses (theories) of how a programme works (Pawson & Tilley, 1997). These are tested in evaluations and refined. In this way, CMOs are built on theory and create theory. Research however generally does not work in the same way as programmes. Research impact is an iterative process where impact can take place by coincidence, or involves external stakeholders as much as the activities done by researchers (Spaapen *et al.*, 2011). It is partially due to this that realist evaluation cannot overcome attribution in the open world system of research, struggles with temporality since it is unclear when impact is expected, and does not address the lack of expertise on impact needed by stakeholders (Spaapen & Van Drooge, 2011). Research follows the scientific process and researchers are mostly experts in their respective fields, not in impact. In research, it is accepted that its impact will be effected (in part) by external non-programme or research project 'stakeholders'. This takes place beyond the 'programme'.

SIAMPI claims that it can in part overcome attribution and replace it with contribution. In doing so, it can circumvent obstacles to assessing SoIR, which realist evaluation cannot overcome. By shifting the focus of research impact assessment from final impact to the research itself, SIAMPI can overcome temporality, and the lack of expertise is no longer a problem, as productive interactions do not require a theory on why research had an impact prior to identifying the interactions. SIAMPI can understand the process of research impact creation, whereas realist evaluation requires an understanding of how research creates impact to develop CMO confiugrations. It is claimed that SIAMPI, through productive interactions, might result in the identification of interactions, or groups of interactions, that can 'project' future impact (De Jong *et al.*, 2014; Van den Akker & Spaapen, 2017).

This does not mean that realist evaluation should be discounted. Realist evaluation might not be able to overcome the challenges posed by assessing the SoIR, but it has numerous aspects that make it well matched with the current dissertation, even as a possible 'evaluation home' for SIAMPI.

The current research wanted to explore the hypothesis that SIAMPI and its productive interactions are compatible with realist evaluation. It might be possible to use SIAMPI as a method within realist evaluation. Even though realist evaluation is a method-neutral approach, the use of theories of change (the tool not the approach) and logic models have become common practice, or often used tools for many who follow the approach. It is not the aim of the current research to do a realist evaluation with SIAMPI included, but rather to determine whether it would be feasible. Regarding realist evaluation in the dissertation, the focus is on understanding the *assessment* of SoIR in realist terms (importance of context, mechanisms and building theory). The method-neutral approach of realist evaluation would be able to accommodate the inclusion of SIAMPI. The current research made use of SIAMPI with the assumption that:

- The SIAMPI approach would be able to identify productive interactions (Van den Akker & Spaapen, 2017; De Jong *et al.*, 2014);

- if the productive interactions show impact at different stages of the research process, theories of change could be built for the case study research projects based on the interactions; and
- the theories of change could be useful in identifying impact pathways.

If SIAMPI is able to identify research interactions that can be used in theories of change **(Phase 1)**, SIAMPI could be used in *ex post* assessments to identify theories of SoIR. The use of theories of change provides a way to visualise what is captured by productive interactions **(Phase 2)**. This theory can then be used to build CMOs for research. The current research did not make use of the theory of change approach, another evaluation approach within theory-based evaluation, but only of theories of change as a tool (as discussed earlier) (Blamey & Mackenzie, 2007; Mountain, n.d.). The use of productive interactions to construct theories of change from which impact pathways can be identified would indicate that SIAMPI could be used within a realist evaluation, exchanging the original development of theory within realist evaluation with the 'self-building' theory that emerges from the SIAMPI productive interactions.

Even with the use of SIAMPI to construct the theories of change, the lack of a single accepted definition of impact means that it is hard to understand to what extent the SoIR is explored through the use of SIAMPI and theories of change. Due to different stakeholders of research operating in different contexts, their understanding of what impact is may differ. Since there is no single definition of what SoIR is, it can be many different things for many different organisations or people.

Impact literacy provides a broader concept of research impact that is useful in this regard **(Phase 3)**. Impact literacy looks at impact in terms of who is producing what and how it is done (Bayley & Phipps, 2017). When looking at the research process through the lens of impact literacy it becomes clear that productive interactions (with theories of change and impact pathways) mainly show how the research process unfolds and who is involved in this process, particularly as seen from a research perspective. Research impact takes place as a process during which there are numerous possible impacts.

The theories of change cover the 'how' research impact takes place, 'who' is involved and mostly 'what' is close in time and space to the research. What is lacking is a focus on the 'what' of impact literacy further removed from the research process, especially in terms of what funders of research view as impact. Since the current research also looked at the research process from the point of view of funders in that it wanted to understand how to assess research impact, understanding what funders view as research impact was critical.

4.8 Conclusion

The SIAMPI approach and realist evaluation hold a process-oriented view of how impact is achieved. SIAMPI shows how this impact is effected during (and after) research through its focus on impact mechanisms, which it calls 'productive interactions'. The novel use by SIAMPI of productive interactions has the ability to overcome some of the obstacles that have hindered the further development of SoIR assessment methods. Realist evaluation has its own impact mechanisms through which it looks at impact, namely CMO configurations. Just like SIAMPI, realist evaluation expands the focus of evaluation from summative judgements to formative assessments that allow for the improvement of programmes or research in terms of understanding how to optimise or increase societal impact. SIAMPI moves away from the summative judgements of research assessment, while realist evaluation accommodates both. Realist evaluation is a more established approach than SIAMPI and the way that it has been implemented as a method-neutral approach but with many similarities to SIAMPI means that it could be an important source for any study exploring the further use of SIAMPI and productive interactions.

One of the tools used in many realist evaluations is theories of change that make the causative theory of an intervention explicit, creating a larger framework within which to understand impact mechanisms. PIPA takes it one step further and includes the future networks needed to push research after it has been completed, to effect longer-term impacts. This places the researcher as one role player amongst many stakeholders who make use of their different types of expertise to translate the research and make it relevant to their contexts. Finally, impact literacy expands on the understanding of impact presented by SIAMPI and realist evaluation by exploring the concept of impact and its 'essential elements'. Impact literacy can show what is missing in a specific understanding of impact, and explains how the absence of an element of impact leads to near predictable outcomes.

The next chapter provides a detailed account of how the current research was undertaken, relying on the four conceptual underpinnings presented in this chapter.

Chapter 5

Research design and methodology

5.1 Introduction

The current research followed an exploratory sequential mixed methods design, comprising three phases. The first two phases used data collection methods typically associated with qualitative research, and the third phase relied on quantitative data collection. In the first phase of the research, four agricultural research projects were selected as case studies – two Winetech-funded and two Hortgro-funded. As part of the case study execution, semi-structured interviews were conducted with the primary investigators and other project stakeholders in order to identify productive interactions and impacts. Project-specific documents were also used to identify productive interactions.

The second phase of the research involved the development of a theory of change for each of the four projects selected as case studies. The theories of change were built from the productive interactions and impacts that were collected (and also appropriately coded) in the first phase of the research. From the theories of change, different impact pathways were identified. Follow-up semi-structured interviews with the primary investigators of the research projects were used to validate the accuracy of the theories of change and to explore the impact pathways further.

The third phase of the research made use of the theories of change developed in the second phase, coupled with the concept of impact literacy, to explore the understanding (comprehension) of SoIR among research funders. A survey was used for this purpose, which incorporated insights from a classification scheme of impacts specifically developed for this study.

5.2 A mixed methods approach

A mixed methods approach refers to the use of both qualitative and quantitative research in a single study, drawing on methodological approaches from both the qualitative and quantitative realms (Bryman, 2012; Jupp, 2006). The benefits associated with a mixed methods design are multiple:

- *Triangulation*: Using both qualitative and quantitative approaches enables the use of additional research strategies for cross-checking results (e.g. in-depth interviews together with surveys).
- *Offset*: Both qualitative or a quantitative methods have strengths and weaknesses, which can be overcome by each other.
- *Completeness*: Including both qualitative and quantitative methods allows the research to explore a research topic from more angles, thereby providing additional insight.
- *Unexpected results*: Mixed methods allow research to alternate between the different methods as required by the data needed for a project. It is not always possible to know which results will be produced by a study. Unexpected results might be better understood through a qualitative or a quantitative approach. With mixed methods, a study is not tied in terms of which methods to select.
- *Instrument development*: Using both qualitative and quantitative research methods can assist in the development of better research instruments. Qualitative research could, for example, produce knowledge-in-context that can be used to inform the development of quantitative survey instruments.
- *Confirm and discover*: Mixed methods research can allow for the use of a quantitative follow-up study to explore data produced by qualitative research, providing deeper insight of results in an applicable research project (Bryman, 2012:635–647).

The research implemented an exploratory sequential mixed methods design (Creswell & Plano-Clark, 2011:71). An exploratory sequential design first collects and analyses data qualitatively, followed by quantitative data collection and analyses (Creswell & Plano-Clark, 2011; Jupp, 2006). In the current study, the first two phases made use of qualitative data collection, followed by a third phase making use of quantitative data collection. The three phases were aligned with the three sets of research questions. Table 5.1 on the following page provides an overview of the three phases. The remainder of the chapter discusses each phase with its various steps in the same chronological order as outlined in Table 5.1.

Table 5.1 Outline of the steps of the three research phases

Phase	Step	Explanation
Phase 1 – productive interactions *Research questions 1 and 2 (addressing research objective 1)*	Step 1.1 – project identification	Four research projects were selected as case studies.
	Step 1.2 – first round of data collection	In-depth semi-structured interviews were conducted with researchers and other stakeholders. Research project documentation was also collected. The interviews and documents provided the data from which to identify (productive) interactions[9].
	Step 1.3 – data analysis	The interview and documentation data were coded in ATLAS.ti to identify (productive) interactions and other forms of impact.
Phase 2 – theories of change *Research questions 3 and 4 (addressing research objective 2)*	Step 2.1 – creation of unique (productive) interactions	For each project, the identified (productive) interactions were grouped into unique interactions.
	Step 2.2 – construction of theories of change	Theories of change were built by relying on codes for (productive) interactions and impacts.
	Step 2.3 – identification of impact pathways	Impact pathways were identified in the theories of change.
	Step 2.4 – second round of data collection	Follow-up interviews were conducted with the principle investigators of the case studies.
	Step 2.5 – validation of the theories of change and impact pathways	The interviews (from step 2.4) were used to validate (and adjust) the theories of change and the impact pathways.
	Step 2.6 – application of the logic of CMO configurations to case studies	The logic of CMO configurations from realist evaluation were applied to examples from the case studies (discussion of which is accommodated in Chapter 8, where the results of the research are discussed).
Phase 3 – impact literacy *Research questions 5 and 6 (addressing research objective 3)*	Step 3.1 – development of impact classification scheme	A classification scheme of research impact was conceptualised and developed, according to which the funders' understanding of impact could be assessed by means of a survey.
	Step 3.2 – building the funders' survey	The survey was built making use of the classification scheme of research impact and further insights from the concept of impact literacy.
	Step 3.3 – third round of data collection	A survey was conducted of Winetech and Hortgro expert committee members (those responsible for funding decisions), which provided evidence about 'what' they view as research impact.
	Step 3.4 – data analysis	The responses to the closed questions were analysed quantitatively and mapped onto the classification scheme. The responses to the open questions were coded.
	Step 3.5 – fine-tuning of the classification scheme	The impacts identified in the four projects (step 1.3) were compared with the impact expectations of the funders (step 3.4). The classification scheme was also developed into a framework of the SoIR, to be used in future studies.

[9] Please see 5.4.1 for a discussion on the productive nature of productive interactions. Till 5.4.1 all interactions are referred to as productive interactions, however, in reality, until proven productive, interactions remain research interactions at most.

5.3 Phase 1 – productive interactions

The first phase of the research focussed on identifying productive interactions in four case studies of completed research projects in agricultural research. Data collection was mainly undertaken through in-depth face-to-face interviews with the primary investigators of the projects, other researchers on the projects, and stakeholders. Possible stakeholders during the interviews were limited to research participants and funders (representatives from funders), in other words, individuals who took part in the research either as research participants or as representatives of the funding organisations (commodity companies) who supported the research. The interview schedules were built on examples provided by the SIAMPI approach (Appendices 1 and 2). Additionally, project documentation was collected for analysis. The research projects were selected by the two commodity organisations: Winetech, working in the wine industry, and Hortgro, working in the deciduous fruit industry.

5.3.1 Step 1.1 – project identification

In the first step of the research, four agricultural research projects were selected as case studies.

5.3.1.1 Case study approach

The research made use of four case studies of agricultural research projects. Case study research is used to explore single cases, such as locations, people and organisations, or research projects in this study, in detail (Donovan, 2008). Although case studies do not lend themselves to generalisation, the aim of case studies is not to generalise their findings to larger populations, but rather to focus on the more nuanced details and to examine single cases in depth. From these examinations, the research can then engage in theoretical analysis (Bryman, 2012). Case studies are useful in understanding a phenomenon as an integrated whole or when the analysis of data is related to a case over time, for example as with a research project in an open world system (Anderson, Crabtree, Steele & McDaniel, 2005).

A case study-based approach was selected based on the above reasons and since it is also proposed by the SIAMPI approach. As Spaapen and Van Drooge state (2011:8) with reference to their SIAMPI project:

> *The case studies were not comparative but exploratory. That is, we wanted to find out what the pros and cons are of our approach of social impact through productive interactions, and also to see what the role is of other actors in the social network around a research project.*

The SIAMPI project made use of case studies because it needed to identify different interactions in context(s), forming part of the narrative of research projects. According to SIAMPI, case studies used in research on productive interactions are not seen as ideal types of how impact takes place or what the productive interactions are in a field, but rather as a backdrop that illustrates the contexts in which productive interactions take place (Spaapen *et al.*, 2011).

Additionally the exploratory nature of the current research lent itself to a case study approach, given the need to trace (retrospectively) the four research projects over time. Case studies focus on *how* and *why* the SoIR (as an example) works in certain research projects and not only on *who* had benefitted at which level from the research (Yin, 2009:10–11). The scope allowed by a case study goes beyond anything that can be delivered by other instruments such as surveys. Finally, the nature of the enquiry, that is, trying to capture the productive interactions of research, meant that multiple sources of evidence were considered, which could be accommodated within case studies (Yin, 2009).

5.3.1.2 Case study selection criteria

The two commodity companies selected within the agricultural sector were identified based on mostly practical criteria:

- Access of commodity companies was taken into account, with a focus on commodity companies that were in the geographic vicinity of the author of this research, preferably in Stellenbosch.
- To further ensure access, the research focussed on commodity companies with a working relationship with Stellenbosch University. For instance, 36 of 116 Hortgro projects in 2016–2017 were housed at Stellenbosch University (Hortgro Science, 2018). Similarly, the Institute for Wine Biotechnology and the Department of Viticulture and Oenology at Stellenbosch University were identified as two of Winetech most important research partners in 2016 (Winetech, 2017).

Beyond logistical considerations, the research considered two additional aspects:

- the diversity of the agricultural sectors in which the commodity companies operated (wine and deciduous fruit); and
- the importance of the industry supported by the commodity company. The focus was on commodity companies in economically important SA agricultural industries. This was taken into account to try to ensure the relevance of the current research.

Based on the above criteria, Hortgro and Winetech, the commodity companies discussed in Chapter 3, were selected. The researcher had conversations with the management of both organisations for initial introductions and a discussion on what the research project would entail.

The management of the commodity companies were asked to identify two projects each, for use in the research. The selection criteria for projects were:

- The project had to have been completed, with the ideal completion date falling in the years 2010–2013. The reason for specifying 2013 as the upper limit was that the current research commenced in 2016, meaning that about two years had to be allowed for interactions to turn productive and for impacts – as defined by SIAMPI – to manifest. Moreover, projects completed between 2010 and 2013 would all still be recent enough that interviewees and respondents would remember most of the details of the projects.
- The project had to be selected based on ease of access to project data. These criteria were included so that projects on sensitive topics with protected results would be excluded.
- The project had to be selected based on ease of access to researchers and stakeholders. The commodity companies were asked to select cases with researchers who would be willing to take part in the research, reducing the risk of being refused.
- Projects had to be seen as successes. It was argued that projects seen as a success by commodity companies would most likely have had the impacts that these organisations want from research – either already in the short term or anticipated and promising impacts in the long term. Since productive interactions form part of the impact-effecting process, the presence of impact would allow for easier identification of these interactions.

In response to the above request, Hortgro provided three projects and Winetech two. Two of the three Hortgro projects were very similar with machines being tested in both, so a selection could be made based on the above criteria.

The four projects that were selected are summarised in Table 5.2 on the following page. The documentation received on the projects included original funding applications, published articles, final reports and progress reports.

Table 5.2 Summary of case studies

Project number	Abbreviated project name	Commodity company (funder)	Summary	Time frame	Funding bracket
Project 1	Oxidisation	Winetech	• Focus: This project explored the effect of oxidisation on SA wines. It looked at oxidisation along the entire winemaking chain. • Potential impact: It was expected at the start of the project that the information generated by the study could inform winemakers on sensory characteristics of wine depending on the level of certain compounds in the wine.	2 years (2012–2013)	R200 000–R300 000 (€12 700–€19 000)
Project 2	Esca disease	Winetech	• Focus: This project looked at the occurrence of Esca, a type of vine disease, in SA vineyards. • Potential impact: The impact of the study was foreseen as identifying the organisms that cause Esca and developing potential control strategies for the disease.	4 years (2009–2013)	R500 000 + (€31 800+)
Project 3	Mechanical thinning	Hortgro	• Focus: This project tested the use of a mechanical thinning machine. A thinning machine removes buds or flowers from a fruit tree to achieve optimal health and fruit growth of the tree. • Potential impact: The results of the research were foreseen to contribute to a better understanding of how SA orchards can be adapted to mechanisation.	2 years (2011–2013)	R200 000–R300 000 (€12 700–€19 000)
Project 4	Forelle pears	Hortgro	• Focus: The Forelle pear project explored how a 'commercial product' (brand name removed) could be used to treat SA Forelle pears in preparation for export to Europe. [Commecrial product] is a product that is used to treat fruit and prevent them from ripening further. In the past, it was mainly used on apples. • Potential impact: The aim of the research was to shorten the time it took to get Forelle pears to market while maintaining an optimal eating quality of the fruit.	3 years (2011–2013)	R500 000 + (€31 800+)

Source: Compiled by author based on data provided by Winetech and Hortgro. Euro amounts are rounded to the nearest 100 and based on an exchange of R15.75 per euro at the time of writing.

5.3.2 Step 1.2 – first round of data collection

The main focus of SIAMPI is to gain a better understanding of research impact through productive interactions. Information on productive interactions is collected through interviews and document analysis, of which both were executed in the current study.

5.3.2.1 Identifying interviewees

After the case studies had been identified, the researcher analysed and summarised the project documentation to identify relevant stakeholders for each project. This process included analyses of the documentation provided, but also web-based research to familiarise the researcher with the different stakeholders, their institutions and affiliates, the projects within which the commodity companies engaged, their structures, and any other contextual information. The principal researchers for the case study projects were identified for the first face-to-face in-depth interviews.

5.3.2.2 Developing the interview schedules

Interview schedules were based on those proposed by Spaapen and Van Drooge (2011:25–26). According to SIAMPI, the main purposes of the interviews are to:

- identify types of interactions between researchers and other stakeholders;
- identify productive interactions, where the stakeholders have attempted to make use of research findings;
- identify some results (possibly even measure these) on the effects of productive interactions; and
- find possible cases where stakeholders provided feedback into the research process, for example by defining or co-defining research questions (Spaapen *et al.*, 2011:24).

SIAMPI presents two different interview schedules, one for researchers (Spaapen *et al.*, 2011) and one for beneficiaries (Spaapen *et al.*, 2011:26). The schedules are similar in layout, with four categories in which questions are asked:

- Background/context questions: These questions focus on the researcher or stakeholder with whom the interview is being held, and on his or her background and context (not to be confused with the next point).
- Context: This section explores the context in which research takes place according to the interviewee. It mainly focusses on the most important actors in the uptake and/or impact of research.

- Mechanisms of interaction: This section focusses on the identification of productive interactions according to the three types of interaction (direct, indirect, and material).
- Outcome and/or impacts: Finally, the last section looks at possible impacts, the monitoring or evaluation of these impacts and any other research effects not captured in the previous parts of the interview where the focus was on productive interactions.

The current research used the same question categories as above, but adapted the 'researcher' and 'beneficiary' interviews provided by SIAMPI. The beneficiary interview schedule was used as the base for a 'stakeholder interview schedule'. The changes were made mainly since 'beneficiary' is a loaded term as it assumes a unidirectional flow of research, which seems to support a deficit model view of the flow of research. Any individual involved in the case study projects, including through benefitting from the research, but not actively involved as a researcher, was classified as a stakeholder (Spaapen & Van Drooge, 2011:25–26). There might also have been an oversight in the SIAMPI report, with the possible intention to have a researcher and stakeholder interview schedule as set out above since these terms are used in the quote below from the co-developers of SIAMPI:

> *When interactions exist, it is in most cases the researchers who will identify potential stakeholders for further interviews. We are therefore applying a "snowballing" technique with two different sets of questionnaires: one for researchers, another one for stakeholders* (Spaapen *et al.*, 2011:27).

The changes made to the original SIAMPI schedules were minimal, and mainly involved adding the case study project names to projects, or adding the specific industry in which the research took place to questions.

5.3.2.3 Undertaking the interviews

Similar to the suggestion made by the quote above, the current study started by first interviewing the primary investigators for each project, thereafter making use of snowballing to identify additional important interviewees. Snowballing refers to the practice of engaging interviewees in terms of additional possible interviewees to approach, for example individuals they feel were important to the research for any number of reasons and who would be important to include in the study (Bryman, 2012:426).

The interviews were semi-structured. The research needed to gather information on productive interactions that occurred during the research process. This meant that there were set parameters of what was relevant and what was not relevant for the current study. However, it was not clear where productive interactions would be found. It was not possible or desirable to try to anticipate all the possible responses. The 'stories' or narrative descriptions of their project by the interviewees provided information on productive interactions that could not have been foreseen. This meant that the semi-structured interview schedules were most suitable due to their open-ended nature in allowing interviewees to answer questions as they saw fit (Gubrium *et al.*, 2012:197; Singleton & Straits, 2010). Interviewees were encouraged to share insights and opinions, allowing them to divert from the prepared interview schedule. All the interview questions were answered in all the interviews.

In total, 15 interviews were successfully completed (Table 5.3). Four individuals were interviewed in each of three case studies (except in Project 3 where an interviewee [P4.2] withdrew). These included the primary investigator, an additional researcher that worked on each of the projects, and two stakeholders.

Table 5.3 Interviewees of first round of data collection

	Code	Role in project	Organisation at time of project
Project 1	P1.1	Principle investigator	Stellenbosch University
	P1.2	Student researcher	Stellenbosch University
	P1.3	Research participant	Wine estate
	P1.4	Co-researcher and co-supervisor of P1.2	Other university (international)
Project 2	P2.1	Principle investigator / co-supervisor	Research performing science council
	P2.2	Student researcher	Stellenbosch University
	P2.3	Research participant	Private company
	P2.4	Research participant	Extension organisation
Project 3	P3.1	Principle investigator	Stellenbosch University
	P3.2	Student researcher	Stellenbosch University
	P3.3	Research participant	Private company
	P3.4	Research participant	Private company
Project 4	P4.1	Principle investigator	Private research organisation
	P4.2	Researcher (withdrew)	Private research organisation
	P4.3	Funder representative	Commodity company
	P4.4	Research participant	Industry representative body

It quickly became clear that the ratio of two researchers and two stakeholders per project was sufficient to reach saturation of responses. This was similar to what was found by the original SIAMPI research project (Spaapen *et al.*, 2011).

The interviews were conducted face-to-face as this allowed the interviewer to adjust questions to convey the meaning better. When discussing research impact interviewees could understandably begin to talk about outputs and their ideas on what their research had achieved (based on comments made by all the primary investigators, this is what they have come to expect from impact evaluations).

With productive interactions, the focus is however mainly on what the researchers did during the research project (although their actions before and after the research are also important) and interviewees had to be 'nudged' back to talking about the research process (from which productive interactions could be identified). The rapport that could be built with face-to-face interviews possibly also helped to reduce the stress of interviewees who feared that they were being evaluated. Since the interviews tended to be around an hour long, semi-structured face-to-face interviews also helped to frame the interviews as conversations rather than pure data gathering, which might h ave felt tedious (Singleton & Straits, 2010).

Where circumstances did not allow face-to-face interviews, interviews were conducted telephonically. One researcher interviewed was based in Europe, necessitating a telephonic interview. Five of the remaining interviews were conducted telephonically as these stakeholders found it easier to schedule a telephonic interview than a face-to-face interview due to time constraints.

5.3.2.4 Challenges experienced in the interview process

It proved harder than expected to organise the required interviews, with interviewees often agreeing to be interviewed, but then stalling on setting a date for the interview to take place. At the start of the interviews, interviewees often described a fear of 'not knowing the answers' of what will be asked in the interview. This never proved to be the case when actually conducting the interviews. The research expected some resistance, but requests for interviews made it clear that the research was not an evaluation. The researchers interviewed however often associated 'research impact' with evaluation. On arrival, the interviewees would provide stacks of articles and other 'proofs of impact' or discuss in breadth how many articles they still plan to publish from the respective projects. It is probably not possible to mitigate this misunderstanding or fear as it seems to be common with evaluations or research related to evaluation.

An additional reason for the difficulty in organising interviews might have been the methodology of aiming at high-impact case studies. This meant that the researchers were often leaders in their fields (nationally and even internationally) with very little time available between research, students and travelling, which they could set aside for interviews.

It should be noted that the SIAMPI method further proposes the use of focus groups to explore the role of stakeholders in the research process from which productive interactions can be identified (see Spaapen *et al.,* 2011). This is however not a central focus for SIAMPI, and interviews are used in conjunction with focus groups to look at stakeholders. If used, the aim of focus groups in the current research would have been to bring together a cross-section of the study population. It would however not have been feasible to use focus groups. Even though the current research was supported by the different funders of the four projects, and these funders were mostly the main funders of the different researchers (which incentivised researchers to participate), co-operation from researchers and stakeholders was not always forthcoming. It took months to organise the interviews since interviewees were hard pushed to provide dates and times for the interviews.

Due to the difficulty of organising the interviews, it was foreseen that it would not be possible to bring the stakeholders and researchers together in focus groups. The fear of the evaluation process experienced by researchers (as seen during the interviews) would probably also have made frank discussions in the focus groups rather difficult, as the researchers might have felt that they had to satisfy the funders present (Arksey & Knight, 1999).

5.3.3 Step 1.3 – data analysis

The interviews were transcribed and loaded onto ATLAS.ti. The various documents that had been collected were scanned (where needed) and also loaded onto ATLAS.ti. These included, among other documents, research articles published following the projects, final project reports, images of websites with information on the projects, newspaper articles, information sheets found on the websites of the commodity companies who funded the projects, and information sheets provided by interviewees during face-to-face interviews. These sources were included to ensure that as many as possible productive interactions could be captured, and to allow for the corroboration of data from different sources. Other than scrutinising the websites of the commodity companies, general web-based searches were also performed. Physical reports from the different commodity companies were also collected and analysed.

5.3.3.1 Coding categories for productive interactions

Coding was based on the productive interaction categories of the SIAMPI approach, namely direct, indirect and material interactions. Tables 5.4–5.6 (direct, indirect and material interactions) provide a detailed list of the various productive interaction codes, along with an example of each code and the source from which it was coded.

The first code name on Table 5.4 is "PI – Direct – Funder/External stakeholder – Present results".

- PI refers to the fact that the code is a 'productive interaction';
- secondly, it is direct;
- thirdly, it identifies between whom the interaction is taking place. In this case, it was between a funder and external stakeholder; and
- the last part of the code indicates to what the interaction of the code relates.

With this code, a funder of the research project from where the code was identified, engaged with an external stakeholder and presented the results of the research project to them.

Table 5.4 Direct productive interaction coding categories and examples

Code groups	Code	Example	Source of data
PI – Direct	PI – Direct – Funder/External stakeholder – Present results	"We've spoken to them. We've actually been there and we told them what to do because if they do this protocol they will be even later than they are now." [Funder on presenting research to competitors]	Interview P4.3
PI – Direct	PI – Direct – Co-authors (external, not from project) – Co-author joint academic publications	Lists of author names in articles related to the research project where non-project researcher names also appear	Final reports or academic articles
PI – Direct	PI – Direct – Researcher – Conferences/Workshops/ Poster[10]	"I think I've spoken about it in a couple of, two or three international conferences."	Interview P4.1
PI – Direct	PI – Direct – Researcher/External researcher – Join/Continue research project	"Not really a co-supervisor, more like a co-worker. […] First, like I said, he is the expert on the topic. […] And this guy he helped with the identification of the stuff [fungi]. Because it is very specialised work." [Translated from Afrikaans]	Interview P2.2
PI – Direct	PI – Direct – Researcher/External researcher – Sharing expertise	"Anyone closer to Australia … where she has been exposed also to other researchers … and other … environments. She was interested in another family of molecules … and diets	Interview P1.4

[10] Please note that this code should have been called PI – Direct – Researcher/External researcher – Conferences/Workshops/Poster or "External researcher" could be replaced by "Academic audience". However, since the audience was not the same for all quotes, the audience is excluded.

Code groups	Code	Example	Source of data
		… which are [also] important.”	
PI – Direct	PI – Direct – Researcher/External researcher – Sharing facilities	“Yes … he was here [external researcher] … almost once a year at one stage. And … we also went to him a few times. […] Like microscopy and … we did DNA extraction there once or twice … Sequencing …” [Translated from Afrikaans]	Interview P2.2
PI – Direct	PI – Direct – Researcher/Funder – Present progress reports	Example: Progress Report 2011/2012	P3_Document_Information Sheet 03
PI – Direct	PI – Direct – Researcher/Industry – Answering queries	“Another thing that’s hard to quantify is the number of calls you get about it.” [Translated from Afrikaans]	Interview P3.1
PI – Direct	PI – Direct – Researcher/Industry – Information days – Sharing information	Mechanical thinning of stone fruit (Hortgro Science technical symposium 2012).	P3_Document_Final Report_01
PI – Direct	PI – Direct – Researcher/Industry – Joint research engagement	“I mean [P4.1] nearly had a heart attack when people said they wanted to do this.” [Industry wanted to expand the trials P4.1 was doing exponentially]	Interview P4.3
PI – Direct	PI – Direct – Researcher/Potential stakeholders – Interest in research process	“It is probably still one of the trials for which there was the most interest, out of all the trails I have done.” [Translated from Afrikaans]	Interview P3.1
PI – Direct	PI – Direct – Researcher/Research participant – Feedback on research	Market feedback was also received via correspondence from SA exporters and their offshore clients.	P4_Document_Information Sheet_07
PI – Direct	PI – Direct – Researcher/Research participants – Take part in research	“Indirectly, yes … obviously, some information in there would have come from us. But it would have been … but it would have been … let's say re-written by them in a way that they wanted it.” [Research participant on his contribution to the research outputs]	Interview P3.4
PI – Direct	PI – Direct – Researcher/Stakeholder – Help conceptualise research	“No, not quite, but what we did do was talk to them to see what realistic levels of oxygen were in wine.” [Translated from Afrikaans]	Interview P1.1
PI – Direct	PI – Direct – Researcher/Stakeholders – Thesis defence	“The thesis defence of his … what he did … yes … I got a copy of his thesis.” [Translated from Afrikaans]	Interview P3.3
PI – Direct	PI – Direct – Researcher/Student – Student builds on research	“Yes, definitely. My student is currently busy with it, so the first thing is, I started the project when I worked there last year and my student basically took it over when I left.” [Translated from Afrikaans]	Interview P1.2

Code groups	Code	Example	Source of data
PI – Direct	PI – Direct – Researcher – Industry/Consumer – Product to market	Five containers of Forelle were successfully exported to the United Kingdom and the Continent and samples were assessed for consumer preference.	P4_Document_Final Report_01
PI – Direct	PI – Direct – Student/Co-supervisors – Act of supervision	Co-supervisor: Prof. [P1.4]	P1_Document_Thesis_01
PI – Direct	PI – Direct – Supervisor/PhD (or student) – Access to funding	"No, it's a package, it is like, here … We have a project for you, and it is funded." [Translated from Afrikaans]	Interview P2.2
PI – Direct	PI – Direct – Supervisor/PhD (or student) – Conceptualising research	"So it was sometime in August that we started the trials and then the student came on board in January." [Translated from Afrikaans]	Interview P3.1
PI – Direct	PI – Direct – Supervisor/PhD (or student) – Exposure to field/topic	"I have to say when I started my master's, I was given a lot of guidance. See, by that time [P1.1] had already applied for funding for projects." [Translated from Afrikaans]	Interview P1.2
PI – Direct	PI – Direct – Supervisor/PhD (or student) – Network(ing) building	Interviewer: "Did you know about [P1.2] before she started this PhD with you?" Interviewee: "No … I was not … no, no."	Interview P1.4
PI – Direct	PI – Direct – Supervisor/PhD (or student) – Productivity push	"I would say, it is definitely [P1.1], give him credit for the pressure that he put one me as my supervisor. He pushes quite hard. You have to publish, you have to speak at conferences, you must make posters …" [Translated from Afrikaans]	Interview P1.2

Table 5.5 Indirect productive interaction coding categories and examples

Code groups	Code	Example	Source of data
PI – Indirect	PI – Indirect – Online direct request – Information sharing	"Google Scholar and so on, you don't really have a choice but to see what happens to your stuff." [Referring to people using her research] [Translated from Afrikaans]	Interview P2.2
PI – Indirect	PI – Indirect – Publication of PhD (or master's)	"I got a PhD …" [Translated from Afrikaans]	Interview P2.2
PI – Indirect	PI – Indirect – Radio/Television	"And in the past Radio Elsenburg was quite a platform. So, it is broadcast on RSG [an SA radio station]. And I did it." [Translated from Afrikaans]	Interview P2.1
PI – Indirect	PI – Indirect – Researcher – Academic publications	"Yes, so we had, how do you call it, five peer-reviewed articles that we got from it, and one article in a very good journal." [Translated from Afrikaans]	Interview P1.1
PI –	PI – Indirect – Researcher –	Popular paper in (name of the journal)	P3_Document_Fin

Indirect	Non-academic publication	on mechanical thinning with (thinning machine) on stone fruit (In process).	al Report_01
PI – Indirect	PI – Indirect – Researcher/Consumer – Marketing	"We had to find a way to actually market it. So there was stipulations that every box had to have this crisp and sweet so wherever the consumer looked they could actually see this and then they knew."	Interview P4.1
PI – Indirect	PI – Indirect – Researcher/Industry – Protocol	FEMA[11] fact file and protocols	P4_Website_01
PI – Indirect	PI – Indirect – Researcher/Research participant – Feedback on research	"We provided them with feedback. We gave the cellar that provided the wine an information sheet [on the research]." [Translated from Afrikaans]	Interview P1.1
PI – Indirect	PI – Indirect – Share/Load research online	"Mechanised Thinning – Research on Track – Mechanical Blossom Thinning" [Title on website of XX]	P3_Webstie_01
PI – Indirect	PI – Indirect – Stakeholder/Other stakeholder – Share research results	"I lot of people contacted me and I shared my experience with them." [Translated from Afrikaans]	Interview P3.3
PI – Indirect	PI – Indirect – Video	"So they [Hortgro] also made a video clip of the student using the machine and they put it on their website." [Translated from Afrikaans]	Interview P3.1

Table 5.6 Material productive interaction coding categories and examples

Code groups	Code	Example	Source of data
PI – Material[12]	PI – Material – External funder/Researcher – Bursary	"For my PhD, I only had NRF [National Research Foundation] funding. But I might be wrong … I can't really remember." [Translated from Afrikaans]	Interview P1.2
PI – Material	PI – Material – External provide lab facility/Office space	"She spent a lot of her time at the lab [at ARC]. And the same for [P2.2]. [P2.2] was based at Plant Pathology [Stellenbosch University], but she spent a lot of her time working [at ARC]." [Translated from Afrikaans]	Interview P2.1
PI – Material	PI – Material – External researcher/Researcher – Help pay for continuation of research	"He pays indirectly. He, for example, the last few times he came, he paid for his own plane tickets." [Translated from Afrikaans]	Interview P2.1

[11] Forelle early market access (FEMA)

[12] Please see Chapter 4 (4.2.1) for discussion on material interactions. Material interactions are by necessity also direct interactions.

PI – Material	PI – Material – Funder/Researcher – Assisted with networking/connections	"No, it was mainly funding and maybe market access you know, putting us in touch with the right people, that type of thing."	Interview P4.1
PI – Material	PI – Material – Funder/Researcher – Financial support	"We acknowledge financial support from Winetech […], the Technology and Human Resources for Industry Programme (THRIP) and National Research Foundation (NRF)."	P2_Document_Article Acadademic_05
PI – Material	PI – Material – Researcher/Farmer/Industry – Free products/Expertise	"At the annual Forelle producers association annual general meeting we have an economist, [Name], looking at the economies of Forelle, where it's doing well and where it's not doing well."	Interview P4.3
PI – Material	PI – Material – University/Student – Additional support	"And the guys from the university helped me." [Translated from Afrikaans]	Interview P3.2

It could rightfully be asked to what extent the interactions identified in Table 5.4 reflect productive interactions. The code discussed above (PI – Direct – Funder/External stakeholder – Present results) is strictly speaking only an example of an interaction. From the quote, it can be deduced that there was an interaction, however there is no indication of the external stakeholder reacting to the interaction. According to SIAMPI, an "interaction is productive when it leads to efforts by stakeholders to apply research results to social goals, i.e. when it induces behavioural change." (Spaapen *et al.*, 2011:2). It is possible that the interaction was productive; however, it would require additional research, which includes possibly interviewing the stakeholder, to determine whether they made use of the research that was shared with them.

Similarly, a code such as 'PI – Indirect – Radio/Television' only shows an example of an interaction. The researcher was interviewed on the radio. Although we can assume that, even though he might have managed to reach an audience that reacted to his research, there is no proof that this interaction was productive. In other interactions, the productive nature is however evident. In the code, 'PI – Direct – Researcher/Student – Student builds on research', a student has been influenced by the research of the project to do a new project related to the first project.

Material interactions again provide another element. SIAMPI views the funding of research or the providing of assistance to research as a productive interaction, presumably based on the fact that a funder has been influenced by the nature of the research to contribute (Spaapen *et al.*, 2011). However, funding of research does not fully fit into the idea of an interaction being productive when a "stakeholder applies research results to social goals" (Spaapen *et al.*, 2011:11).

The word 'productive' should therefore be read as implying 'possibly productive'. What was important to the current research was that these (the 'productive' interactions) are possible indicators of the process effecting research impact. All the identified interactions could lead to impact. It was never the intention of the current research to trace each interaction individually. The aim was to construct theories of change from the identified interactions (from here on again called 'productive' interactions), which is not affected by the proved or unproved productive nature of the interactions.

5.3.3.2 Coding categories for impact

The fourth category in both the SIAMPI researcher schedule (Spaapen *et al.*, 2011:2) and the beneficiary schedule (changed to 'stakeholder schedule' in the current research) (Spaapen *et al.*, 2011:26) are 'Outcome/Impacts'. Its aim is to identify possible impacts or outcomes that a stakeholder or researcher might have noticed from his or her research. These are mainly impacts and outcomes that do not reference interactions, or at least not specific interactions. The aim is not to track individual interactions and see whether they lead to impact but rather to look at the larger impact pathways. Table 5.7 provides the 'Impact' codes with examples for each that were identified from this interview category.

Table 5.7 Impact code categories and examples

Code groups	Code	Example	Source of data
Impact	Impact – Commercial value for industry	"And that fruit is just, they lose money because we know the Forelle producers are, they don't take any prisoners, you know, because they're protecting that brand and it's become a brand now, this FEMA fruit, so instead of just being a cultivar it's become a brand of pink lady or something." [Created brand power]	Interview P4.1
Impact	Impact – Created industry-relevant knowledge	"Well, I think the feedback that I've got is that there's been a tremendous positive acceptance of this outcome to the industry. And we've, in fact, visited a lot of […] exporters. […]. So they [are] very happy, everyone's very happy."	Interview P4.1
Impact	Impact – Expanded science	"The outputs of the project were very academic. It is like, unidentified things that are now identified. And now we know more about them in the cycle." [Translated from Afrikaans]	Interview P2.2
Impact	Impact – Influenced own future research	"And then we are using it in two follow-up projects. We are beginning to see very interesting results in the follow-up studies, which I think will indirectly have a much larger impact on winemakers, save money and that type of thing." [Translated from Afrikaans]	Interview P1.1
Impact	Impact – Leading to research/researche	"And then there are other outputs that I haven't been involved with. People like yourself have contacted us, [commercial company] has contacted us, you know."	Interview P4.1

	d by others		
Impact	Impact – Research institution – New equipment	"Meanwhile, we have now brought the analysis here and we can now do it here, which is really great and also indirectly a result of the project, where it was not actually an aim of the project." [Translated from Afrikaans]	Interview P1.1
Impact	Impact – Success unlocked funding	"Yes, quite a bit. I think this had a large impact on funding." [Translated from Afrikaans]	Interview P2.1
Impact	Impact researcher – Job/professional opportunity	"I have a student with P1.1 now, I am the co-supervisor. So we still have a lot of contact." [Translated from Afrikaans]	Interview P1.2
Impact	Impact researcher – Network expanded	"So … obviously in that time, we got to know each other a little bit better, but … ja, certainly … I would say our relationship is good, ja."	Interview P3.4
Impact	Impact researcher – Professional advantage	Interviewer: "And do you think it gave you any kind of advantage, compared to other people in your field, where you are now?" Interviewee: "Yes, I think so, yes, it definitely has." [Translated from Afrikaans]	Interview P1.2
Impact	Impact researcher – Skills development	"Yes, she has, it is actually hard, I was sorry to see her go, but yes, I do think it helped her [the research project], so that she managed to get a good position." [Translated from Afrikaans]	Interview P1.1

In the code 'Impact – Expanded science', the interviewee (P2.2) indicated that she believed the research had expanded the knowledge base. She referenced outputs, which are necessary to contribute to the academic literature, but she did not give enough information to identify an interaction that led to the change.

> Interviewee P2.2: *The outputs of the project were very academic. It is like, unidentified things that are now identified. And now we know more about them in the cycle.* [Translated from Afrikaans]

In another example, P1.1 was discussing P1.2. He said that the research project helped P1.2 to get a good job. Again it was not clear what exactly the *interaction* was that led to this, but rather, as in the first example, it seemed to be the project as a whole (the code is 'Impact researcher – Skills development').

> Interviewee P1.1: *Yes, she has, it is actually hard, I was sorry to see her go, but yes, I do think it helped her [the research project], so that she managed to get a good position.* [Translated from Afrikaans]

Productive interaction codes derived from the first three categories in the interview schedules (see again section 5.3.2.2) and focussed on interactions. Impact codes derived mainly from the fourth category of the interviews and focussed on impacts that stakeholders or researchers identified from the research projects.

It is possible that some quotes coded as 'impact' could also have been coded as 'productive interactions' and vice versa. This is however not a problem. The main aim of Phase 1 was to identify possible productive interactions, and the impact codes provided a safety net that allowed the collection of additional data. Codes were also cleaned. Moreover, as will be discussed in the section on Phase 2 of the research (see 5.4.1), 'impact codes' and 'productive interaction codes' were carefully assessed in the construction of the theories of change to ensure that all possible productive interactions were included.

5.3.3.3 Cleaning of codes

Once all the interview transcripts and documents had been coded, the data was exported to Microsoft Excel 6 and cleaned, specifically looking for any errors or possible repetition and uniformity of definitions of codes (based on what was included under each code) (Bryman, 2012:303). A number of codes were merged as a result.

5.3.4 Concluding comments on the first phase of the research

The most important output of the first phase of the research was a list of all the productive interactions captured in the four case study research projects, separated into the three categories of productive interactions for each project. The second important output that was captured was the 'impact codes' for impacts or effects of the research identified directly by the interviewees with weak or no references to identifiable interactions. Impact codes mainly provided data on effects of the research that could not be linked to an interaction easily or as a source of overlooked productive interactions, or of longer-term higher-level impacts.

5.4 Phase 2 – Theories of change

In the second phase of the research, the focus was on building theories of change from the productive interactions identified in the first phase. From these, impact pathways could be identified. Productive interactions organised into impact pathways can create a 'theory' of how research impact forms, and as mentioned earlier (see 4.4.1), could thus be used in the first phase of a realist evaluation (although doing such an evaluation was beyond the scope of the current research).

To build the theories of change, the researcher analysed the data on productive interactions and impact (as reflected in the coding codes) to identify the unique interactions present in each project. Semi-structured follow-up interviews were conducted with the primary investigators of each research project to verify the four research processes (these are the Conceptualisation-, Operationalisation-, Execution- and Post-research impact-effecting- phases of research, discussed in 5.4.2) as captured through the productive interactions in the theories of change and impact pathways.

5.4.1 Step 2.1 – creating unique (productive) interactions

The productive interactions captured in the first phase of the research included all instances where possible productive interactions were identified. This meant that the same interaction, for example the same conference presentation, could be counted more than once.

Interactions were captured by the type of interaction and not the unique instance of the interaction. 'Type' here does not refer to the classification of direct, indirect or material, but to the type of direct, indirect or material interaction. Examples could include a direct interaction through a telephone conversation between a researcher and research participant, or an indirect interaction where a stakeholder sees the researcher speaking on television (examples of the actual codes appear in Tables 5.4–5.6). It would arguably have been useful to identify only unique interactions as repetition of references to one interaction might provide an inaccurate picture of the data. This would not have been feasible however since it would require a new code for every unique interaction.

Additionally, knowing which interactions are captured by which data sources is crucial, irrespective of whether such interactions are unique. It shows which possible monitoring data are currently being captured in which data sources (for example in reports or articles or only in interviews).

Importantly, though, the coding did not prove to be an obstacle in the building of the theories of change. After being exported from ATLAS.ti and cleaned in Microsoft Excel 2016, the different productive interactions (and impact codes) for each of the projects were printed out. Non-unique references to interactions were manually organised into unique interactions. For example if there were two references to a presentation at a specific conference (continuing the conference example), these were assumed to refer to the same interaction.

Other quotations were more difficult. For example in 'PI – Material – Funder/Researcher – Financial support', which relates to a material productive interaction where a funder provided research funds to the researchers of the project. The quote below is from an academic article published by Project 2.

> *We acknowledge financial support from Winetech […], the Technology and Human Resources for Industry Programme (THRIP) and NRF* (P2_Document_Article Acadademic_05).

In the code, which relates to the funding by Winetech, it is clear that THRIP and the NRF provided additional funds. However, it is not clear how the funding was structured, whether the Winetech funding was provided for the same project as the NRF or THRIP funding, or what the possible different interactions were that led to the funding. For this reason, this quote and all other quotes referring to Winetech, NRF and THRIP funding for this project would be separated into three interactions: a material interaction that provided Winetech funding, a material interaction that provided THRIP funding, and a material interaction that provided NRF funding. This allowed the researcher to create lists of unique productive interactions for each project.

Once the unique productive interactions had been identified, these were scrutinised to determine whether the interactions could be organised into different phases of the research process. The interactions were copied to Microsoft Word and organised into a chronological narrative from which the phases of research could be identified.

An additional issue concerns the productive nature of 'productive' interactions. The current research is aware that the research interactions identified in the first phase of the research are only potentially productive interactions. Strictly speaking these should only be referred to as research interactions. A research interaction only becomes productive once it has been proven that some use has been made after the interaction to apply some aspect (for example new knowledge) gained from research. For this reason the term 'research interaction' is used in the results chapters (Chapter 6 and 7), when referring to potentially productive interactions. However, once these interactions are included in theories of change, which illustrates the use of and thus productive nature of the interactions, they are referred to as such (productive interactions).

5.4.2 Step 2.2 – construction of theories of change

What became apparent in the analysis of the productive interactions for each project was that the interactions, organised into a research narrative, formed logical groups related to specific time frames in the projects. These phases were similar to the ASIRPA 'steps on the (impact) pathway', but especially similar to phases 0 to 6 of the payback framework (Donovan & Hanney, 2011b; Joly *et al.*, 2015). According to PIPA, impact is effected by different groups of actors working together in different combinations at different times during the lifespan of the impact-effecting process of a research project (Alvarez *et al.*, 2010). The phases represent these different combinations.

The current research identified four main phases, which were the same for all the research projects (four since the intermediary formation phase, discussed below, is not counted as a time frame but only presented for clarity). The similarity to the payback framework is purely by chance, and rather than an issue, the current research viewed it as an early indication of the value of SIAMPI and productive interactions in that it seems to capture a comprehensive view of the research process.

The current research made use of theories of change as a tool. Whereas theories of change are usually built before a project takes place, in consultation between stakeholders, in the current research, the theories of change were built after the completion of the research projects. However, the process described was still constructed from the opinions and inputs of 'programme stakeholders' (project stakeholders). The study made use of completed projects to assist in understanding how to monitor future projects. It is worth mentioning again that the theories of change were seen as a visualisation of the entire research process or scope of the research projects. In contrast, the impact pathways identified within the theories of change were the linking together of different productive interactions contributing to a specific impact. The four phases are (five if counting the Execution phase):

Conceptualisation phase: during this phase, an actor, be it the researcher, funder or another stakeholder, identifies the problem that needs to be addressed (Donovan & Hanney, 2011). Additionally, an idea is formed about what is expected of the intended research. Generally, a project proposal can summarise what is decided in this phase. This phase seems to relate to Stage 0 of the payback framework, 'Topic or issue identification' (Donovan & Hanney, 2011:182). In terms of a theory of change, the conceptualisation phase would equate to the problem identification and goal setting elements in a theory of change (as presented in Figure 4.1 Simplified example of a theory of change).

Operationalisation or input phase: During the operationalisation phase, all the preparations for doing the actual intended research are put in place. Additional funding is secured, PhD candidates are recruited and co-supervisors are brought in. This phase could also be called the 'input phase', as it is similar to the 'Input phase' in the ASIRPA fictive impact pathway (Figure 2 in their article) (Joly *et al.*, 2015:447). This phase relates to Stage 1 of the payback framework, 'inputs to research' (Donovan & Hanney, 2011:182).

Execution phase: The execution phase is important as it shows how research takes place. It fits between the input and output phases of ASIRPA (Joly *et al.*, 2015). It captures the network for the time frame before research outputs are published (produced). This is similar to Stage 2 of the payback framework, 'Research process' (Donovan & Hanney, 2011:182). With regard to theories of change, the execution phase describes activities and the actors involved in these activities. The phase can also present short-term outcomes, which turn into longer-term outcomes in the 'Post-research impact-effecting phase'.

Intermediary formation phase: This phase is not a real phase but presents the reality that research has to be changed into another form for consumption, understanding and/or spreading. It is where the artefacts for later impact effecting are created and from where they 'flow out'. This phase includes the writing of academic articles, popular articles and PhD theses, or any other form of output. This phase can possibly be connected to the 'Intermediaries phase' of ASIRPA, or more directly to the Stage 3 of the payback framework, 'Primary outputs from research' (Donovan & Hanney, 2011:182).

Post-research impact-effecting phase: This phase is split into a 'near' and a 'distant' phase. During the **'near' phase**, the artefacts created during the research are engaged in productive interactions. Journals are read, videos are watched, and researchers attend conferences and give input at industry information days. All of this takes place in the 'near' section of the phase. The **'distant' phase** takes place further away from the researcher and the research, thus away or distant from productive interactions (not directly linked to the researchers). Where there is control on how the 'Near post-research network' is constructed, the 'Distant post-research network' is beyond the controlled environment of most research projects. What is interesting about the PIPA interpretation is that it also expands the work of research impact beyond just the researchers of a project and into this distant phase. In fact, an actor network in PIPA might not even have a researcher in the network after a certain point (Alvarez *et al.*, 2010; Douthwaite *et al.*, 2007). This part of the phase is included due to the realisation that research (or the researcher) is only a part of what is needed in the effecting of impact (as understood by PIPA). This is essential, but it is not all that is needed. More practically, in the current study, the codes used to construct the distant phase generally did not include productive interactions. Although there are productive interactions in the phase, the data were mainly captured through the *impact* codes.

No assumptions or additions were made beyond what was explicitly captured in the data by the productive interaction and impact codes. The theories of change were exclusively representations of what was captured through the productive interactions and impact codes. All the interactions and impacts included in the theories of change (presented in Chapter 6) are supported by one or more often numerous quotations.

5.4.3 Step 2.3 – identification of impact pathways

Impact pathways were identified from the theories of change by reflecting on the longer-term outputs of the different projects. These longer-term outputs or impacts were mainly captured by the impact codes and included in the 'Distant post-research network'. Although impact is not just a linear process and the different productive interactions indicate effects taking place all along the research process, the use of these larger impacts allows the research to see towards which bigger impacts each project built. An example of a longer-term impact could be capacity building. A person, trained during a project, is taken up by industry to work in a position that continues to benefit industry in a competitive way, for example through skills to which the industry did not have access before. The impact pathway is the identification of productive interactions that contributed to the skills development of that person.

5.4.4 Step 2.4 – second round of data collection

Although the theories of change were constructed from the data generated from project documentation and interviews, the research also engaged in follow-up interviews with the primary investigators of the case studies through semi-structured face-to-face interviews. In these interviews, the researchers could then provide comments and insights on both the theories of change and the impact pathways. The interviews were between 40 minutes and an hour long. The intention was to interview each of the investigators; however, the primary investigator for Project 2 had to withdraw due to an international exchange obligation. After completion, the interviews were transcribed to ease analysis of what was said.

The interviews consisted out of three sections:

- presentation and validation of the theories of change;
- presentation and validation of the traditional 'final impacts'; and
- exploration of the processes that led to the creation of impacts.

In the first part of the interviews, the interviewer presented the completed theories of change to the researchers. The interviewer discussed each of the different phases of the research. The interviewees were allowed to interrupt when they disagreed or where they wanted to provide clarity or additional detail. All the interviewees freely engaged with the interviewer during this part of the interviews. Generally, the theories of change proved resilient in that only minor changes had to be made. Some examples were the correcting of names where some interviewees had used outdated names for organisations, or in another case replacing 'Australia' with 'New Zealand' as the country of a study exchange.

In the second part of the interview, the researchers (interviewees) were presented with a list of all the longer-term impacts that had emerged from the analyses. These impacts were mainly interesting in terms of how they came to be. The researchers were asked whether they agreed with the impacts and whether they could think of any additional impacts. This was asked as a safeguard in case there were other interesting examples of research impact that had been missed by the data collection or analyses. No new impacts were identified.

The final part of the interview focussed on the impacts that had been identified as well as possible impact pathways. The interviewee discursively explored the different impacts, asking the interviewees (researchers) to talk through the impacts and how they came about. P1.1, for example, was asked to discuss the impact of P1.2 getting a research position in the private sector. He spoke about the work she did during her PhD, the international visits and exchanges on which she went and how she made a strong impression on a 'recruiter' at a conference discussing her PhD work. The interview further explored what P1.2 (who was P1.1's PhD student on Project 1) was doing professionally at the time of this research and which skills she employed in her position, how the skills she gained in her PhD created capacity at the university where she studied, but also where the ideas for her PhD came from (from P1.1). Thus, the processes and networks around an 'impact' were explored, fleshing out the specific impact pathway.

5.4.5 Step 2.5 – validating theories of change and impact pathways

Once the follow-up interviews had been transcribed, they were used to make small changes in the theories of change. The responses on the questions that explored how impact was effected were included in the results and analyses of the current research through the impact pathways that relate to the ability of productive interactions to be used in reconstructing research impact. The responses helped to create a better understanding of the links between different productive interactions. These are presented in Chapter 6.

5.4.6 Step 2.6 – application of the logic of CMO configurations to case studies

The logic of CMO configurations of realist evaluation were applied to examples from the case studies to expand on the conceptual idea that CMO configurations are in some ways related to productive interactions – specifically with productive interactions as mechanism of change (or impact). This section shows how productive interactions and their similarity to mechanisms in realist evaluation allow for the possible use of these interactions in a realist evaluation. The discussion of CMOs is accommodated in Chapter 8.

5.4.7 Concluding comments on the second phase of the research

The second phase of the research made use of the data collected in Phase 1 of the research to create lists of unique productive interactions (referring to unique interactions) and impacts for each of the agricultural research projects. These unique codes were then used to construct theories of change as a way of showing what is captured by productive interactions as presented by SIAMPI. From these theories of change, the researcher was able to identify impact pathways in all the research projects. This was done in order to see whether productive interactions could be used to build theories of change and impact pathways as a way of illustrating their use in possibly projecting (future) research impact, or in other words, if they could be used to develop theory to test in a realist evaluation.

Phase 2 of the research focussed primarily on the 'how' and 'who' of research impact in the theories of change, as viewed by impact literacy (Bayley & Phipps, 2017). Additionally, the process was primarily assessed from a researcher or research perspective. To counter the focus on the researchers and to create a more nuanced image of the networks and an understanding around research impact, the quantitative phase of the research (Phase 3) shifted the focus to the funders of agricultural research. In addition to creating a nuanced understanding by looking at the producers and funders of research, it also expanded on the 'what' of impact literacy in terms of how funders view the SoIR.

5.5 Phase 3 – impact literacy of the funders of the four research projects

In the third phase of the research, the focus of the research was on ascertaining the opinions of the two research funders (Winetech and Hortgro) on what they viewed as important societal impacts of research. When looking at the theories of change in Phase 2 through the lens of impact literacy, it was clear that a more nuanced 'funders view' was needed, and it had to focus on 'what' impact is (in addition to the 'who' effects impact, and 'how' it is effected).

Both Winetech and Hortgro make use of expert committee panels (funding panels) to identify important areas of research, select projects for funding that relate to these priorities, and monitor the progress of these research projects. Expert committee members are various representatives from the agricultural industries supported by Winetech and Hortgro, and include private consultants, university researchers, farmers and commercial industry players. Winetech relies on 60 expert committee members, while Hortgro relies on 30.

An online survey of the members of the funding panels was therefore conducted to ascertain their views about what impact is. For this purpose, an impact classification scheme was developed, which classified SoIR based on its position in relation to those benefitting from specific impacts. The development of the classification scheme is discussed next.

5.5.1 Step 3.1 – development of impact classification scheme

In order to develop a survey through which to assess the ways in which funders look at SoIR, it was necessary to find or develop a classification scheme that could accommodate the different notions of impact that emerged from the four case studies. It was realised that these impacts (from the case studies as presented in the theories of change) take place at different levels. Some of the impacts affected an entire industry, while others only affected a single organisation or even individual. It was also noticed that impacts could apply to different groupings (such as individuals or organisations) that were either directly involved in the research project (undertaking research) or who were direct stakeholders (the funders or research participants). Impact could also occur with groupings who had no direct relation to the research.

After considering the above, the idea was formed to plot the impacts of the four agricultural research case studies on a classification scheme, which could then be compared with a similar plotting of impacts regarded as important by the research funders. The framework that was developed, of which Figure 5.1 summarises the main idea.

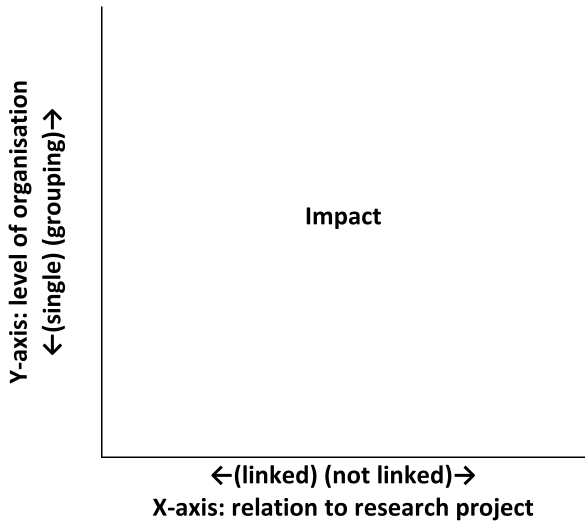

Figure 5.1 Two-dimensional classification of the impacts of productive interactions

Figure 5.2 (shows the final version of the classification scheme, as used in the current study.

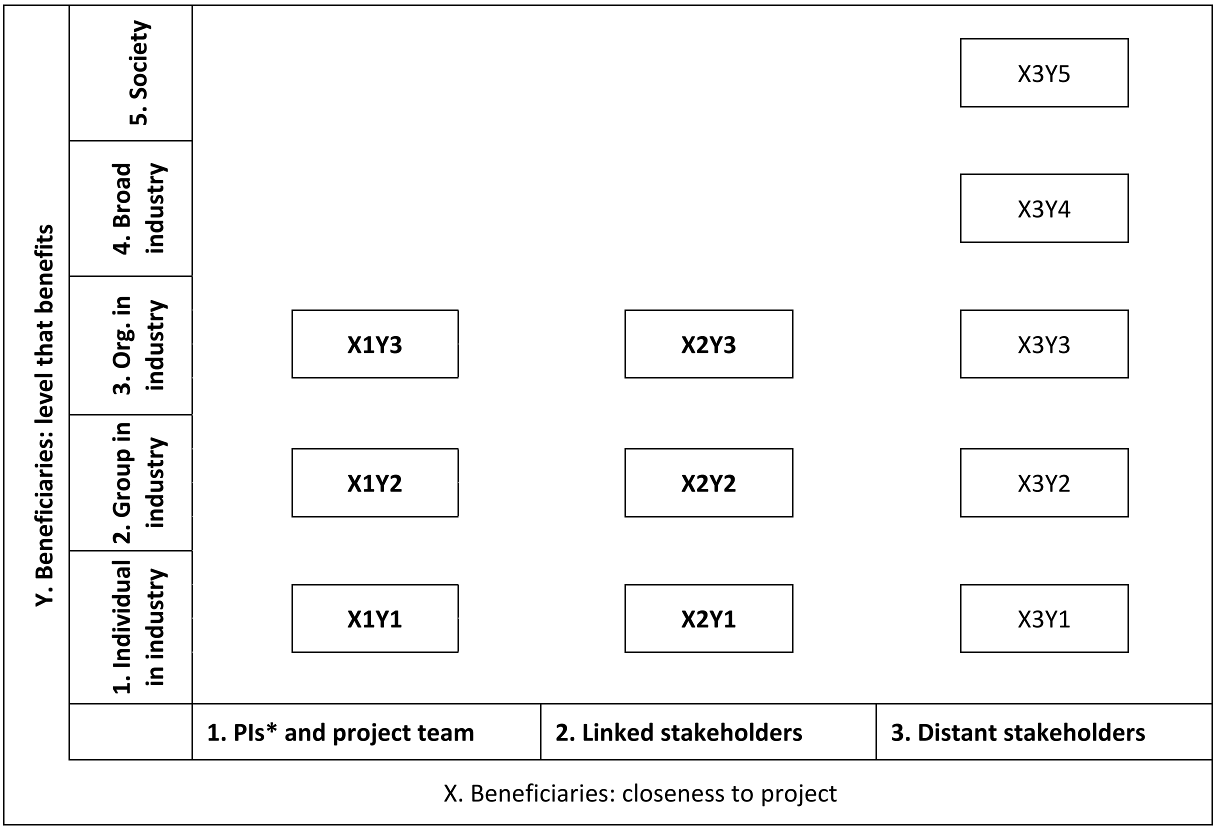

Figure 5.2: Societal impact of research classification scheme

*Principle investigators [PI]

The framework(s) plot research impact according to the proximity of the 'beneficiary' to the research project on the x-axis (linked stakeholders and unlinked stakeholders) and the level of organisation on the y-axis. This created an understanding of 'what' the different impacts recorded by the research in Phase 1 and 2 were.

5.5.2 Step 3.2 – development of survey of funders

The theories of change had visualised the process of effecting impact, as from the point of view of the principal investigators and other stakeholders of the four projects selected. The survey was built to assess how research funders at Hortgro and Winetech view research impact. Since the examples of research impact could be industry-specific, two versions of the same surveys were developed: one for Winetech and one for Hortgro. Great care was taken to ensure that the questions, although industry-specific, were the same in terms of research impact.

Each survey comprised four sections. The full surveys can be found in Appendices 3 and 4 of the dissertation. The four sections were:

- scenarios of research impact that test the scope of understanding of research impact by research funders;
- open-ended responses to what funders view as ideal impacts and as least desirable outcomes of research;
- views of funders on who or what is important in making research impact occur; and
- collection of very general self-identification data to provide some background to the different funder responses.

The first section of the survey comprised 22 statements of impact, which the respondents had to rate by means of a 4-point Likert-type scale. For each of these statements, or rather scenarios of impact, they had to indicate whether it reflected a very important impact of Hortgro/Winetech research, a moderately important impact, a slightly important impact, or an unimportant impact. There were two scenarios for each of the 11 cells (X1Y1 to X3Y5) in the SoIR classification scheme (Figure 5.2 above). The scenarios originated from two sources. Impacts identified in the four case studies were converted into statements and placed in the appropriate cells. In other cases, scenarios had to be invented. The invented scenarios were tested with the commodity companies to ensure that they were realistic or believable.

Below is an example of an impact scenario that originated from one of the case studies in phase 2 of the research:

> A public sector laboratory working in the wine industry recruits an employee who received training or obtained a qualification by means of a Winetech-funded project.

The example above would fall in cell X3Y3 in Figure 5.2. The actor benefiting is the public sector laboratory, which is an organisation (Y3). Since the organisation did not have anything to do with the research, it is a distant stakeholder (X3).

The different scenarios were randomised to prevent pattern recognition. The survey was pilot tested on four individuals (university-level researchers who are familiar with survey development). None of the individuals noticed a pattern.

In section two of the survey, respondents were asked to specify three ideal research impacts of Winetech/Hortgro projects. A second question then asked them to identify aspects of projects that they thought 'were a waste of money' (in other words, least desirable results), and to provide reasons for holding that view. This section explored the main types of research impacts funders prefer and the main reasons for failed projects, or for research having little value.

The third section in the survey asked respondents to rate role players (organisations) in knowledge and technology transfer on a Likert scale (which ranged from very important to unimportant, with a 'do not know' option included). The organisations presented were selected in consultation with Winetech and Hortgro. The aim of this section was to see whether respondents were aware of the fact that research impact is created by diverse actors and role players, or whether they perceived themselves, the researchers, or some other group as most important in building research impact. There was also an option to include an organisation they felt had been missed by the survey.

The final section comprised a single question that required respondents to indicate their employment or positions at work. More than one selection was possible. The options were:

- university-based researcher or academic;
- researcher in the public sector;
- researcher in the private sector;
- technical advisor;
- executive officer or manager of a firm, company or cellar;
- farmer, winemaker or producer;
- technology or knowledge transfer professional; and
- industry consultant.

The relevant demographic question was included to enhance the possible options in the data analyses. University researchers who were 'funders' (i.e. serving on funding panels) might have had a different view on impact than, for example, industry consultants. The different types of employment were selected after consultation with and feedback from both Winetech and Hortgro.

5.5.3 Step 3.3 – third round of data collection

The survey for Winetech was administered online. Winetech sent an introduction letter via email to all its expert committee members, which included a hyperlink to access the online survey. In the case of Hortgro, paper copies of the survey (together with an introduction letter similar to the one for Winetech) were distributed at the annual meeting of the Hortgro expert committee members. Hortgro advised that the use of hard copies would improve the response rate, as the annual gathering was taking place at the same time as data collection had been planned for the survey. For an optimal response rate, Hortgro also emailed the introduction letter and hyperlink to committee members who were unable to attend the annual meeting. The completed paper copies received from Hortgro were captured on the online survey system by the researcher.

Eventually, 23 out of the 30 Hortgro committee members (76 per cent), and 44 out of the 60 Winetech committee members (73 per cent) completed the survey.

5.5.4 Step 3.4 – data analysis

The survey for both Winetech and Hortgro was completed online (either by respondents or uploaded by the author of this dissertation). The individual responses were downloaded and exported to a Microsoft Excel 2016 file. Data analyses were also performed in Excel once the responses had been cleaned and recoded. Analyses mainly comprised percentage frequency distributions and data visualisations, which were produced separately for each funder. Responses to the impact scenarios of section one of the survey were also mapped onto the societal impact classification scheme.

5.5.5 Step 3.5 – adjustment of the classification scheme

The results of the data analyses of the surveys (for Winetech and Hortgro) were used to adjust ('fine-tune') the research impact classification scheme. The results and changes to the scheme are presented in Chapters 7 and 8.

5.5.6 Conclusion of the third phase of the research

During the third phase of the research, a classification scheme was developed on which to plot the SoIR that had been identified in the previous two phases. The phase also expanded on the 'what' (or what impact is) of impact literacy. The most important data collected in the phase however related to the opinions of the funders of the research (Winetech and Hortgro) on what they viewed as the SoIR, but also how they perceived the effecting of impact and the stakeholders involved. The expectations of funders directly linked back to the first two phases of the research. The first two phases identified productive interactions that were visualised in theories of change from which impact pathways were identified. These impact pathways revealed *how* and *who* came together to achieve the *what* that impact funders indicated as important in Phase 3.

5.6 Ethics

Ethical clearance for Phases 1 and 2 of the research was applied for and received from Stellenbosch University in 2017. Following completion of these two phases, ethical clearance for Phase 3 was applied for and received from the same university in 2018. Two applications were required since Phase 3 relied on data captured in Phase 1 and 2.

5.7 Conclusion

This chapter outlined the steps followed in executing an exploratory sequential mixed methods design. The first phase of the research identified the different productive interactions from the data collected through the in-depth interviews and project documentation. The data on productive interactions were used in the second phase to construct theories of change and identify impact pathways. The third phase, which involved a survey, made use of the lens of impact literacy to expand the understanding of impact by including the views of research funders. The results from the first and second phases of the research are presented in Chapter 6, followed by the presentation of the survey results in Chapter 7.

Chapter 6

Results: Productive interactions and theories of change

6.1 Introduction

This chapter presents the results of the data from phases 1 and 2 of the research on productive interactions (presented here as research interactions)[13] and the theories of change with impact pathways that were constructed from these interactions. Data were collected by means of in-depth interviews and by means of project documentation. These documents and data sources represent most if not all the available published data sources for each of the four project case studies.

The chapter is divided into two main sections: the first presents the research interactions that were extracted from the case studies, and the second, the theories of change that were constructed based on the interactions. The case studies are introduced through a short overview and a breakdown of research interactions in each of the cases. This is followed by an overall theory of change for each project. Following the theory of change, the research presents the five separate phases of each case. The theories of change were constructed from the coded research interactions and impacts.

6.2 Sources of data on research interactions

This section provides a general overview of research interactions (possible productive interactions). Interviews proved to be the largest source of research interactions as can be seen in Table 6.1 below. A total of 426 interactions were identified across the four cases. Of these, 230 were generated from the two interview types (researcher interviews and stakeholder interviews), which combined accounted for 230 out of the 426 instances of identified research interactions. These interactions, as explained in 5.4.1 on the methodology of the research, do not necessarily represent unique interactions, but rather the number of times a specific type of interaction was identified.

[13] A detailed discussion on research interactions and productive interactions is provided in 5.4.1 on the research methodology. In essence, a research interaction is an interaction that has the potential to be productive but that has not been proved to be productive.

Table 6.1 Sources of data on interactions (non-unique) across all four projects, broken down by the three broad types of interactions

Sources of data on interactions	Three broad types of interactions			Total
	Direct interactions	Indirect interactions	Material interactions	
Researcher interviews	118	30	28	176
Project reports	95	34	6	135
Stakeholder interviews	30	10	14	54
Academic publications	11	14	17	42
Popular publications	0	9	0	9
Websites	0	8	0	8
Protocol	0	2	0	2
Total	**254**	**107**	**65**	**426**

Three perspectives emerge from the data presented in Table 6.1. In the first place, it is clear that direct interactions are the dominant type of interaction across the data sources. Out of the 426 identified interactions, 254 are direct. Direct interactions are trailed by indirect interactions, with 107 out of 426 interactions. Secondly, the researchers' narratives dominate as a source of identifying interactions. The researcher interviews and most of the project reports reflect the opinions or narratives of the researchers (researchers for example write the progress and final reports). If these two data sources are combined, the researchers' narratives dominate in all the interactions (118 + 95 for direct; 30 + 34 for indirect; 28 + 6 for material). Academic articles are however also an important source of material interactions (17 out of 65 interactions), followed by stakeholder interviews (14 out of 65).

The third perspective relates to the main interactions that can be derived from each data source. Focussing only on the top three data sources, one can see that each of these (research interviews, reports and stakeholder interviews) mainly generated direct interactions. From the two sets of interviews, researcher interviews provided by far the largest number of direct interactions. Reports showed a similar pattern to researcher interviews, with more direct and indirect interactions than material interactions identified. Academic articles had more material interactions than direct interactions due to the inclusion of grant or funding acknowledgments in many journals. Popular publications, websites and protocols only provided indirect interactions.

Although researcher interviews and project reports were important sources of researcher interactions across all the projects, Table 6.2 below shows that the sources of interactions can nonetheless vary beyond those two main sources. Stakeholder interviews is, for example, the third most important source of interactions in Project 4 (21 out of 91 interactions), whereas it is one of the least important sources in Project 1 with only 1 interaction.

Table 6.2 Sources of data on interactions (non-unique), by project

Sources of data on interactions	Project 1 (Oxidisation)	Project 2 (Esca disease)	Project 3 (Mechanical thinning)	Project 4 (Forelle pear)[14]
Researcher interviews	64	41	44	27
Reports	30	49	21	35
Academic publications	22	20	0	0
Website	2	1	2	3
Popular publications	1	5	0	3
Stakeholder interviews	1	14	18	21
Protocol	0	0	0	2
Total	**120**	**130**	**85**	**91**

For any project, the two main sources of interactions were researcher interviews and project reports. Articles themselves constitute research interactions and accounted for the most indirect interactions.

There are also other noticeable differences between the projects. In Projects 1 and 2, for example, interactions were identified in academic articles, while none were identified in academic articles in Projects 3 and 4. Some of the differences depended on the aims of the project. Project 3 had a different pattern since no articles had been published from the research, except for a popular article published in the *South African Fruit Journal*. The type of research thus has an effect on where interactions could possibly be found.

6.3 Types of research interaction

The types of research interaction (possible productive interactions) were very similar in each of the four project cases in terms of distribution between direct, indirect and material interactions. Direct interactions were the most common by far, generally followed by indirect interactions. This only differed in Project 3, where the second most common group of interactions were material interactions. This difference is probably due to the high number of stakeholders involved in the project (such as fruit distributers, fruit exporters and fruit producers). All these stakeholders

[14] Please keep in mind that only three interviews were undertaken in Project 4. For this reason Project 4 has been grayed out. However, the main sources remain reports and researcher interviews.

provided some benefit or input to the research. Figure 6.1 below shows the number of different types of researcher interactions per case study.

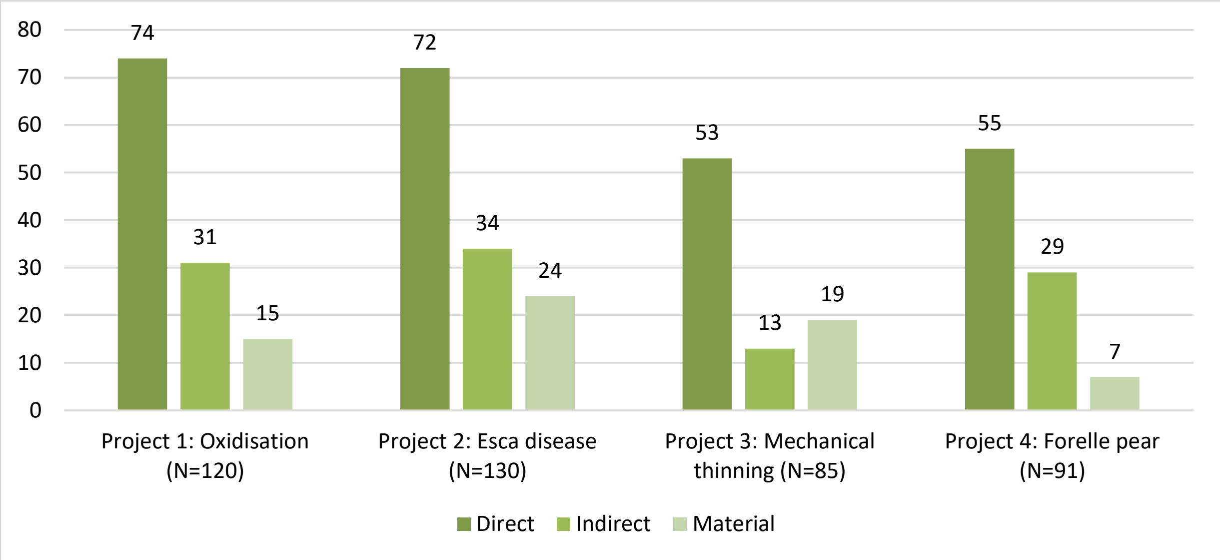

Figure 6.1 Three broad types of interactions (non-unique), by project

The focus below shifts from an analysis of the three broad types of interactions discussed above to an analysis of the finer interaction codes within the broad categories (the coding of the latter was explained in section 5.3.3.1). Table 6.3 shows the 10 most frequently occurring interactions (in terms of the finer coding categories) across all four projects. Eleven interaction codes are shown since the last two interactions had a similar count.

Table 6.3 Ten most common research interactions (in terms of finer coding categories) across all four projects

Interactions	Count
PI – Direct – Researcher – Conferences/Workshops/Poster	68
PI – Direct – Researcher/Research participants – Take part in research	43
PI – Indirect – Researcher – Academic publications	42
PI – Indirect – Researcher – Non-academic publication	32
PI – Material – Researcher/Farmer/Industry – Free products/Expertise	32
PI – Direct – Researcher/Industry – Information days – Sharing information	24
PI – Material – Funder/Researcher – Financial support	22
PI – Direct – Researcher/External researcher – Sharing expertise	13
PI – Direct – Supervisor/PhD (or student) – Conceptualising research	11
PI – Direct – Supervisor/PhD (or student) – Access to funding	10
PI – Direct – Supervisor/PhD (or student) – Network(ing) building	10

The most common direct interactions were paper or poster presentations at conferences and workshops. These types of interactions probably benefitted from being reported as outputs in various data sources, but also from being one of the main forms of information sharing in academia. Publications, which are indirect interactions, were the third (academic) and fourth (popular) most common interactions. Table 6.3 also shows that, in terms of finer codes, it is not necessarily direct interactions that dominate but rather specific types of direct interactions.

Researchers were the main actors in seven of the ten (eleven) most common interactions (involved in the interactions). Table 6.4 below presents the sources of data related to each of the most commonly identified interactions, highlighting the two main sources of data for each interaction.

Table 6.4 Ten most common interactions (in terms of finer coding categories) across all four projects, by source of data on interactions

Interactions	Sources of data on interactions					
	Academic publications	Popular publications	Reports	Research interviews	Stakeholder interviews	Website
Direct – Researcher – Conferences/Workshops/Poster	0	0	52	16	0	0
Direct – Researcher/Research participants – Take part in research	2	0	19	14	8	0
Indirect – Researcher – Academic publications	10	0	19	9	4	0
Indirect – Researcher – Non-academic publication	1	9	11	7	4	0
Material – Researcher/Farmer/Industry – Free products/Expertise	6	0	3	11	12	0
Direct – Researcher/Industry – Information days – Sharing information	0	0	6	12	6	0
Material – Funder/Researcher – Financial support	10	0	3	7	2	0
Direct – Researcher/External researcher – Sharing expertise	3	0	0	9	1	0
PI – Direct – Supervisor/PhD (or student) – Conceptualising research	0	0	0	11	0	0
PI – Direct – Supervisor/PhD (or student) – Access to funding	0	0	0	10	0	0
PI – Direct – Supervisor/PhD (or student) – Network(ing) building	1	0	0	9	0	0

Table 6.4 shows that different interactions are extracted from different sources of data. The widest range of research interactions (types of interactions) were coded from researcher interviews. It is one of the top sources of data for nine of the eleven most commonly found interactions (reports are second, being important as a source of data for five of the interactions).

A breakdown of the 10 most common interactions (in terms of the finer coding categories and again including a joint 10/11) by project shows that the categories of interactions vary by project. While there are similarities in distribution of the types of interaction by case study (direct, indirect and material interactions), this does not hold true for interactions that might be context-specific.

Table 6.5 Ten most common interactions (in terms of finer coding categories), by project

Interactions	Project 1 (Oxidisation)	Project 2 (Esca disease)	Project 3 (Mechanical thinning)	Project 4 (Forelle pear)
Direct – Researcher – Conferences/Workshops/Poster	25	35	5	3
Direct – Researcher/Research participants – Take part in research	4	3	14	22
Indirect – Researcher – Academic publications	18	17	4	3
Indirect – Researcher – Non-academic publication	2	11	2	17
Material – Researcher/Farmer/Industry – Free products/Expertise	5	9	17	1
Direct – Researcher/Industry – Information days – Sharing information	6	3	8	7
Material – Funder/Researcher – Financial support	8	9	1	4
Direct – Researcher/External researcher – Sharing expertise	5	3	1	4
PI – Direct – Supervisor/PhD (or student) – Conceptualising research	4	3	4	0
PI – Direct – Supervisor/PhD (or student) – Access to funding	4	4	2	0
PI – Direct – Supervisor/PhD (or student) – Network(ing) building	5	4	1	0

This concludes the discussion of researcher interactions (possible productive interactions) captured by the research. The next sections (6.5 to 6.8) will focus on the construction of the theories of change and impact pathways that were built from the research interactions identified in the first phase of the research. Before moving to the development of the theories of change, 6.4 discusses the way in which the study treated the productive nature of research interactions.

6.4 Research interactions: commenting on their 'productive' and 'unique' nature

This section briefly expands on the discussion on the productive nature of productive interactions discussed in 5.4.1. In addition to coding the case study data captured in Phase 1 of the research, in terms of productive interactions (or interactions), the same material was also coded in terms of impact (see again Table 5.7 Impact code categories and examples). To this point, the research has produced research interactions that took place in the case studies, but which have not been proved to be productive, along with impacts (and outcomes) identified by researchers and other stakeholders.

Additionally, the interactions that were captured were not coded as unique interactions. The same conference proceedings could have been captured numerous times if it were reported in different sources of data. However, neither the non-uniqueness of interactions nor the unproved productivity of interactions presented an insurmountable challenge to the current research. In constructing the theories of change, all interactions were assessed individually. All apparent repetitions were combined, resulting in only unique entries being included in the theories of change presented in the remainder of this chapter. Since the research was interested in the impact pathways of the project cases and not in measuring the exact contribution of each interaction, over-reporting of, for example, a conference presentation was not an issue. The latter will not receive a different weight in a theory of change, since each conference will only be reported once (no matter the number of times it was coded).

Lastly, although the interactions in the theories of change were not proved as productive, they were treated as productive. There were numerous reasons behind this. For one, it was not practical to test all the different interactions to determine whether or exactly how productive they were. This would require resources and time beyond the scope of the current research. However, more importantly, the interactions were treated as productive since they represented different 'steps' in the research processes of the four case study projects, and each of the case study projects was associated with a number of impacts. This means that, per definition, the interactions could all be considered productive interactions that effected impact in one way or the other.

Sections 6.5 to 6.8 are devoted to discussions of the theories of change developed for each project, which also make clear the links between interactions and impacts in each case (see 4.4.1 Theories of change).

6.5 Constructing a theory of change for Project 1

Project 1, titled "Antioxidant and oxygen program for South African white wines", was launched by the Department of Oenology and Viticulture at Stellenbosch University. It was led by a senior academic in the department who, in turn, was supported by a PhD candidate specifically recruited for the research. The PhD candidate was co-supervised by a professor from a Portuguese university who also took part in the research. Winetech was the primary funder for the project. According to the final report for the project, the aim of the study, was to "investigate the effect of controlled oxidation as could happen in a winemaking environment and assess its effect on a South African white wine's composition and quality" (P1_Document_Final_Report). In other words, the project looked at the ways in which exposure to oxygen affected SA white wines. The research aimed both to expand knowledge in the field and to make practical findings applicable to wine making. Table 6.6 shows the four individuals who were interviewed in this case study.

Table 6.6 Researchers and stakeholders interviewed in Project 1

Code	Role in project	Organisation at time of project
P1.1	Principle investigator	Stellenbosch University
P1.2	PhD candidate	Stellenbosch University
P1.3	Research participant	A South African wine estate
P1.4	Researcher and co-supervisor of P1.2	Porto University (Portugal)

The defining aspect about Project 1 was the production of a PhD candidate and the repercussions this had. After completion of her PhD, the candidate worked as a post-doctoral fellow before taking up employment in the wine industry. The experience she gained during her PhD contributed directly to the development of a scarce skill (in her case an analytical capacity). In combination with the funding from the project that developed analytical capacity, her expertise (built in Australasia and Europe) enhanced the research capacity of the SA wine industry. Winetech's funding of the research of the PhD promotor produced much more than the results of the study or just a PhD candidate. It also contributed to the analytical capability of the industry at large by building expertise and industry capacity through the research project. The theory of change developed for Project 1 is presented in more detail below. The theory of change is divided into six parts, with each section representing a phase in the research process. The theory of change shows the interactions of different researchers and stakeholders involved in the process of effecting impact. The research process as presented here was important for the current study since it is through the research process that change is effected. Figure 6.2 below reflects the theory of change for Project 1 and shows the entire research process.

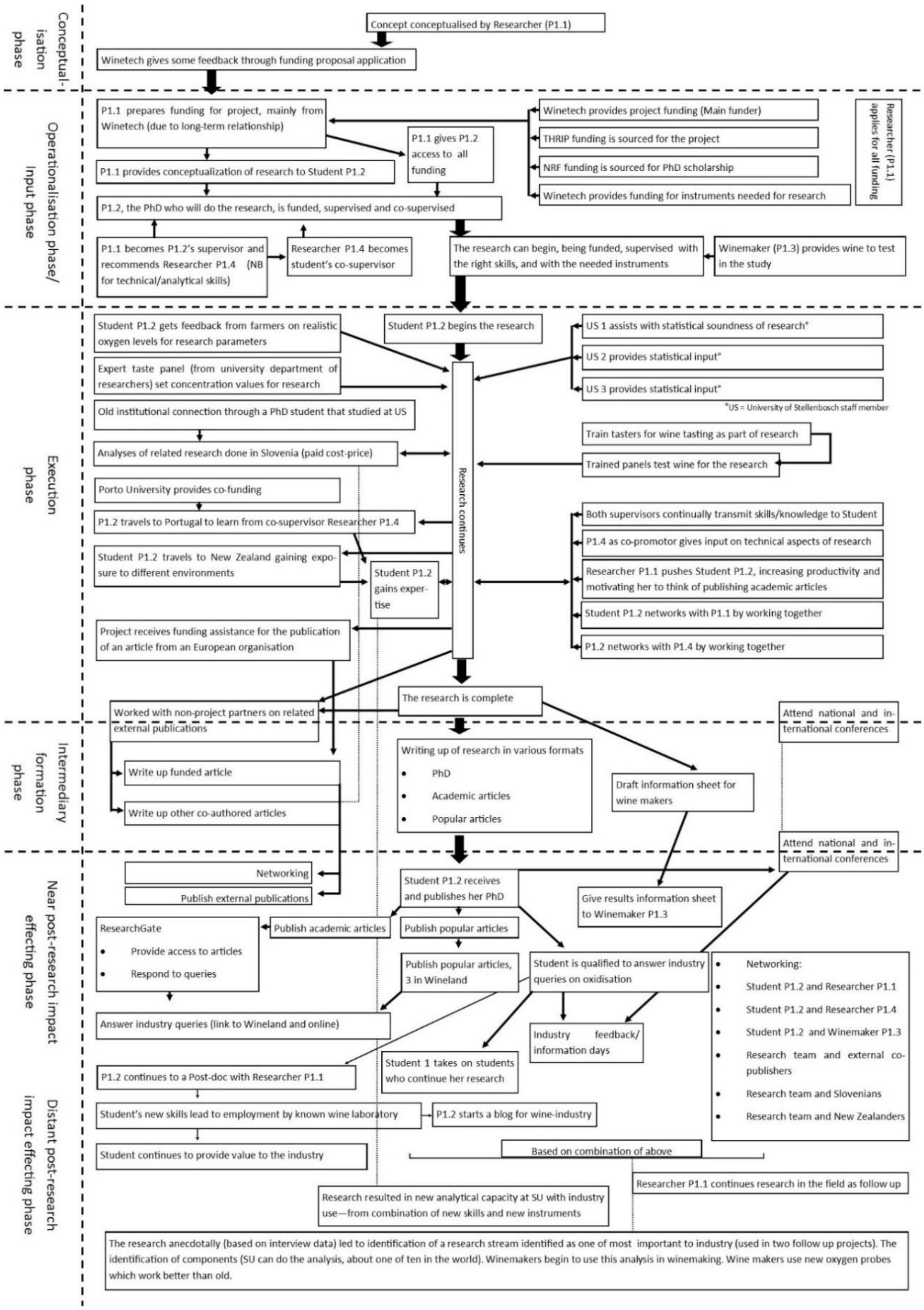

Figure 6.2 Project 1: Theory of change

Source: Author's own compilation

This visualisation is a combination of different interactions that took place during the research process. The current research viewed theories of change as visualisations of the entire research process. Although all the productive interactions included in the theories of change contribute to the formation of impact, they do not necessarily link directly (or at all) to final impacts. Impact pathways in contrast link together productive interactions that lead to a specific impact. Impact pathways are seen as forming part of theories of change. Theories of change as used in the current research were expanded on in Chapter 4 (see 4.4.1 Theories of change) and Chapter 5 (see 5.4.2 Step 2.2 – construction of theories of change). Additional figures are used to present the different phases of the research in detail (Figures 6.3–6.5). Figure 6.2 presents an overview of all these phases. A similar logic is used for each of the four case studies (presented in order of Project 1 to Project 4 later in the chapter, see 6.6.1, 6.7.1 and 6.8.1).

6.5.1 The conceptualisation phase

The conceptualisation and operationalisation phases of Project 1 are shown in Figure 6.3. The different colours correspond to the type of interaction. The interaction type is also included above each interaction, along with the quotation numbers referring back to the actual coding of the case study material in ATLAS.ti.

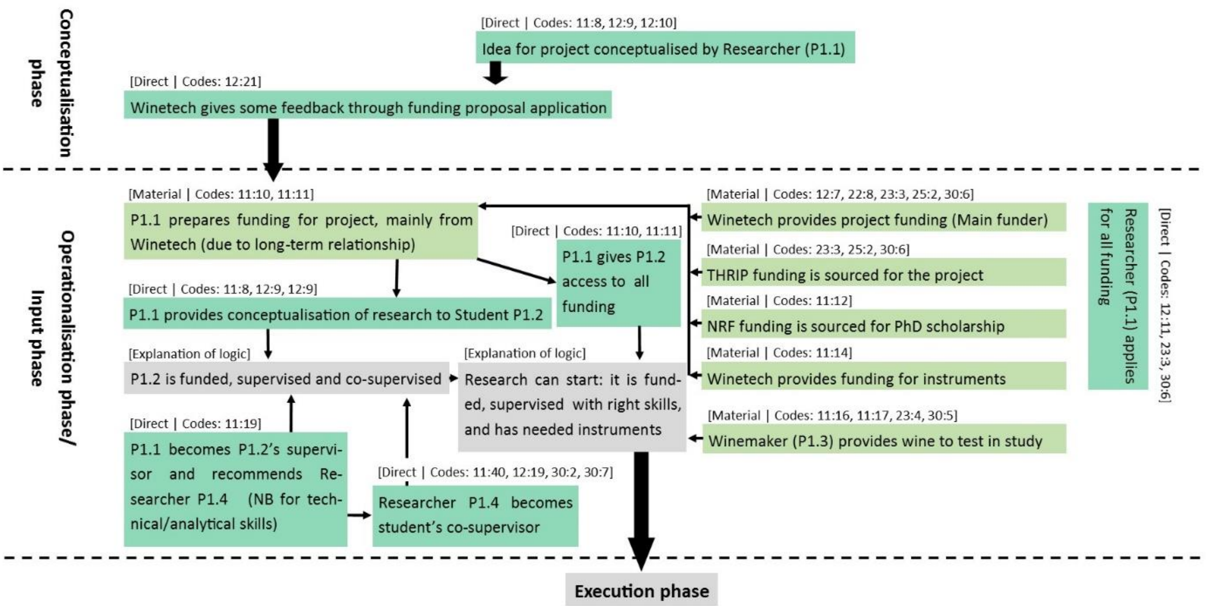

Figure 6.3 Project 1: Conceptualisation and operationalisation phases with supporting interaction codes

Source: Author's own compilation

The concept for the research project was finalised by researcher P1.1, the main researcher in the project, who worked at Stellenbosch University as a lecturer and researcher at the time of the research project. P1.1 conceptualised the research problem after having worked on related research for at least ten years before starting Project 1.

The idea for the research developed out of a possible gap in the literature that was identified by P1.1, in addition to a personal interest he held in the topic.

> Interviewee P1.1: *Everyone always thinks as little oxygen as possible is good in wine […] but that assumption is based on research where they pumped a lot of oxygen into wine all at once and basically just put it in an oven to speed up the process. […] I wanted to test it in a [real]-life situation. The research developed out of my own interest and to see if it really works the same way in normal conditions as it does in sped-up tests done in the literature*.

As the PhD student P1.2 (who assisted P1.1 with the research) made clear, the supervisor sourced the funding for the research, and conceptualised the topic of what was to be researched.

> Interviewee P1.2: *You see [P1.1] […] had already applied for funding for the projects [from Winetech] at that time. In the end, he decides what you will do your research on. […] So that one was for me, the one project that he had, it was appealing to me, so, yes [I started work on the oxidisation project]*. (Translated from Afrikaans)

In the above quote, the PhD candidate explained an interaction between her supervisor P1.1 and Winetech (the relevant funding organisation), thereby describing a material interaction. In addition, she provided insight into her interactions with her supervisor. He provided funding for her (a material interaction). He also gave her the idea of what to research and provided expertise and support for her to understand the topic. These are additional direct and material interactions.

The funding and even the recruitment of the student fell in the next phase, the operationalisation phase of the research. Important here is that the idea for the research was P1.1's.

Researcher P1.1 submitted a proposal for the research to Winetech, in this case, based on the fact that Winetech was P1.1's main funder and had been for many years. They had a relationship and the new proposal linked with previous work P1.1 had done for Winetech.

> Interviewee P1.1: *Well […] Winetech, already when I started doing research in 2002/3, I applied to them for funding. So, I have done many projects with them. […] I have had other projects with them, before this one. […] So, it flows from that, not the same work, but I mean […]. It is my main source of funding, Winetech.* (Translated from Afrikaans)

Winetech, as is standard practice, gave feedback on the project, helping to conceptualise it further.

> Interviewee P1.1: *We actually do it indirectly. […] Because when you are presenting the project to them for funding […] you have to write a proposal with a lot of detail in [it]. […] I am sure there was feedback from them, maybe to say, sometimes they give feedback maybe just saying you have to look at this. They do not provide too much technical feedback, but they might say you should rather look at this thing or bring in that factor.* (Translated from Afrikaans)

After the researcher had identified a research problem, he convinced Winetech of its importance and submitted a successful application for funding. Although the first phase only had two direct interactions, they were supported by four codes (Figure 6.3). The fact that the SIAMPI method means that non-unique interactions are captured, can thus be a positive point providing triangulation of sources. In the phase, it is shown that P1.1 conceptualised the research, and there were three codes relating to three different times the same code was captured, thus collaborating the interaction.

6.5.2 Operationalisation phase

Based on the long-term relationship between P1.1 and Winetech, and the apparent importance of the proposed research to Winetech, the research was granted funding. However, the nature of the research required a PhD student to undertake the bulk of the work. P1.1 set about to access different funding streams to prepare the project for a PhD candidate to take over. He accessed THRIP funding to supplement the Winetech funding. THRIP is an SA government initiative where the government provides an equal ratio of research and development funding to that provided by a private business (Blankley & Kahn, 2005). In addition to statements on Winetech being the main source of funding, the NRF was thanked in both the PhD dissertation produced from Project 1 and in some of the academic articles published from the research.

P1.1 assisted P1.2 to apply for the additional NRF scholarship funding based on the research project (Project 1) that he had prepared. Although P1.2 benefitted from the funding, she could not recall applying for it. According to P1.2, she only started to apply for funding on her own after she had started her postdoctoral work at Stellenbosch University.

> Interviewee P1.2: *After my postdoc yes, then I started to [apply for funding] on my own. That was the first time that I started to apply for funding. To be honest, as a student you do not really know how it works or where the funding is coming from.* (Translated from Afrikaans)

The project required a researcher with strong analytical capabilities. To ensure that the project had access to the right skillset, P1.1 suggested the inclusion of a co-supervisor. P1.1 selected P.1.4, an international expert from Portugal, as P1.2's co-supervisor.

> Interviewee P1.2: *And [P1.4] […] because he has the strong analytical side, he works on […] he has also done a lot of work on oxidisation. So he and [P1.1] have worked together a lot and when we realised that we have a gap and need help, or need help with the analytical part, we decided to include him.* (Translated from Afrikaans)

When asked who suggested that they contact P1.4 (the co-supervisor), P1.2 (the PhD candidate) said that it was her supervisor P1.1. P1.1 had come up with the idea for the project, successfully applied for various sources of funding, recruited a PhD candidate and connected her to a co-supervisor with skills needed in the project. P1.1 was bringing more to the project for Winetech than just skill or a final research result. His international network potentially enhanced the quality of the research.

Finally, the researcher and PhD candidate contacted a winemaker at a respected estate for wine to be used in the research. The winemaker agreed and the research project was ready to begin.

> Interviewee P1.2: *That wine, yes, it was from the industry from [P1.3's wine estate].* (Translated from Afrikaans)

The donation of the wine, a material interaction, was mentioned in the acknowledgements of some of the academic articles published from the research and in the PhD dissertation. It is another example of the same interaction being captured numerous times. However, it shows where this type of interaction was captured (which data sources) and provides additional strength to the inclusion of the interaction since there was more than one source corroborating it.

In Project 1, the main researcher, P1.1, was clearly the driving force behind the project. Although as will be seen in the execution phase, the PhD candidate, P1.2, did much of the research, P1.1 came up with the idea for the project (a direct interaction transfers this idea to P1.2). His connections linked the project to funding (more direct and material interactions) and he had awareness of whom to approach as co-supervisor. He also knew where and how to access additional funding. The PhD candidate could come into the project with a funded and mostly conceptualised research idea supported by P1.1.

6.5.3 Execution phase

This phase is the continuous execution of the research as planned, with a number of factors influencing either the success/viability of the research or other aspects improving the chances of positive outcomes (either for the project or for the researchers involved). Figure 6.4 presents the different productive interactions (coded by colour) in the execution phase of Project 1.

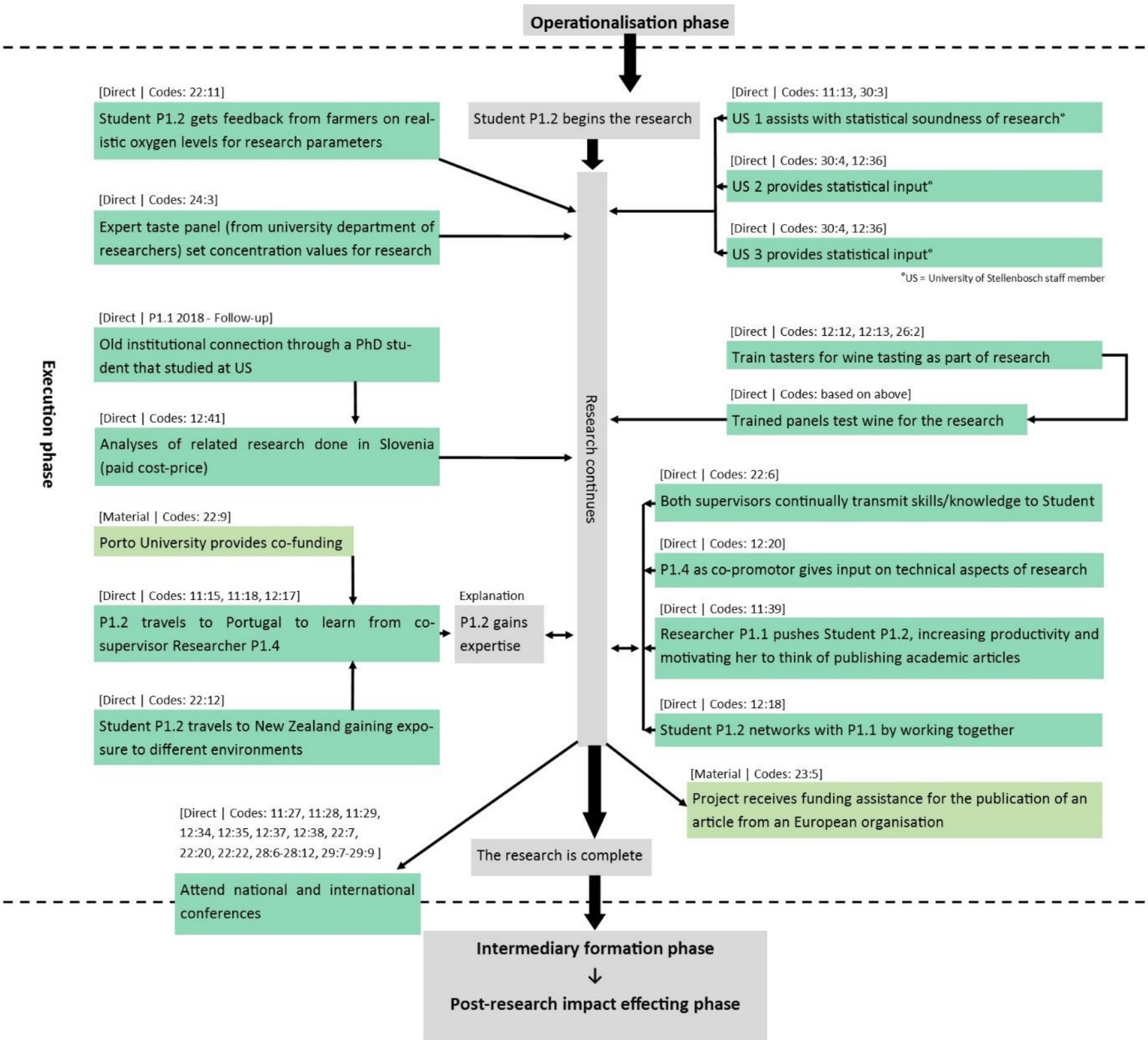

Figure 6.4 Project 1: Execution phase with supporting interaction codes

Source: Author's own compilation

To ensure that the research, as planned by the researchers, fitted with what happened in industry or the field, P1.2 approached winegrowers and gathered feedback from them regarding realistic levels of oxygen in wine.

> Interviewee P1.1: *What we did do was talk to them [winegrowers] a bit about what oxygen levels they find in wine. It does not help if we take levels that they never get in wine, so we spoke to them for a bit, it was just informal to try and find out what levels they get in their wine?* (Translated from Afrikaans)

This allowed the research to replicate real-world conditions, making the results more realistic and hopefully more user-friendly by industry.

Additionally, wine 'testers' were trained to test the taste of different wines. Reference is made to this in P1_Document_Article_Acadmic_04, an academic article published following the research. It states, "[t]he sensory panel consisted of 12 judges (all female between the ages of 27 and 64, mean age 39)."

> Interviewee P1.1: *Yes, we mainly use housewives for it, how can I put it, I don't really know why […]. Yes, so you go through with them, you go through the wines with everyone and then you tell them, so what flavours do you get out of the wine, and then you decide ok, you get the five, six main flavours en then you give them examples of strong and weak smells which gives you a good half-way, especially if the differences are not very big. You have to calibrate them to be very sensitive, or else the data might be unclear.* (Translated from Afrikaans)

What is interesting in the above quote is that it describes a productive interaction. To some extent, the women were informed of the research. As a direct result of the research, the women have increased knowledge on how to taste wines. However, beyond being important in the execution of the actual research, it did not really make a difference to the targets of the research after completion. It did however have an effect on the research. The testers had to be 'calibrated' to ensure that the study remained objective. The participants were research instruments testing the different wines.

Finally, the researcher (now referring to the PhD candidate P1.2), was also continually supported by her supervisor, P1.1, and co-supervisor, P1.4. Both continued to transmit skills to her, and support her with their areas of expertise for the duration of the project. As shown, P1.1 provided input into the topic, had a long history of working on oxidisation in wine and an international professional network. P1.4, on the other hand, was an international expert on the analytical aspects of which the project made use.

Beyond 'just what is needed' for the general execution of the research, there were also aspects that affected the possible quality of the research. These aspects improved the chances that the research might be of a higher quality, or might gain greater national and international exposure. Since the PhD candidate was a Stellenbosch University student, she had access to numerous aids, including a pool of experts who assisted her with her research free of charge. She was assisted by a professor to improve the accuracy and validity of her statistical research.

> Interviewee P1.2: *Yes, and then the project, and then to go and see the statistician to make sure that your project is statistically sound, so that you don't realise later that, oh hell, but I should have done five reps instead of three. […] And then go and see him, and then, you see him the whole time that you are busy with the study.* (Translated from Afrikaans)

Another senior academic and a colleague at the university also provided input on her statistics. Beyond Stellenbosch University, the project made contact with a European organisation that provided funding for a joint publication with external partners (material interaction). As part of the collaboration, the researchers, P1.1 and P1.2, travelled to Europe, where they undertook analytical research at the host organisation (laboratory work).

> Interviewee P1.1: *No, my goodness, that analysis, it was in […] I remember we actually did it in Slovenia. […] Yes, we started in Slovenia, but she was also in Auckland. Sorry, it was Slovenia. So we did not pay for it … Did we pay? I think we paid a little bit, but we had, we made some of them co-authors. That I can remember.* (Translated from Afrikaans)

Finally, there were aspects that affected the quality of the research, but also clearly provided a benefit to the professional development of the PhD candidate (P1.2). As part of her research, the candidate was co-funded by a Portuguese university to travel to Portugal where she worked with her co-supervisor on her research, but also gained professional expertise.

> Interviewee P1.4: *[S]he was … she was covered by … South Africa. And we … from Portugal … I think we also made some contribution*.

The Portuguese professor (P1.4) provided P1.2 with analytical guidance for her research, but also helped to develop her own analytical research capacity. In addition to travelling to Portugal, P1.2 gained access to funding that allowed her to travel to New Zealand:

> Interviewee P1.4: *[T]o [New Zealand] … where she has been exposed also to other researchers … and other environments. She was interested in another family of molecules and diets … which are important for … also … they are very sensitive […] So … that was something also that … [P1.2] was exposed to. [This meant that she was exposed to] several different … environments.*

In New Zealand, P1.2 developed her analytical research capacity in a technique for the testing of specific molecules. She later helped to establish this testing capacity at Stellenbosch University.

With the needed support of research participants, industry input from the farmers, the support of the supervisors and Stellenbosch University, additional support by experts at Stellenbosch and external funding that allowed travel to and research in New Zealand, Portugal and Slovenia, the research was successfully concluded. Next, the research had to be written up and distributed and communicated to the funder and industry.

There was one overlapping interaction or group of interactions that took place during the research Execution phase and the later post-research impact-effecting phase, namely conferences. Conferences, workshops and other different types of presentations can take place based on preliminary results or the final results. For this reason, these are the only interactions that are often found in two phases. Joint research projects can also be found in more than one phase. A joint research project can be an academic article that is completed before the research has been finalised based on early statistical data and analyses, or a spin-off project related to the research. This article will then transition from the execution phase to the post-research phases, depending on whether the main research project has been completed or not.

6.5.4 Intermediary formation phase

The intermediary formation phase in Project 1 did not contain any productive interactions but only represented the time when the PhD was written up, along with academic and popular articles. Some other academic and non-academic texts were also written.

6.5.5 Post-research impact-effecting phase (near)

During the post-research phase (near), depicted below in Figure 6.5, academic articles written in the intermediary formation phase were published in journals.

The researchers also published popular articles and loaded the various articles online, mainly to ResearchGate. The researchers engaged industry by presenting at industry-focussed information days. Interviewee P1.3 said they did, “workshops for industries … symposiums for industries …”. P1.2 also made a distinction between conferences and industry workshops.

> Interviewee P1.1: *We did, I know [P1.2] also spoke at forums, not meaning scientific conferences, but she also spoke at workshops and things*. (Translated from Afrikaans)

In addition to loading the articles online, P1.2 distributed articles that she wrote in relation to the research at industry information days. She also wrote a series of popular articles for the *Wineland* magazine, one of the most popular sources of information in the South Africa wine industry. SA winegrowers show a very high degree of reliance on conceptual use of research findings (in other words they make use of research findings to understand winemaking) (Boshoff, 2014).

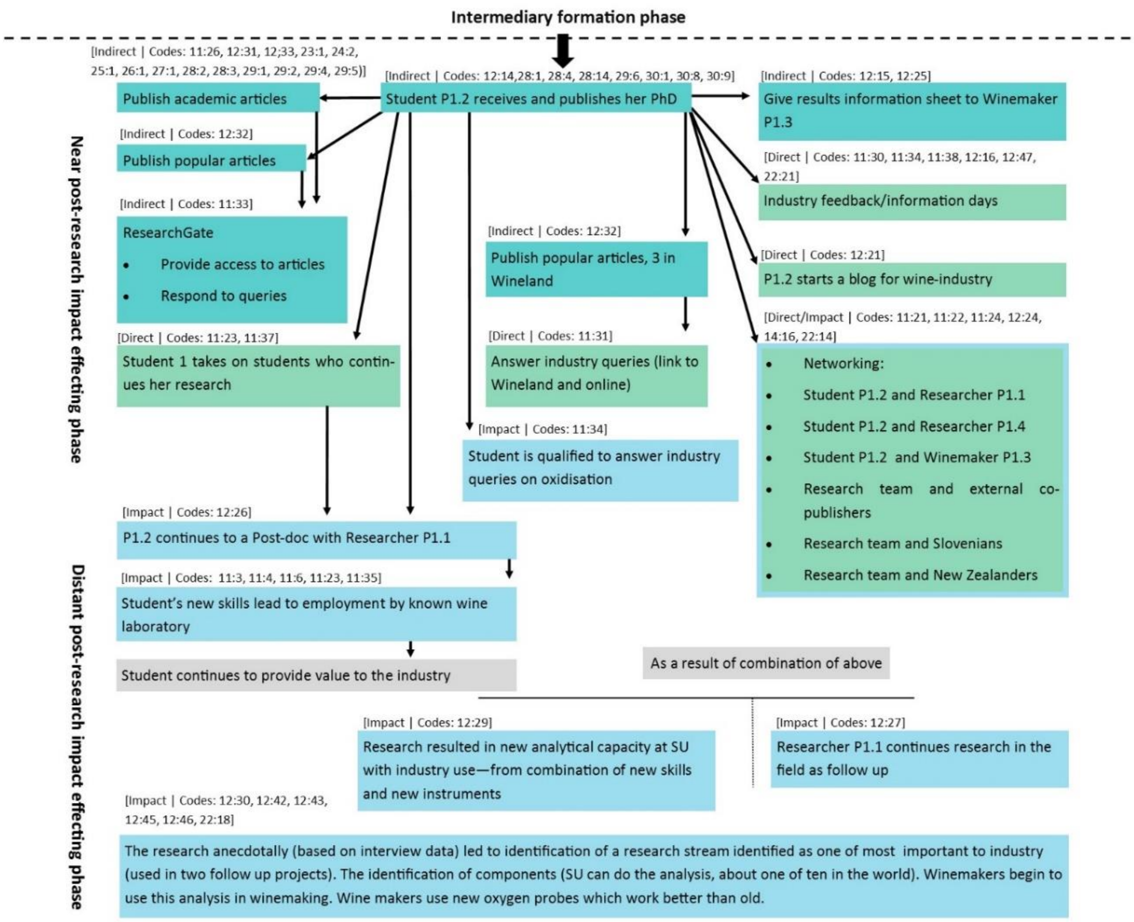

Figure 6.5 Project 1: Post-research impact-effecting phases with supporting codes

Source: Author's own compilation

Although there is no single information source used by the industry, the *Wineland* magazine has been found to come the closest. Of the winegrowers, 74 per cent reported reading part or all of the monthly edition of the *Wynboer* or the *Wineland* magazine (Boshoff, 2014:16).

> Interviewee P1.2: *I wrote popular articles. In the* Wineland*. There were three of four parts that were published in it. And then also on these days [information days] we also hand out articles that I wrote and give it to people. And you will be amazed at how many people respond to these articles. Ask questions, they will phone and say, but often it is very basic questions, but for them, its basic for me, but it is not basic for them. […] So definitely, there are many interactions, with my research, even long after my PhD has been completed.* (Translated from Afrikaans)

From the quote, it can be gathered that the PhD candidate had become a source of information in the industry and that she regularly engaged in productive interactions on the results of her research in Project 1. It is possible that the articles gave her exposure, which has resulted in winegrowers calling with general questions. However, the last sentence is also very important as it makes it clear that the information people are interested in is what she acquired during her research.

Further, although P1.1, P1.2 and P1.4 (and apparently the winemaker P1.3 as well) are now all part of each other's professional networks, this has led to actual actions. P1.2 for example supervises students at Stellenbosch University who are continuing her work.

> Interviewee P1.2: *My student is now busy with it, so the first thing is, when I left there last year after starting the project, my student basically took it over after I left. So he is continuing with it.* (Translated from Afrikaans)

P1.2 also successfully applied for funding for a project from Winetech, which was taken over by P1.1 when she left the university.

> Interviewee P1.2: *And then his project, I applied for the funding from Winetech. [P1.1] has taken it over now after I left […], but I would say it was originally my brainchild.* (Translated from Afrikaans)

According to the Final Report for Project 1, the project ended in the current phase. The report mentions the publication of articles, the production of a PhD and the *Wineland* articles. However, even though that is where the project ended for the researchers, the effects and what has been put in place by the research continues after the 'end' of the project. The 'distant' post-research impact-effecting phase is further removed in time and space from the researchers, or more precisely in the current case, from the original project. The researchers who engaged in Project 1 are still affected by the project after its completion.

6.5.6 Post-research impact-effecting phase (distant)

Impact in this phase can, but does not have to, take place completely removed from the researchers and their research. In Project 1, this was not the case, as the researchers were still involved, although, if the final report for the project is taken into account, the researchers themselves did not view these impacts (see below) as part of the project, since they did not mention it in the report. In the current case, the impacts (or effects) are distant to the original project (the most commonly found impact codes are presented in Table 6.7).

Table 6.7 Most common impact codes in Project 1

Impacts	Count
Impact researcher – Job/professional opportunity	7
Impact – Influenced own future research	6
Impact researcher – Network expanded	6
Impact – Created industry-relevant knowledge	5
Impact researcher – Skills development	5
Impact – Commercial value for industry	2
Impact researcher – Professional advantage	2
Impact – Leading to research or is researched by others	1
Impact – Research institution – New equipment	1

Another option where the researchers and the research findings themselves would not be involved, would be where artefacts created by the research could have taken on a life of their own. An article could have inspired someone to do research, or as was the case, a qualified person (P1.2) could move to a new company and produce value for them. This is also distant, as P1.2's role has changed. The project could not have foreseen her future employment in a different part of the industry, or at least, 'future employment' would not have been included in the project as a deliverable. Although the changes could be traced to the research, it would probably not have been possible to plan for such changes.

Getting back to Project 1, 'technology developed, products and patents', was one of the criteria on which researchers could report in the final project reports for Winetech. Here, the report for Project 1 states, "No new products have been developed, but valuable information regarding the oxidation of white wines has been generated" (P1_Document_Final_Report, 2015). This is somewhat surprising since this would be an understatement, if the data coded for impact (the impact codes) were taken into account.

In fact, the research done in Project 1, led directly to the identification of a stream of research that has become one of the most important in the industry (anecdotal). It also created analytical capacity at Stellenbosch University for testing wine at a component level, making it one of only around ten places in the world that has developed this capability. In addition, the research led to the use of a new oxygen probe, an improvement over the old one, which is now being used by some winegrowers in the industry. These distant post-research impacts were captured not through productive interactions, but through impact codes.

On a personal level, for the researchers involved in Project 1, the project provided P1.2 with future job opportunities. She first worked at Stellenbosch University, after which she moved to a position at a different institution. When asked whether the project helped her to get a job, P1.2 was clear that it had.

> Interviewee P1.2: *Oh yes, lots. Yes, lots. No, definitely. It is, goodness. No, I think that is why I was employed […] it is because of this background. I know how important sampling is, I know how to do it correctly, to what extent sampling can have an effect on your results, with results how, what to analyse, what to look out for.* (Translated from Afrikaans)

The impact of the project however went much further and to areas that are arguably of more interest to funders or the industry as a whole. The project created capacity at Stellenbosch University to test for components in wine, making it one of only a handful of institutions in the world with this capacity.

> Interviewee P1.1: *We developed these methods that the industry is increasingly using to monitor these components in wine. […] There's probably only about ten places in the world that are able to do this, because it is so hard to measure, but we can do it. (Translated from Afrikaans)*

In addition, the focus of the project led to the industry realising the importance of testing for components in wine to understand how to produce quality or 'winning' wines. Research on these components has become a main research stream for the industry.

> Interviewee P1.1: *And in the meantime, the wine industry has also started to target these components as some of the most important for further research. I think our research might have been the first to start testing for these things in South Africa.* (Translated from Afrikaans)

Finally, the project as stated earlier, also introduced a new oxygen probe to SA, tested it in the project and showed that it works in the SA context. This improved probe is now used by the wine industry.

> Interviewee P1.1: *Also something that came out of the oxygen study, we started using new oxygen probes. In the wine industry, they are using it more now, more people are beginning to use it in their cellars because the new probes work better than the old ones. We did not develop it; we did the tests with it and showed that the probes work well in SA conditions.* (Translated from Afrikaans)

The use of the oxygen probe was not specifically an aim of the research. The probe was used since it was more efficient than what was used in the past. The first case study gave insight into the development and training of a PhD student, and the process that led her to become a highly skilled individual working in the wine industry. The impact of the project extends much further than the results of how oxidation works in white wine.

6.5.7 Impact pathways in Project 1

An impact pathway is a logical organising of how an impact was effected (Nederlandse Organisatie voor Wetenschappelijk Onderzoek, 2018). In the current research, productive interactions were used to describe the impact pathways, describing how the research impact was effected.

In the two examples of impact pathways below, the impacts are both related to capacity building. In the first example, the capacity developed is in an individual and in the second example, at an institution.

6.5.7.1 Building skills for the wine industry

Description of the impact

The research in part produced an individual with scarce skills that were needed by a sector in the wine industry. P1.2 gained a PhD qualification with in-depth knowledge of wine and wine making, and an analytical research capacity. She was then employed by a private laboratory that does research for clients in the wine industry.

Reflection on the productive interactions that constitute the impact pathway

P1.2 was employed by the laboratory based on her scarce skills that were needed in the industry, specifically in the research sector that does analyses of wines for wine producers. P1.2's scarce skills are based on the combination of her understanding of wine and winemaking and her analytical research capacity with the expertise of analysing certain components in wine. These components can help to steer winegrowers in the process of wine making, potentially assisting in the production of higher quality wine ('prize-winning' wines).

P1.2 gained her knowledge of wine and winemaking from her supervisor, P1.1. P1.1 introduced P1.2 to the importance of the relevant molecules and provided her with a conceptualisation of the research process needed to develop the necessary research capacity in South Africa. P1.1 also provided P1.2 with access to his international network allowing her to travel to different research environments (New Zealand and Portugal) where she was exposed to a range of skills that assisted in honing her abilities as a researcher. Though individual interactions are important, it should be kept in mind that the main aim of the theories of change is not to identify 'the most productive' productive interactions, but to understand the context in which research impact is effected. Context is created through a combination of different productive interactions. To understand the productive level as such of each of these interactions would not be feasible.

P1.2's co-supervisor, introduced to her by P1.1, was a Portuguese professor, P1.4. P1.4 trained the PhD candidate (P1.1) in the analysis of wine (testing of molecules as done in the project). She had already gained some of this analytical capacity on a previous research exchange to New Zealand. P1.4 developed her skills further. With the analytical research abilities and in-depth understanding of wine and winemaking, P1.2 gained scarce skills needed in the wine industry. The development of this capacity was a direct result of Project 1.

Some contextual elements were important in P1.2 gaining employment. Though some of these are discussed in the current chapter, the discussion chapter (Chapter 8), greatly expands on the topic of context, specifically in relation to CMOs. As will be argued (in 8.3) the current research suggests that impact pathways are best understood through a CMO lens.

Beyond having been accepted to a PhD scholarship, to train in a skill needed by the wine industry, P1.2 was also adequately funded. Adequate funding allowed for the purchasing of instruments required to complete the research in the project. Funding also allowed P1.2 to travel internationally gaining (analytical) research experience.

P1.2 was offered employment after having been spotted by her future employer during a conference presentation (this is contextual as, although beneficial to P1.2, her skills would have made her eligible for employment even if her employer, or another employer, found out about her in another way). The funding of a research project on oxidisation, allowed P1.1 to undertake the training of a PhD with skills needed by the wine industry. The training of P1.2 was not a primary objective of Project 1, but it was arguably an impactful outcome.

Crucially, the skill that P1.2 developed during the research was in demand by the wine industry. It can even be argued that the research itself contributed to raising awareness of the importance of the skills she developed, leading to an employment offer.

6.5.7.2 Developing new analytical capacity at Stellenbosch University

Description of the impact

Project 1 resulted in Stellenbosch University developing the ability to test for components in wine that assist in the winemaking process. The analytical capacity that was developed at Stellenbosch

University made it one of only ten institutions in the world with the capacity to test for certain components in wine.

Reflection on the productive interactions that constitute the impact pathway

To develop the capacity the university needed to buy the correct instruments, but also develop the expertise to do the analyses. Project 1 provided some of the funds that were needed to purchase additional instruments. The largest contribution of Project 1 was however bringing the necessary expertise or skills to the university through the project. P1.2 gained experience internationally (as described in the previous impact pathway), which provided the expertise to undertake the analyses with the correct instruments.

The contribution of the project however goes back further than the development of skills. If it had not been for P1.1's realisation that the development of this analytical capacity was important for Stellenbosch University, the capacity would not have been developed at the university. The project thus contributed to a larger extent of creating awareness on the importance of these components in wine.

In this example, we can also see how the second impact pathway is supported by the first impact pathway. Without the development of the required skills, the capacity could not have been established at the university.

As mentioned in the first impact pathway example, the industry was not necessarily aware of the fact that they needed the capacity that was developed by the research. Rather, having developed the capacity, the project started to make the industry aware of the availability of the analyses and that Stellenbosch University had the capacity to do the analyses.

> Follow-up P1.1: *Yes, I think the contribution was to make industry aware of these things. Making them aware of this method, but also aware that Stellenbosch has the capacity to do it. And that it is important in wine.* (Translated from Afrikaans)

Project 1 helped the industry to realise that the testing of molecules in wine can contribute to the development of wines. The project further helped to develop the capacity at Stellenbosch University, after which it then assisted in making industry aware of its importance and its availability (arguable an additional impact also building on the first two impact discussed above).

6.6 Constructing a theory of change for Project 2

Project 2, "The epidemiology and aetiology of fungi associated with Esca disease of grapevine", was a Winetech-funded project led by a researcher from ARC Infruitec, supported by a PhD candidate from Stellenbosch University and her supervisor at the university (researchers and stakeholders interviewed are presented in Table 6.8). The project studied Esca disease (a type of vine disease) in SA grapevines.

The project itself stated its objectives as identifying the fungi associated with Esca disease in SA vineyards, and identifying other fungal species associated with wood rot and creating a molecular identification technique for the detection of Esca-related fungi.

Table 6.8 Researchers and stakeholders interviewed in Project 2

Code	Role in project	Organisation at time of project
P2.1	Principle investigator/Co-supervisor	ARC
P2.2	PhD candidate	Stellenbosch University
P2.3	Research participant	Nursery
P2.4	Research participant	VinPro

The identification technique that was developed by the project allowed for rapid recognition of Esca that could be done through photos sent via mobile phones, reducing the diagnosis time from weeks to potentially minutes, providing a diagnosis while the farmer, winemaker or consultant was still in the vineyard.

The theory of change for Project 2 is presented in Figure 6.6 on the following page. Project 2 shows the importance of supporting pushers in their research. A researcher pushing a research topic has the potential to provide momentum to the adoption of results or the undertaking of research in an unexplored field. In the current case, the researcher, being funded for doing the research in which he was interested, developed a comprehensive general knowledge of his field allowing him to spot the presence of a previously underreported vine disease in South Africa.

Research driven and pushed by the researcher based on his personal interest in the topic made the industry aware of the problem, which was much larger than previously thought. He had to apply for funding three times before he was able to convince the industry that he had identified a real problem worth understanding. The researcher was able to identify the disease based on his international exposure as he had come across the disease in Europe.

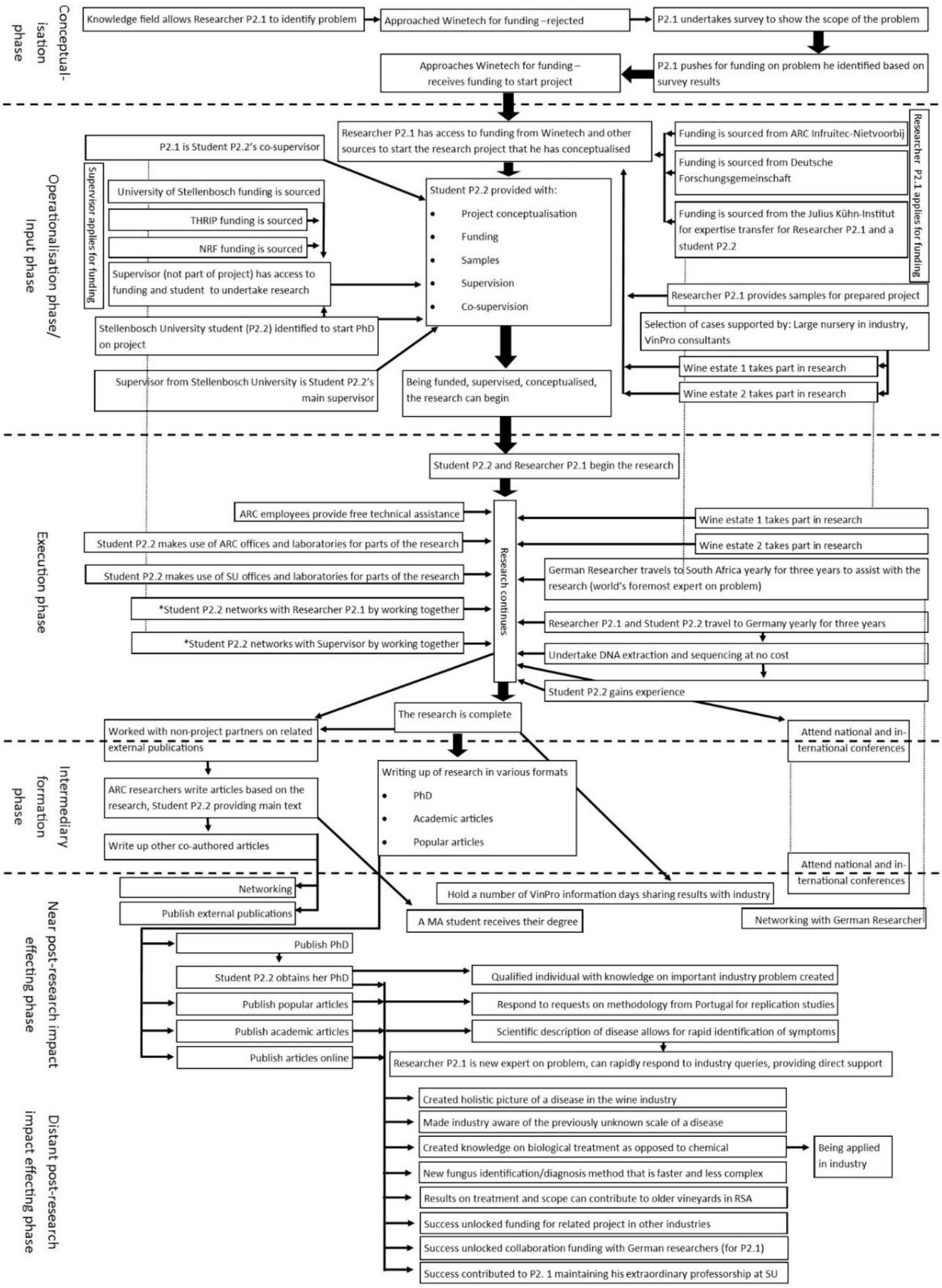

Figure 6.6 Project 2: Theory of change

Source: Author's own compilation

6.6.1 The conceptualisation phase

In Project 2, the principle investigator, P2.1, identified an extensive problem of Esca disease in SA vineyards (see the conceptualisation and operationalisation phases of Project two in Figure 6.7 below).

> Interviewee P2.1: *Winetech rejected this project for funding … I think two or three times. They were not aware of it. So, every time, I had to get more evidence … and I tried every time because I knew it was a very big issue. […] Because these things have a tremendous impact, they have a big impact, and they [Winetech] were not aware of it*. (Translated from Afrikaans)

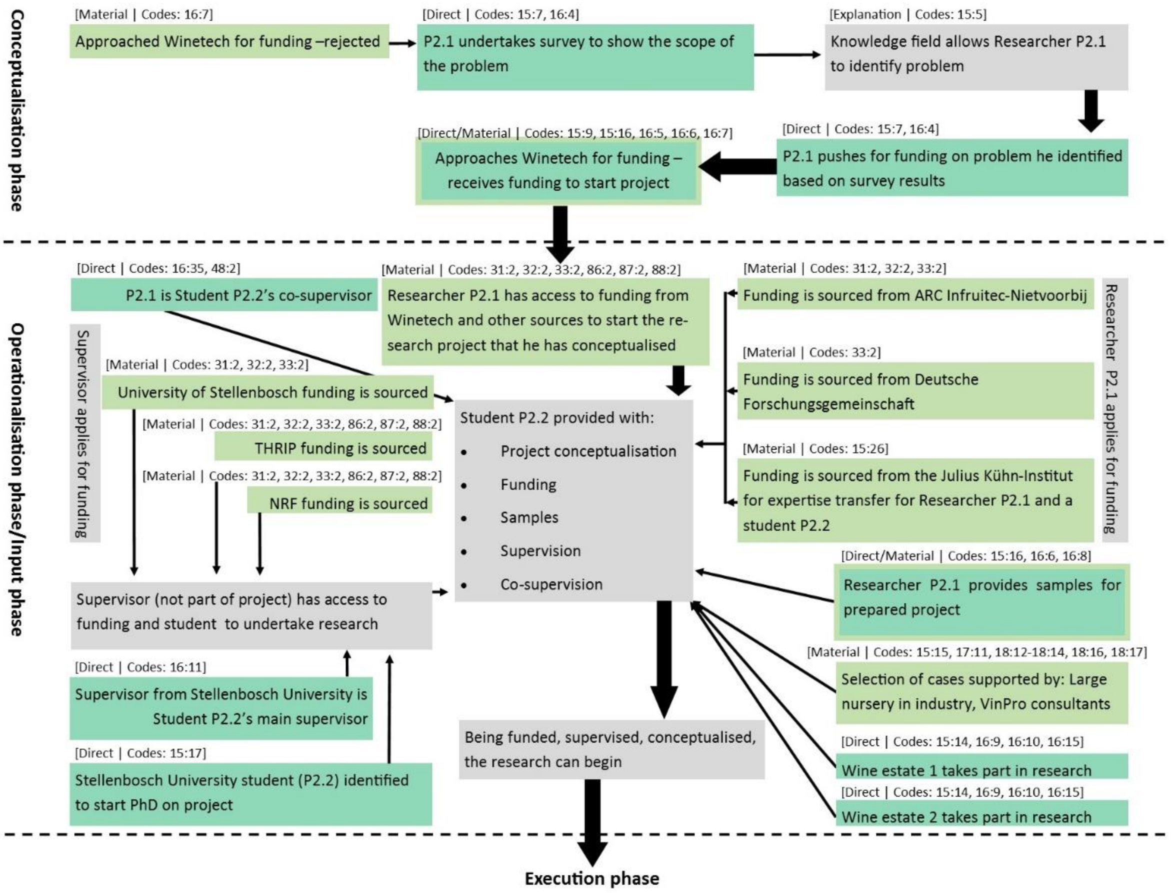

Figure 6.7 Project 2: Conceptualisation and operationalisation phases with supporting interaction codes

Source: Author's own compilation

It took an expert in the field (P2.1) with an international knowledge of fungus to see the symptoms (which he knew from European cases) and connect them to the right cause.

> Interviewee P2.1: *Because I obviously have knowledge of vineyard diseases, I specialise in vine diseases and I know that this disease is in other countries. So, I very quickly saw that it is here,*

> *but we had no idea of what caused it … And the farmers did not know about it at all.* (Translated from Afrikaans)

Usually VinPro, an extension company linked to Winetech, will identify problems in the industry. However, in this case, a researcher pushed the issue from his side.

> Interviewee P2.1: *It's usually … there is an organisation, VinPro. VinPro is the consultants, and they are on the ground getting information from the different producers in the different areas. And they have regional representatives, so they get information from all the different areas.* (Translated from Afrikaans)

In this case, the researcher made use of a national survey, with his own resources and through his own network, to see how widespread the problem of Esca was. This finally convinced Winetech that it was an issue to look into.

> Interviewee P2.1: *Yes … no, what we did, we decided to do a survey … and to look at all the different areas. […] And we found it everywhere. So, we took that data to them and said, "Listen, it's definitely here and it is a big problem."* (Translated from Afrikaans)

This is an example of a researcher pushing the agenda of his research. If it had not been for the experience and knowledge of the researcher, Winetech would not have become aware of the scope of the problem.

6.6.2 Operationalisation phase

During the operationalisation phase, three main aspects came together. Firstly, Stellenbosch University came on board with a PhD student and her supervisor, along with university funding. In effect, although he was the co-supervisor, P2.1 was the main contact point for P2.2 in the research with empirical data mainly being collected and later analysed by P2.2 supported by P2.1. Secondly, P2.1 and the ARC provided their Winetech project funding, along with additionally sourced funds and P2.1's collection of samples collected over many years (essential to the research). This collection was important in the research as the study was on different fungi causing the Esca disease. Lastly, different industry players came on board, such as P2.3, the owner of one of the largest nurseries servicing the wine industry in the province, who provided expertise. A number of farms also joined the project, providing access to their vineyards for experimentation.

It is easy to identify funding sources based on acknowledgements in the academic articles produced by the project. In one of the articles the authors, "thank the ARC, Department of Plant Pathology, Stellenbosch University, Winetech […], THRIP and the NRF for financial support"

[P2_Document_Article_Academic_01]. The THRIP funding is linked to Stellenbosch University and the NRF funding is linked to the PhD candidate. Although the student applied for the NRF funding, she was supported in this by researcher, P2.1. As the PhD student in the project, P2.2, recalled funding and the project itself all seemed to come together as a package.

> Interviewee P2.2: *No, it is a package, here, we have a project for you, and it is funded.* (Translated from Afrikaans)

Students were selected to be part of projects based on a so-called 'mix-and-match' system.

> Interviewee P2.1: *And then we have a kind of mix and match. But we … for example, I'm involved with a fourth-year practical class that I take to the farm and show them vineyard illnesses. And then I usually ask who is interested. […] And then I plant the seed there.* (Translated from Afrikaans)

When a student is interested, he or she is encouraged to either apply for NRF funding, or he or she receives NRF funding from a block grant for which P2.1 applied, and had already received.

> Interviewee P2.1: *And we would often ask them to apply for NRF bursaries. Or, I also have a block grant from the NRF. I think 100, say for 100 scholarships.* (Translated from Afrikaans)

The PhD student from Project 2 explained that researcher P2.1 from the ARC was generally the one to supply funding, while Stellenbosch University provided students and primary supervision.

> Interviewee P2.2: *The thing is, the project sort of belonged to [P2.1]… but they split it in half. So, the university component is with her [the university supervisor], and she is your primary supervisor in the department. And [P2.1] is your co-supervisor. He gets most of the funding and things.* (Translated from Afrikaans)

P2.1 also had connections with international organisations and research partners from which his projects benefitted financially. This is similar to Project 1, where the network of the researcher became part of the project funded by the commodity company. Below he describes an agreement with the Julius Kühn-Institut, a research institute in Germany.

> Interviewee P2.1: *Yes, specifically. So, for example, they funded this project that focussed on the exchange of experts between countries. So, they provided me with the opportunity to bring in world experts on the fungus, to bring them to South Africa, to work with me.* (Translated from Afrikaans)

As mentioned, researcher P2.1 also provided samples that he had been collecting for over a decade. By providing these samples in a personal capacity, there was a material interaction between the researcher and his own project.

> Interviewee P2.2: *[P2.1] is well connected, so … this research is … a large part of the research has taken place on collections he made 10 years ago. So … or … you know … I think he started with the collections in like 2000 or something.* (Translated from Afrikaans)

To a large extent, the research was a continuation of a field of interest that P2.1 had been working on for many years. In addition to the funding sourced by both Stellenbosch University, P2.1 and through the student, P2.2, industry players contributed their expertise to the project. VinPro consultants assisted in identifying farms where they suspected the Esca problem was the worst. The process of pointing out farms is an indication of a number of possible interactions. Contacting the VinPro consultants and talking about the project is a direct interaction transmitting information, as they became aware of the project. With the consultants giving suggestions of farms to visit, they were contributing expertise through material interactions. This greatly eased the process as they could identify farms, and farmers could identify specific vineyards.

> Interviewee P2.1: *Then, before that time, I will contact the VinPro consultant in that area and ask him where the worst vineyards are. Then he would say it's that farmer. Then I contact the farmer and we make arrangements … and the guy can take me directly to the vineyard, instead of having to walk around.* (Translated from Afrikaans)

The expertise shared might seem small, but this type of cooperation could save hours off a project, which could relate to thousands of rand saved on the researcher's time. Similarly, P2.1 was assisted in identifying problem farms by an owner of a large nursery in the industry, P2.3. Nurseries sell certified virus-free plants, so they are also aware of farms suffering from fungus or other problems. Beyond identifying farms, P2.3 also provided input into how the research might be done.

> Interviewee P2.3: *I … you know we have had conversations about … I probably advised about… how to handle the thing … research is its own field of study … I did not want to be very involved with it. We spoke about my practical experience with Esca.* (Translated from Afrikaans)

Finally, the research was able to convince farmers to allow the researchers to experiment in some of their vineyards. No small feat if one keeps in mind that this entailed injecting healthy vines with spores, contaminating them.

6.6.3 Execution phase

The execution phase of the research was less complex than in Project 1. Most of the interactions in the execution phase were based on the researchers, mainly the PhD student (P2.2), receiving assistance and making use of material support from Stellenbosch University and the ARC. ARC employees, for example, provided free technical assistance for the duration of the project. The assistance of the employees is acknowledged in three different academic journal articles where they are thanked by name (this is one of the fastest ways of identifying material interactions). Figure 6.8 presents the execution phase for Project 2.

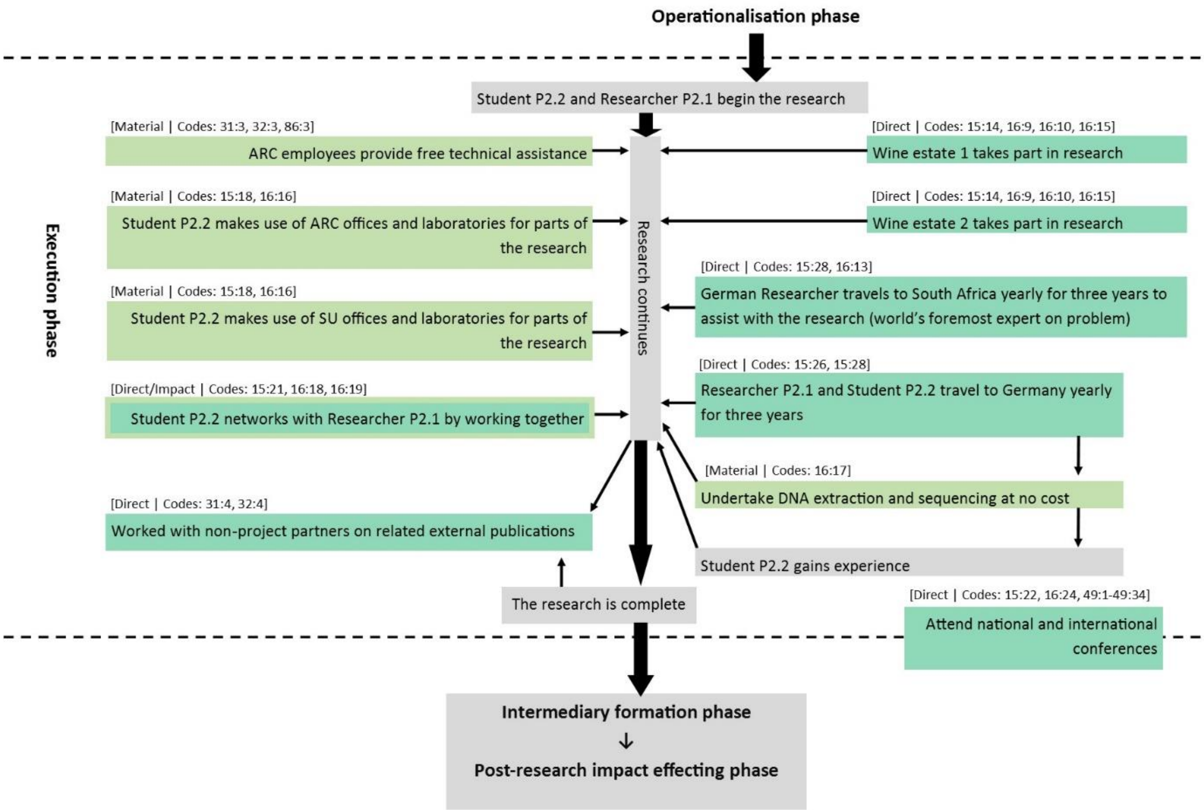

Figure 6.8 Project 2: Execution phase with supporting interaction codes

Source: Author's own compilation

The PhD candidate (P2.2) also made use of the research facilities at the ARC, even though she was a registered student at Stellenbosch University and officially working from the university laboratories.

> Interviewee P2.1: *[P2.2] was based at Plant Pathology, but also often worked at Nietvoorbij.* (Translated from Afrikaans)

The research further benefitted from P2.1's network and the additional funding he had secured from the Julius Kühn-Institut.

> Interviewee P2.2: *[German researcher] is a guy who … is a researcher in Germany. He is at the Julius Kühn-Institut. They focus on viticultural research specifically. […] He was here almost once a year at one stage. And … we also went to him a few times. He is the … he is the world's kind of … leading expert on the organisms we worked with in the project.* (Translated from Afrikaans)

The researcher from the Julius Kühn-Institut was considered a world expert in the field. The exchange project was funded for three years.

> Interviewee P2.1: *Then one of the students and I again … yes. That thing was for three years. We went there once a year, and he came here afterwards. [German researcher] is from Germany. The project was funded for three years.* (Translated from Afrikaans)

The SA researchers would do DNA extraction and sequencing at the Julius Kühn-Institut. This interaction is important, since it was funded by additional external funds.

> Interviewee P2.2: *Yes, yes. Like microscopy and … we did DNA extractions and … sequencing once or twice.* (Translated from Afrikaans)

During the run of the execution phase of Project 2, the researchers also attended international and national conferences. The quote below is a good example of how an interviewee might reference interactions, but unravelling exactly how many interactions and how productive they were remain hard to determine.

> Interviewee P2.2: *[Attended] a bunch of conference talks, also international, and things like that. I think I did one poster. No, I did two posters and one international conference. And nationally I think I did a poster the one year, and I spoke at the viticulturist conference two times.* (Translated from Afrikaans)

It is possible to corroborate some of the comments. By looking at the final report for Project 2, P2.2 presented at two international conferences (one in Spain and one in Thailand). It might be possible however that she only attended one and received credit for contributing to the other, which would explain why she claimed to only have attended one international conference. Beyond the number of conferences, however, it is hard to say whether these were productive or not. It was not possible to survey the other researchers who had attended the conference presentations. The research approached this potential issue by 'assigning value', or more correctly, understanding the interactions (potential productive interactions) by looking at their context in the research process. We would know that the conferences had value if there is a later interaction that refers back to, for example, the conference presentation.

6.6.4 Intermediary formation phase

During the Intermediary formation phase, P2.2 wrote up her PhD, and P2.1 and P2.2 wrote popular and academic articles. ARC researchers also published articles with the researchers, with P2.2 often providing the main text. This is common practice it seems, and some publications were completed only after P2.2 had already received her PhD and stopped working on the project.

> Interviewee P2.2: *No, all of us on the team. I wrote the primary text and so on. And then the supervisors and co-workers helped.* (Translated from Afrikaans)

P2.2 mentioned that a PhD candidate who had not worked on her project, completed some of the sketches (drawings used in scientific descriptions) for some of her articles. Additionally, the names of the supervisor (P2.1), co-supervisor from Stellenbosch University and the Julius Kühn-Institut also all had to appear on published articles. As P2.2 explained:

> Interviewee P2.2: *We eventually got another guy. He started his PhD after I left there [the ARC], and he helped with some of the sketches for one of the articles and so on. So, it is basically a whole team there. It is always myself, [Stellenbosch University supervisor] … and [P2.1] and [German researcher]. On all of the articles.* (Translated from Afrikaans)

In this case, an individual became part of the research effort, technically after it had already ended. A researcher, unrelated to the project, engaged in producing outputs for the project, even after it had officially ended.

6.6.5 Post-research impact-effecting phase (near)

The productive interactions identified in the post-research impact phase (near) were mainly related to traditional academic outputs. It has to be emphasised again that this does not mean that impact is or should be viewed as linear. However, the outputs of a project, the sum of the artefacts a project produces, can only be viewed after the project has been completed, and these are grouped together for the sake of clarity and presented in Figure 6.9.

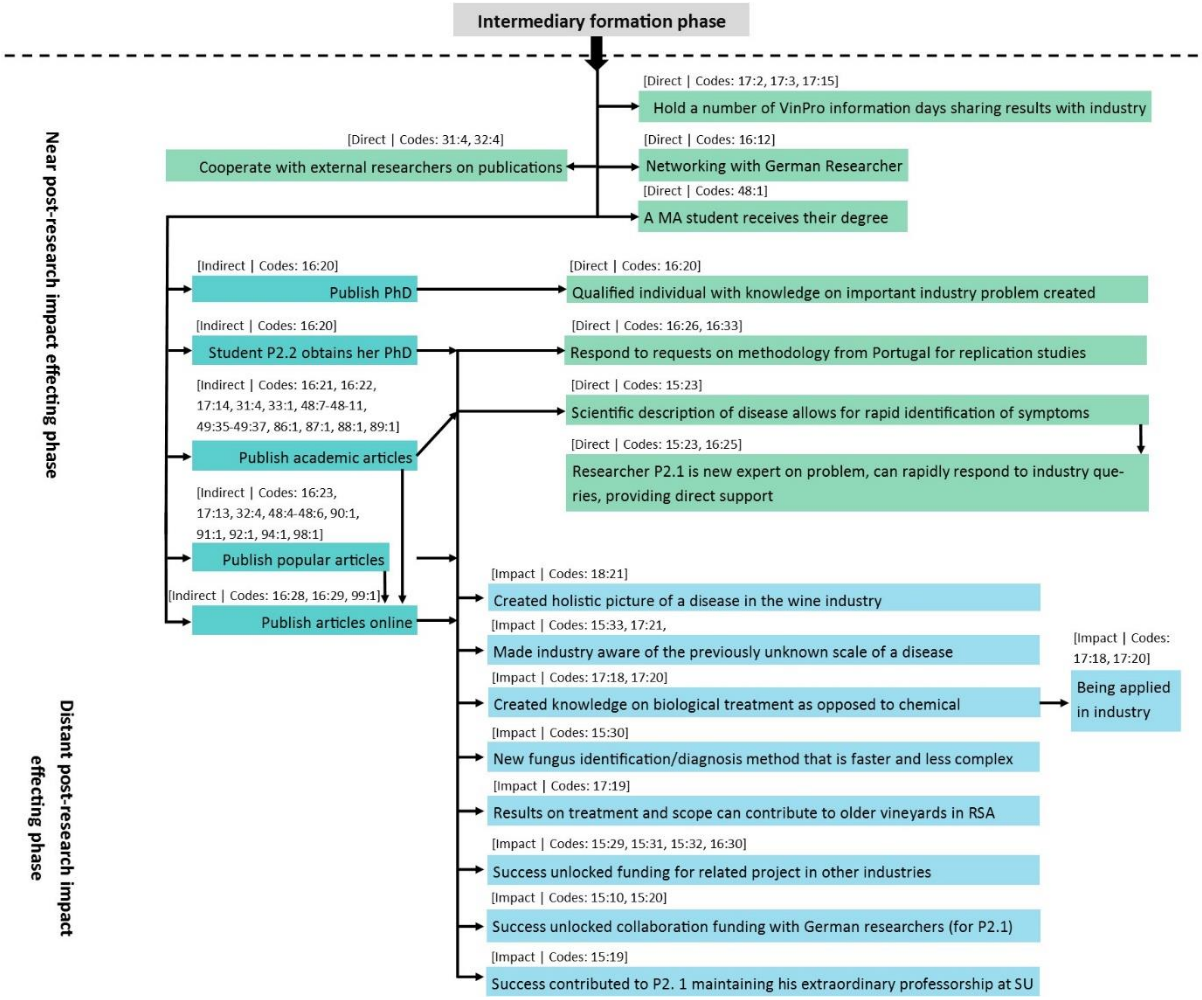

Figure 6.9 Project 2: Post-research impact-effecting phases with supporting interaction codes

Source: Author's own compilation

The project produced a number of academic articles, but also some popular articles. Popular articles appeared in the *Wineland,* and the project was reported on in the *Landbou Burger*. The popular publications produced interest from some producers.

> Interviewee P2.4: *Yes, yes, I saw it there [in the* Wineland*]. And then there were a few producers who also asked me about it [after reading the article], about more information on Esca. So, then we asked him [P2.1] to come and talk to us about it.* (Translated from Afrikaans)

The project also produced a master's student and a PhD student. The master's student was not mentioned in any of the interviews, but is mentioned in the final report for the project (P2_Document_Final_Report_01).

The researchers shared their publications online, including on ResearchGate making them freely available, keeping track of the engagement through ResearchGate and Google Scholar.

Interviewee P2.2: *Well, you kind of keep an eye on it. Look, with ResearchGate and Google Scholar and so on, you almost do not have a choice but to see what is happening.* (Translated from Afrikaans)

The researchers shared their results with industry through information days, including days organised by VinPro.

Interviewee P2.4: *I am aware of it. I had him as a speaker at one of my information days, on Esca. We had some queries, some suggestions from producers, to have a talk on vine diseases and so on, you know. So, then I asked him to come and do a presentation.* (Translated from Afrikaans)

The project drew queries, including queries from a replication study in Portugal. This is an indirect interaction leading to a direct interaction.

Interviewee P2.2: *I received some kudos here and there, but not too often. A Portuguese guy actually emailed me once, to find out what material we used in the experiment.* (Translated from Afrikaans)

Beyond the students trained by the project, the main researcher, P2.1, also benefitted from the project and has become the industry expert on Esca in SA vineyards. The description of the disease has produced knowledge that can be used for the rapid recognition of Esca without the need for tests on physical samples, as was done in the past. A consultant can send photos of infected plants (for example via WhatsApp), and receive a near immediate response. P2.1 describes the new ease of making a diagnosis:

Interviewee P2.1: *A viticulturist has asked me about two different symptoms on two different occasions. He cuts a branch, sends it to me [via a WhatsApp photo message], and while he is in the vineyard with the farmer, I can write back and make a recommendation. In the past, that would have taken weeks.* (Translated from Afrikaans)

6.6.6 Post-research impact-effecting phase (distant)

One of the main contributions of the research was that it made the wine industry aware of a problem of which it was not aware before. P2.4, a VinPro consultant, explained how the industry has become much more aware of the problem and how it might begin to push further research.

Interviewee P2.4: *So, where we came from, from around 2000 when they did not even know about the disease, to where we are today […]. Where they could come to us and say, listen we know what the impact is of what we are discussing. And that they could see that it was such a large problem.* (Translated from Afrikaans)

P2.3, the nursery owner, agreed with P2.4.

Interviewee 2.3: *Yes, I think it was very vague, we knew what it was, but we did not know what caused it. So, I think it shed a lot of light on the subject. So, I think it is very valuable that it exposed that type of thing.* (Translated from Afrikaans)

Table 6.9 shows a list of the most commonly found impact codes in Project 2.

Table 6.9 Most common impact codes in Project 2

Impacts	Count
Impact – Created industry-relevant knowledge	9
Impact – Expanded science	5
Impact researcher – Network expanded	5
Impact – Influenced own future research	4
Impact researcher – Skills development	3
Impact – Success unlocked funding	2
Impact researcher – Professional advantage	2
Impact – Commercial value for industry	1
Impact researcher – Job or professional opportunity	1

Beyond just identifying the problem, Project 2 also created knowledge on how to fight the disease biologically. At the time of writing, this information had already been taken up by VinPro consultants and was being used by some farmers to counter Esca.

> Interviewee 2.4: *I mean the work that they did, especially on Trichoderma especially is pioneering work. Especially on fungus, to try and prevent the stuff. So, I think it is very positive, and I recommend it to all my clients.* (Translated from Afrikaans)

He stated that there is widespread use of the recommended Trichoderma.

> Interviewee P2.4: *Yes. Yes. Yes … for sure. Like I said, Trichoderma that you apply to cutting wounds, it's being, it's being used a lot.* (Translated from Afrikaans)

The success of the research further benefitted the main researcher, P2.1, professionally. It unlocked funding for him to engage in a range of similar studies, including expansions of the study into the apple and pear industries with funding from Hortgro.

> Interviewee P2.1: *We have expanded the project to apples. So, deciduous and stone fruit. So, I think, at Hortgro, we now have a similar project with them on apples. Apples and pears … and then also, we are looking at apricots and plums, and things like that.* (Translated from Afrikaans)

The research also led directly to additional funding from Germany for research collaboration.

Interviewee P2.1: *I also got a collaboration project from Germany out of the research project.* (Translated from Afrikaans)

Although these new projects are not part of the older Winetech project, the success of the Winetech project contributed to the expansion into other projects. The Winetech project indirectly contributed, which means that it contributed to skills development or an increase in the capacity of an SA research institute (in this case, the ARC bringing in foreign experts). However, more importantly, this case study shows the importance of a researcher being enabled to bring his or her expertise to the industry and showing the industry where a problem lies. Although the narrative of a linear impact model has been shown to be incorrect, this case study shows that there are nonetheless cases where the expertise of a researcher should be engaged and supported.

6.6.7 Impact pathway in Project 2: Developing new techniques for the wine industry

In Project 2, some of the main impacts of the project are related to the primary investigator, P2.1, who realised that Esca was a problem in the industry without the industry realising that it was a problem. The primary investigator had to push for funding to undertake research on the problem. The research did not provide follow-up input from the primary investigator in Project 2, as he had to withdraw from the research at a very late stage due to overseas work commitments, which he could not have foreseen when he agreed to take part in the research.

Description of the impact

Researcher P2.1 identified Esca vine disease as a problem in the SA wine industry. His research on Esca allowed for the development of a rapid recognition (diagnosis) system, reducing diagnosis from weeks to potentially minutes.

Reflection on the productive interactions that constitute the impact pathway

Prior to this project, the wine industry was not aware of the scale of Esca vine disease in South Africa. P2.1, through his knowledge of vine diseases, became suspicious of the possibility of the disease in SA vineyards. Having identified the problem, he was unable to convince industry that it was indeed a priority. His rejection of application for funding (twice) represents two productive interactions where the outcome was not what was wanted by the project. The problem was presented to the funder, and the funder rejected it as unimportant or as an unproved problem.

Next, the researcher had to engage with industry, and launched a research project on his own to prove the scope of possible problem. Only after the results had shown that the disease was potentially widespread was funding made available by Winetech.

The research achieved its aim of describing the disease, and proved that Esca was prevalent in SA vineyards. The knowledge about the description of the disease allowed for the development of a rapid recognition system of the disease based on visual characteristics. It is now possible for an expert to diagnose Esca visually based on photos. Understanding which combination of fungi contributes to Esca disease (based on the description) also allowed for the development of biological control strategies (Interviewee P2.1).

Having developed a solution to a previously unknown problem, viticulturists and winemakers now engage with P2.1 to assist in identifying Esca in their vineyards.

There were a number of contextual elements that contributed to the success of the research. P2.1 had the reputation needed to convince the industry that he was competent to identify a new disease. His stature and expertise in the field gave added weight to his professional opinions, which led to a third successful funding application. P2.1 also had a large collection of samples of infected vines that he had been collecting for almost 20 years giving him the capacity to do the study in a limited period. Access to the large collection allowed the research to progress faster than it would have without it.

Also related to speed, P2.1 had a network through which he was assisted in identifying problem farms where potential Esca was widespread. This meant that time could be saved on identifying farms, and focus could be placed on describing the disease. Finally, P2.1 had international exposure that made him aware of the existence of Esca in Europe, which allowed him to recognise the same disease in South Africa. All of these various 'attributes' constitute the context and is based on different productive interactions that form part of the theory of change as illustrated in Figure 6.6, or originate from before the project started. The interest of P2.1 in Esca must have developed from interactions he had while abroad. He brought that expertise to the project and thus he himself interacts with the research contributing to the success of the research project. . Again, it should be kept in mind that productive interactions create a context for research.

The above impact pathway shows the importance of a (arguably competent) researcher pushing his research even in the face of rejection. Without his experience, confidence and competence, the Esca problem in South Africa would not have been addressed as quickly as it has been.

6.7 Constructing a theory of change for Project 3

Project 3, "Evaluation of mechanical thinning and GA[15] application on crop load of plums", was undertaken by the Department of Horticultural Science at Stellenbosch University, under the leadership of a professor in the department (P3.1). Her research was supported by a master's student (P3.2) and funded by Hortgro. The project mainly looked at the viability of making use of the mechanical thinning machine in SA orchards. The aim of the project was not necessarily implementation, but rather understanding of the viability of mechanisation technology and its use in SA orchards.

Table 6.10 Researchers and stakeholders interviewed in Project 3

Code	Role in project	Organisation at time of project
P3.1	Principle investigator	Stellenbosch University
P3.2	Master's candidate	Stellenbosch University
P3.3	Research participant and researcher for large stone fruit producer	Large producer
P3.4	Research participant import company (owner)	Import company

Project 3 shows an interesting dynamic between research, the agricultural industry and corporations (farming equipment business in this example). In this case study, the researcher, working on her own topic of interest, produced knowledge that benefitted her scientifically, the industry strategically and an import company (the farming equipment business) financially. All three of these cooperated through the project and benefitted accordingly in their own spheres.

15 Gibberellic acid

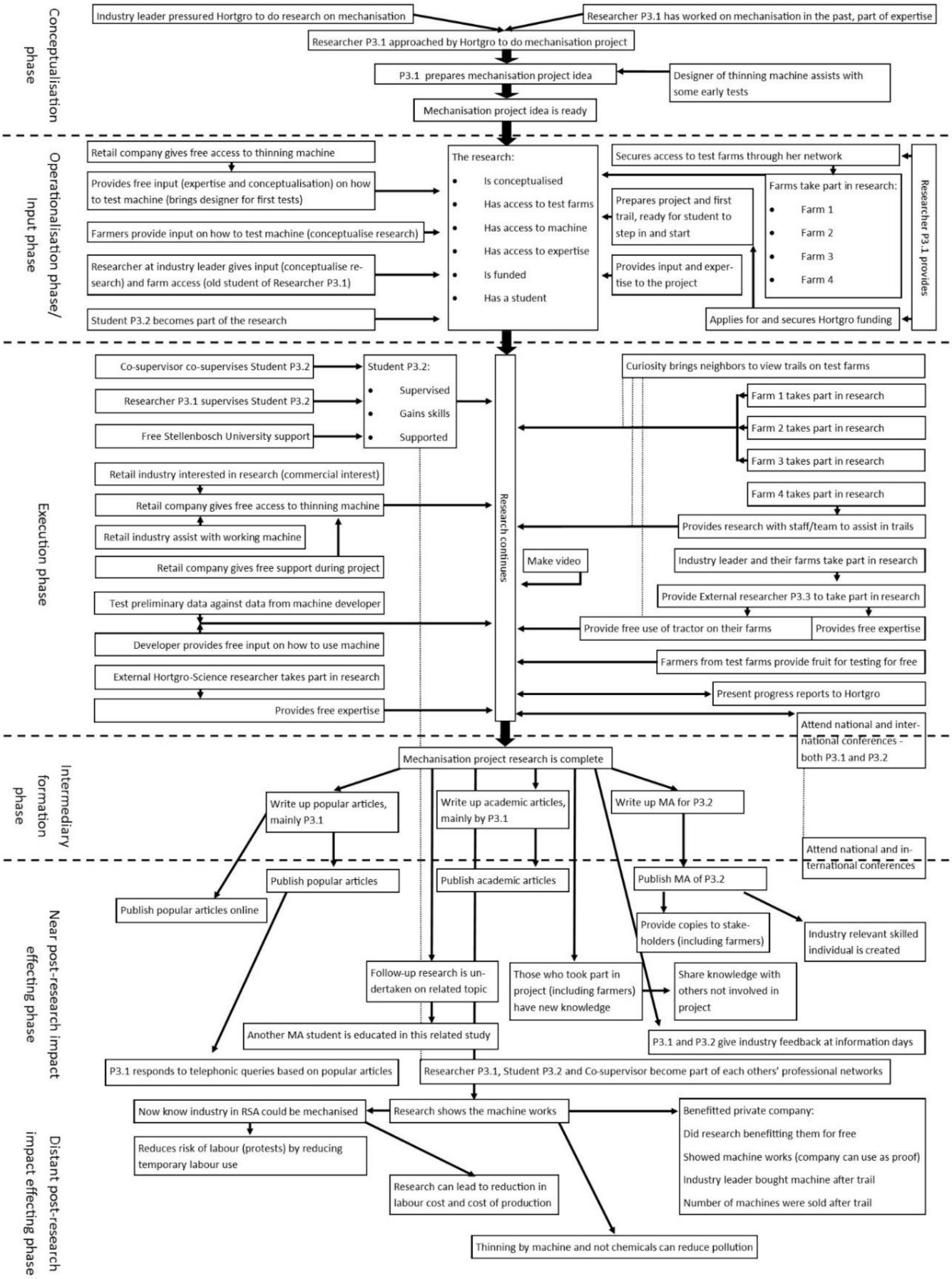

Figure 6.10 Project 3: Theory of change

Source: Author's own compilation

6.7.1 The conceptualisation phase

Project 3 came about because of the combination of two 'pressures'. The first was a push for research on mechanisation in SA orchards by a large producer in the industry. The producer requested Hortgro to launch studies on mechanisation in general, not only on thinning. The second aspect that affected the research was an interest in mechanisation and mechanical thinning by the main researcher in Project 3, P3.1.

> Interviewee P3.1: *I also started to wonder if we would be able to use the machine [the mechanical thinning machine], and it was actually by chance, it is strange how things come together, that [large producer] at the time started pressuring Hortgro for research on mechanisation, not just on thinning.* (Translated from Afrikaans)

Figure 6.11 presents the conceptualisation and operationalisation phases for Project 3.

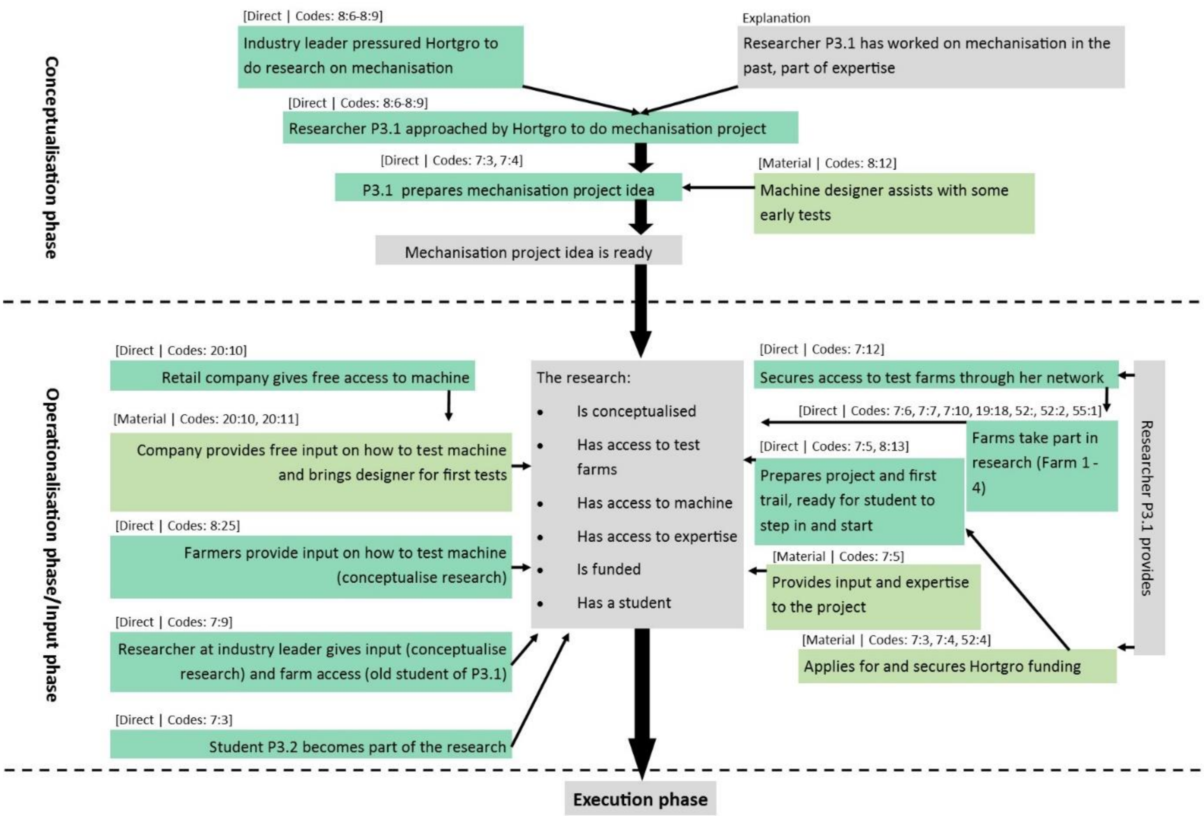

Figure 6.11 Project 3: Conceptualisation and operationalisation phases with supporting interaction codes

Source: Author's own compilation

By coincidence, an import company had just imported one of the mechanical thinning machines that P3.1 was interested in testing. Being eager to have evidence on the effectiveness of the machine, the importer was willing to lend the machine to the researchers. They also went one step further.

> Interviewee P3.1: *They actually brought the designer of the machine from Germany, because it can be quite unnerving when you are speeding around in an orchard with a tractor and you just see things flying.* (Translated from Afrikaans)

The project came together almost serendipitously, with a demand from industry, an independent desire to do the research from the researcher's side, and the support of an importer along with the designer of the machine. With all these aspects, the project was launched.

6.7.2 Operationalisation phase

During the operationalisation part of the project, the three different groups, namely the industry, the researcher and the importer all came together pooling their resources and expertise. P3.1 recruited a master's student to take part in the research, although the project was very clearly her interest (P3.1, the primary investigator) and formed part of her own research. As the master's student reported, P3.1 had already started with the research before he had even started the master's.

> Interviewee P3.2: *Ok. I have to say, [P3.1] basically did the first trial [she started the research]. I got the project like that, so I didn't begin to analyse the project from the start [he joined an already running project]. So, it was kind of nice, yes. Then we started the [next] trials and it went from there.* (Translated from Afrikaans)

This seems to have been part of P3.1's general strategy, since she also decided to do a second project in which she tested another machine, for which she also recruited a master's student.

> Interviewee P3.1: *And when the next season came, I brought another student on board. All of them M students. I brought another student on board that worked on stone fruit.* (Translated from Afrikaans)

Anecdotally, P3.1 said that the reason for using master's students is not only the ease of having more hands to help with the research. She also sees the training of the students as part of her responsibility as a lecturer, as especially not enough professionals are being trained to satisfy the industry demand.

From Hortgro, the project received the funding needed, while the industry player who pushed for the research provided access to their farms, along with the support of one of their researchers. A number of farms also gave access to their vineyards (P3_Document_Final_report_01). According to the master's student in the project, P3.1's networks also made it easy to gain access to farms.

> Interviewee P3.2: *Those were networks coming from [P3.1].* (Translated from Afrikaans)

In addition to the industry player who requested the research, the project also gathered input from other farmers and producers regarding their opinions on how the tests should be done, for example which trees should be used or how to thin the trees.

> Interviewee P3.1: *And you know, you speak to those guys [producers] and you say, "well, you know, I am thinning a tree, but with a handheld thing. But, now I have, you know, do I just thin the tops, or just on top of the branches'?* (Translated from Afrikaans)

The importer of the machine provided the machine itself, but also made its technical support staff available for the duration of the project.

> Interviewee P3.4: *We gave them expertise … we gave them the … the technical support. If something could have or would have gone wrong with the machine … which it didn't, but … in case it did … we were on stand-by for that.*

The support staff, similar to the farmers who advised on what is feasible in thinning, assisted the research with what is feasible to do with the machine.

> Interviewee P3.4: *So that her eventual design could take into consideration how the machine can work. I am just going to simplify this for the sake of the discussion on … on high, medium and low. […] Eventually she could say … well, the machine performed best on medium. Or best on high … or best on low, whatever it was. I am just simplifying it, obviously for now.*

What makes the operationalisation phase of Project 3 so different is that there were three (or four if counting the student) groups all with their own interests, working together on one project, all hoping for something different. For each of them the impact they expected was different. The industry player wanted research to be done on mechanisation in general, contributing to a mechanisation strategy for SA stone fruit producers. The researcher wanted to see if something that is growing in popularity in Europe could be used in South Africa, the importer wanted to sell his products and the student wanted a degree.

6.7.3 Execution phase

During the execution phase (Figure 6.12 below) of the research, the different interest groups maintained their presence, each ensuring that the research was being done in an unbiased and realistic manner.

P3.4: *P3.1 was extremely professional and her way of dealing with the whole thing was … you know … she really dealt with it in a very … very professional way. And … You know … I think she was mindful of the fact that she doesn't work for [importer of mechanical thinning machine] she works for a … university or research … […] She wasn't doing it for [the import company]; she was doing it for the industry.*

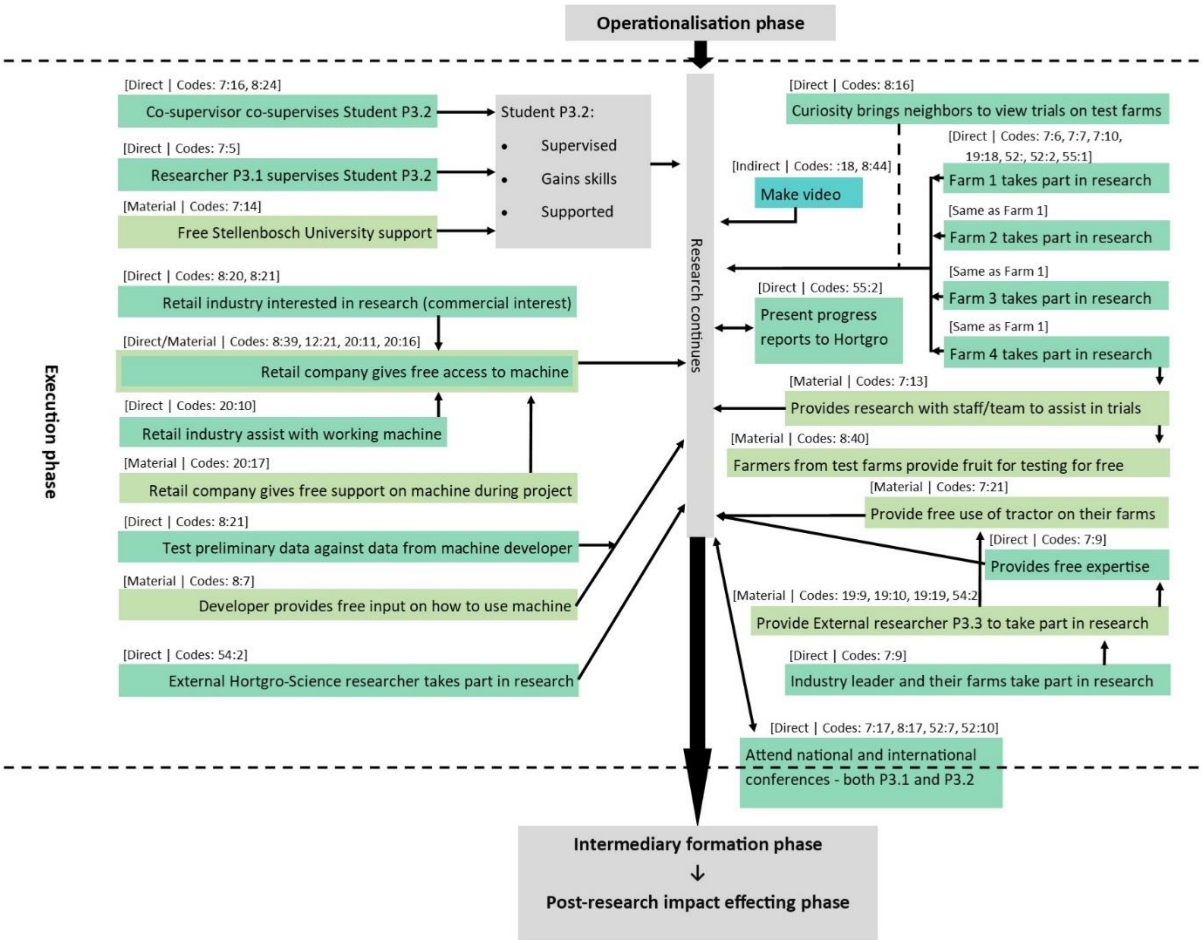

Figure 6.12 Project 3: Execution phase with supporting interaction codes

Source: Author's own compilation

The three main groups of researchers in this phase were the main researcher P3.1, her master's student, P3.2, and the student's new co-supervisor, who worked at Hortgro Science. The importer and designer of the mechanical thinning machines made up a second group. The final group comprised interested parties (mainly farmers and producers) from the industry who were either taking part in the research or attending the trials out of curiosity. P3.1 remained the master's student's (P3.2) main supervisor, with a co-supervisor being appointed.

Interviewee P3.2: *And he was just the co-supervisor, the one doing marking and so on. And I think he might have provided some input if I remember correctly.* (Translated from Afrikaans)

P3.2 was also supported by some of his peers at the university, who assisted him in doing the trials. The student was thus supported by his supervisor, co-supervisor, some 'colleagues' and the university support system.

The importer of the machine was a private company. The researcher (P3.1) understood that they were interested in the research, because they wanted to sell some of the machines.

Interviewee P3.1: *Yes, because the guy who designed the machine was extremely curious about our results and to see what our data look like, and can, you know, will he be able to sell more machines.* (Translated from Afrikaans)

The importer of the machine confirmed this in his interview.

Interviewee P3.4: *P3.1 was obviously indirectly doing us favour. […] I mean, her research might have concluded that the machine is a crock and … and that it doesn't work. So … so … I mean … we did it in a … we tried to do it in as objective a way as possible. […] So obviously in the end … because her … in my opinion her results were, […] they were very, very positive in my opinion. […] At the end of the day … that's … ja … that's why we did it.*

This explains why the company provided the machine free of charge to the research. The researcher confirmed that they did not charge her for using the machine.

Interviewee P3.1: *No, no … They just provided the machine.* (Translated from Afrikaans)

In addition, the company provided support in terms of how the machine works.

Interviewee P3.4: *We gave them [the research team] expertise … we gave them the … the technical support. […] We set up the machines … we coordinated … they obviously needed a tractor … so we coordinated the tractor with the clients … that there would be a tractor available. We provided … know-how from the factory … so … we … we brought the factory here. The owner of the factory … and who doubled up as a technician as well.*

The cooperation of the importer and the German designer of the project (through the importer) ensured that the research was undertaken in a proper way. The designer, for example, assisted the researchers in understanding how to use the mechanical thinning machine correctly.

Interviewee P3.1: *So we actually caused a great deal of damage. Luckily the German [designer of the mechanical thinning machine] showed up and he said, "no, no, no", we have to drive as close to the tree trunk as possible.* (Translated from Afrikaans)

Contact with the designers of the machine also allowed P3.1 to test her early results against their results. This provided some early options of correlation and adjustment.

> Interviewee P3.1: *The guy [designer of the mechanical thinning machine] is more of an academic, I contacted him regularly to check my data against his.* (Translated from Afrikaans)

There was a clear correlation between the interests of the importers (and designers of the mechanical thinning machine), and the researchers who conducted the study. Although the researchers remained objective, the importer hoped to gain from a favourable result.

From the industry side (the farming sector and Hortgro) there was a need to do research on mechanisation. Mechanisation, although a sensitive topic due to the fear of possible job losses, has the potential to contribute significantly to the agricultural sector of a country, especially in poorer countries. Mechanisation allows for the development of commercial agriculture (or expansion), increases the efficiency of production, could increase the diversification of agricultural crops, reduces the environmental cost of farming, and also increases the income and quality of life of farmers (Gauchan & Shrestha, 2017; Onwude, Abdulstter, Gomes & Hashim, 2016).

In addition to the interest of the large producer in terms of mechanisation, P3.1 (the primary investigator in Project 3) also had a connection with the producer through a researcher who worked there (P3.3). P.3.3 had been P3.1's master's student.

> Interviewee P3.2: *I think at the [large producer], we worked with [P3.3]. [P3.3] also did his master's with [P3.1]. So, when she contacted him it was easy to get access through him. That is why [farm] joined the project.* (Translated from Afrikaans)

P3.3 assisted the project in practical ways, contributing expertise and time, even though he was a full-time employee of the large producer.

> Interviewee P3.3: *Well, I think more on the practical side, not necessarily the statistical design and so on. I am not great with that, because they are. But the practical side in terms of what works practically, and what they should not add, and what they should look at and so on.* (Translated from Afrikaans)

The research had little trouble in gaining access to farms. Farmers were also keen to provide support, for example, by making their work teams available.

> Interviewee P3.2: *Yes, I did. I had to contact the manager on [farm] and [farm] and they just told me when I had to be there. And then they would give me their team and we would start harvesting and so on.* (Translated from Afrikaans)

Part of the reason for the willingness to participate came from curiosity. Farmers were curious to see what was happening – not least because researchers were bringing machines into orchards that made things "shoot and shake" (translated by author from Interviewee P3.1).

> Interviewee P3.1: *And the guys [the producers] spoke about it a lot, because you just see things shoot and shake the tree, and well, I did also present on other alternatives, but with this, when the guys find out that I am starting a trial, there would always be a neighbour coming along to see what we were up to. It was probably one of the trials for which I have had the most interest.* (Translated from Afrikaans)

With the support of the importer, designers of the machine, the industry (not least the funding) and a willing researcher, the project was completed.

6.7.4 Intermediary formation phase

The main aim of the research was to see whether the mechanical thinning machine was more effective (and to what degree if so) than hand thinning. This was done by comparing the time it took to thin an orchard by hand to the time it took the machine to do it. From this, the researchers (mainly P3.1) produced the final report, a number of academic articles and P3.2 wrote his master's thesis. Additionally, as in the other projects, the researcher and master's student attended national and international conferences during and after the completion of the research. The only productive interaction captured in the intermediary phase was a direct interaction between the researcher (P3.1) and the importer of the mechanical thinning machine.

> Interviewee P3.4: *Indirectly, yes … obviously, some information in there would have come from us. […] but it would have been … but it would have been … let's say re-written by them in a way that they wanted it. […] I can't claim to have any … part of that. I mean … apart from the fact that we gave them the machine to test.*

P3.4 explained his role in the publications that were written after the research had been completed. He indicated that his only further role was providing additional data.

In the post-research phase (near), the academic articles and popular articles were published. P3.2 also received his master's degree. What came out strongly in Project 3, other than just finishing the master's, was that the researchers made an effort to distribute the results to the industry. P3.3, the employee from the large producer, for example, received a copy at the master's defence.

> Interviewee P3.3: *The thesis … the defence that he did … Yes, I received a copy of his thesis.* (Translated from Afrikaans)

6.7.5 Post-research impact-effecting phase (near)

Similarly, the importing company was provided with a copy (see Figure 6.13 for the post-research impact-effecting phases of Project 3).

> P3.4: *I think she gave them to us […] initially. I think … let me certainly correct it … there was a student that … sort of worked on it … for her … or worked on it. And … and he completed it and he gave us that … that research in a bound copy I think.* (Translated from Afrikaans)

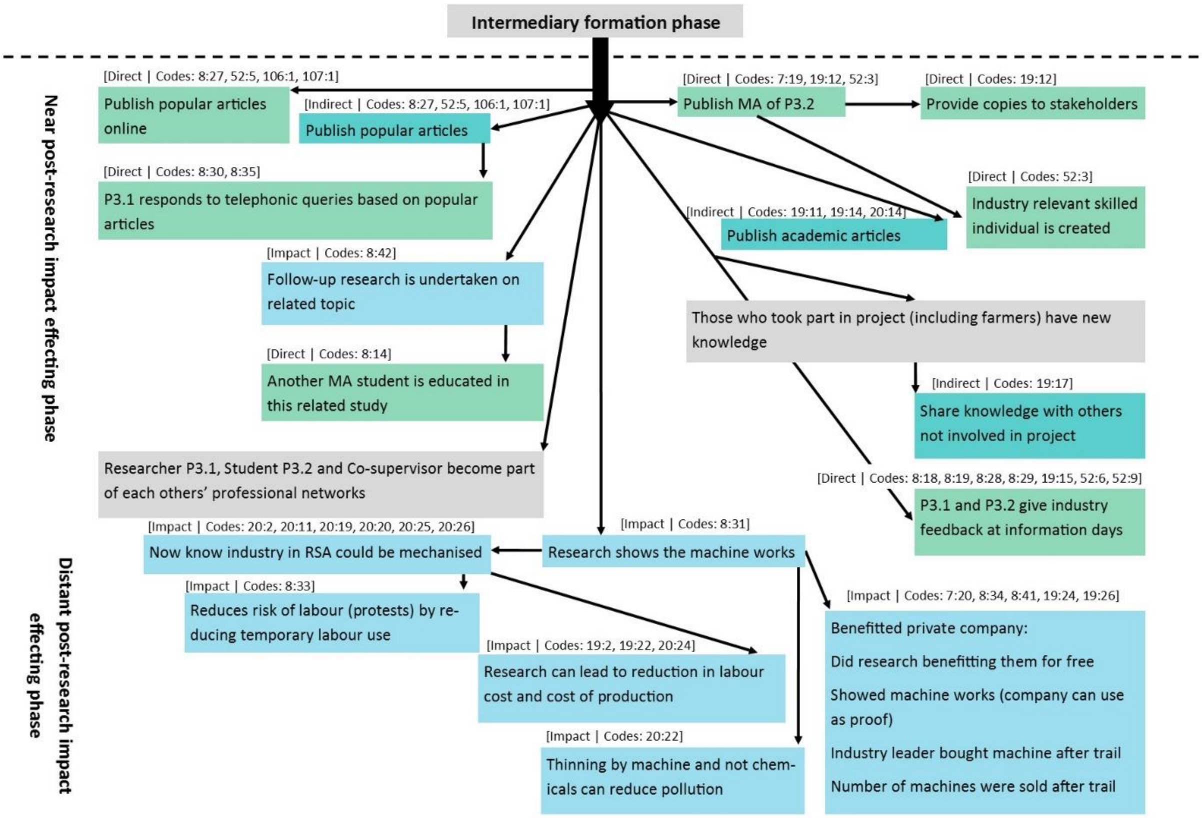

Figure 6.13 Project 3: Post-research impact-effecting phases with supporting interaction codes
Source: Author's own compilation

The results were published in the *South African Fruit Journal*, a popular magazine in the fruit industry. Hortgro also prefers that all the projects it funds should publish at least one article in the magazine.

> Interviewee P3.1: *And then I wrote a popular article on it in the* South African Fruit Journal*, which is more transmitting the information to the technical community than to say, higher-level farmers or producers.* (Translated from Afrikaans)

Both the master's student (P3.2) and the main researcher (P3.1) mentioned that 'someone' published a video clip of the tests in the orchards online. Even for the researchers involved in the study, the image of a machine driving through an orchard with flowers flying everywhere was a novelty. It seems the video was posted online due to the novelty, less than from a desire to educate. The video clip could not be located by the researcher in the currect study.

> Interviewee P3.1: *So, I think they also posted a video of the student working with the machine on their website. I do not know if it still there.* (Translated from Afrikaans)

The publication in the *South African Fruit Journal* drew most attention from the industry in general.

> Interviewee P3.1: *And another thing that is hard to quantify is the number of calls you receive about it. Your name is usually printed with the article, and the guys know where to find you. If they do not know, they will find out and phone you. Yes, it is interesting …* (Translated from Afrikaans)

Other than publications, P3.1 also directly engaged the industry through information days, including one where all the main players (according to her) were present.

> Interviewee P3.1: *Yes, I think it is. And the one lecture was definitely at the Hortgro Sciences symposium, so that is a group of 500 people, and they are literally the most important people in the industry that you reach there. And then also a few lectures primarily in the stone fruit field.* (Translated from Afrikaans)

Lastly, the information produced by the research also benefitted the company that sells the mechanical thinning machine. For them, other than the providing the machine and expertise, the research was free.

> Interviewee P3.1: *[Also of interest is] … the fact that you work with the company that imports the machine, that you provide them with all of the information and they basically use that information to sell it.* (Translated from Afrikaans)

The above quote refers to the symbiosis that emerged in the project. Different actors coming from different networks came together in one project. The results of the project had a very different meaning for each of the groups.

For the researcher, it created an opportunity to teach students, to satisfy her curiosity and to build her career. For the company, it provided an opportunity to have their product tested, hopefully for them, leading to scientific credibility of its abilities. For Hortgro, the project formed part of achieving their mandate to support industry-relevant research and development.

6.7.6 Post-research impact-effecting phase (distant)

The main impact category in Project 3 was the creation of industry-relevant knowledge. This is similar to Project 2, however, the knowledge created is clearly somewhat different. In Project 2, this knowledge related to the understanding, diagnosis, prevention and treatment of Esca. The knowledge of the project was thus arguably directly usable. In Project 3, impact-relevant knowledge can also refer to, for example, the fact that the mechanical thinning machine works.

Table 6.11 Most common impact codes in Project 3

Impacts	Count
Impact - Created industry-relevant knowledge	19
Impact - Commercial value for industry	15
Impact researcher - Skills development	3
Impact researcher - Network expanded	2
Impact - Influenced own future research	1
Impact - Leading to research/researched by others	1

Although the research started with the aim of mechanising farming practices, the context of high unemployment rates in South Africa meant that it was not socially acceptable or responsible to mechanise. However, mechanisations strategies can have other benefits, as mentioned above, for example making the orchards easier to work in for labourers.

> Follow-up P3.1: *I think, when we plant new orchards, we have to improve access. If you could drive in our orchards at double the speed that you can now, you will not be taking a job from anyone, but you will be able to use the implements you already have a lot more efficiently. So, I think there are a lot of other things that we learned from the process.* (Translated from Afrikaans)

One of the negative results of mechanisation in most industries is the reduction of labour. While this is often seen as an acceptable cost for improved efficiency and competitiveness, the reduction of employment opportunities is a very sensitive topic in South Africa. In this case, it also shows how research is not only something that develops knowledge to be dispersed, but also a process that has to learn from the environment within which it is. In this example, the social setting of the research affected the research. The context of research, just like the social context of a social programme, is important.

There were three main areas of distant impact. The one focussed on the academic offshoots, the second on the benefit to the import company, and the last on mechanisation (the focus of the study) in South Africa. After the successful completion of the mechanical thinning machine project, P3.1

started new research studies looking at other machines and their effectiveness. The mechanical thinning machine study became one mechanisation study in a larger body of work.

> Interviewee P3.1: *Yes, the other two instruments I tested on apples and pears and other planting systems, but our [South African] tree forms are not suitable to it, or not as suitable to it.* (Translated from Afrikaans)

For the import company, the research showed that the machine worked. With the proof, the company was able to sell a number of machines to the industry. According to the researcher from the large producer who requested the research, their purchase of the machine was directly related to the research. The research showed the mechanical thinning machine worked.

> Interviewee P3.1: *Yes, I know of a few guys in the industry who bought it. As a result of … you know it has been statistically proved on a number of cultivars … it's not just trials on his farm or whatever. I think four or five guys bought the instrument.* (Translated from Afrikaans)

The importer also agreed that proof produced by the research benefitted his company. He did however also state that he cannot be sure to which degree his salespeople or the research was the cause of sales.

> Interviewee P3.2: *Now … how many of those we sold as a result of … of the research of Professor [P3.1] … or how many we sold as a result of the initiatives of my own salesmen … are two different discussions. And … It's probably … let's say … a little bit of an overlap between the two.*

The quote above provides an illustration of contribution. One of the impacts of Project 3 was the selling of thinning machines. The fact that the industry bought the machines shows that they are seen as contributing value to the producers buying them. This impact, of selling the machines, only emerged as a result of research or productive interactions by non-linked stakeholders (individuals who did not take part in the research project).

Finally, the project made a contribution to the understanding of mechanisation in the SA fruit industry. It showed that use of a machine such as the mechanical thinning machine can save farmers labour time.

> Interviewee P3.1: *They have a stone fruit farm, and they said that the benefit to them would be the nectarines that they can thin with it. So, it is a relatively new farm with uniform planting, so they can easily use the instrument there. It would cut thinning time by about a third.* (Translated from Afrikaans)

The effectiveness of the machine can also reduce labour risks, by allowing farmers to employ only full-time staff.

> Interviewee P3.1: *And then the other benefit, and politically it might be a bigger issue, you can have the permanent labour do all the hand thinning without getting in seasonal workers.* (Translated from Afrikaans)[16]

The machine has the potential to reduce labour costs. Although mechanisation is approached with great caution due to the sensitivity of the issue, it does give the industry additional options.

> Interviewee P3.3: *No … I mean, it is a 100 per cent new technology with which you can save on labour. So, it is a big benefit.* (Translated from Afrikaans)

The sensitivity to the labour issue shows how the results of research can be affected by the context (social and political). Although relevant and useful research results had been produced, the context (a need to protect labour) means that the machines will not be adopted on a large scale.

6.7.7 Impact pathway in Project 3: Creating an evidence base for a commercial product

In Project 3, the impact pathway related to the combination of three different groups of stakeholders in one project, but also to the wider context in which research took place. In the project, stakeholders from academia, industry (the stone fruit industry) and the commercial sector worked together.

Description of the impact

The research in Project 3 showed that a product, which is commercially available to farmers, was effective at reducing thinning times (thinning is the process of reducing the number of flowers on a tree to achieve optimal fruit-carrying capacity for a fruit tree). It showed that the product worked. This led to some farmers buying the product.

Reflection on the productive interactions that constitute the impact pathway

In Project 3, three different interests came together, that of industry (stone fruit industry), a commercial company, and researchers. Industry players had begun to put pressure on Hortgro to fund research of mechanisation strategies in stone fruit production. This led to funding being made

---

[16] Please note: Due to the risk of reducing employment in the deciduous fruit industry, along with a number of other considerations, the industry has opted not to follow the route of mechanisation. (P3.1 Follow-up, 2018)

available for research that worked on mechanisation. P3.1 had just returned to South Africa from a conference in Europe where she had seen a specific thinning machine that she wanted to test in SA orchards. P3.1 had previous expertise on mechanical thinning. It also happened that a commercial company had begun importing the very machine that P3.1 wanted to test.

From these three converging interests, the project was born. When Hortgro put out a call for mechanisation strategy research, P3.1 applied to test the thinning machine she had seen in Europe, and the commercial company offered her a machine to test. In addition, the company flew in the designer of the machine to assist P3.1 in understating how to use the machine correctly so that it could be assessed fairly. The farmers in the stone fruit industry were also willing to give access to their orchards to test the machine since they were interested in the results.

With everything in place, the machine was tested in SA orchards by P3.1 and found to be effective in reducing thinning times. The results contributed to Hortgro being able to expand on the mechanisation strategy they were asked to develop, and led to the sale of some of the machines (benefiting the commercial company).

In Project 3, the coming together of three different stakeholders' interests at the same time created an optimal condition for the project to take place in. The results of the project however later proved to be less important to the industry as the context of possible job losses due to mechanisation meant that the focus on mechanisation was dropped by the stone fruit industry. There are other benefits that can still be implemented without losing labour opportunities.

> Follow-up P3.1: *It [mechanisation] is on the backburner. I think the big thing is that it is important to make our orchards more 'mechanisation-friendly', but not to mechanise. In the process you also make your orchards friendlier for labourers to work in.* (Translated from Afrikaans)

The results of Project 3, although leading to some sales of the thinning machine has had a reduced impact due to a shift away from mechanisation in many farming sectors. The context in which the research was undertaken changed during the research process with labour unrest in the farming industry. The unrest became politically and racially loaded, which made mechanisation and potential job losses an unrealistic strategy.

6.8 Constructing a theory of change for Project 4

Project 4, "Early market access of Forelle pears to EU market using [commercial product] and targeted maturity fruit", was commissioned by Hortgro from ExperiCo, a private research company, with a history of working with the commodity company (Hortgro). SA Forelle pear exporters were being outcompeted in the market by lower quality Chilean Forelle pears. SA exporters focussed on quality, reducing astringency and improving taste, while the Chileans exported their smaller volume without these quality checks in place, instead focussing on speed to market. This both damaged the brand of Forelle pears in Europe, and meant that Chilean pears could get to market faster than SA pears. The research set out to find a way to remedy this, preferably by reducing the cold storage needed to ensure SA fruit quality.

Table 6.12 Researchers and stakeholders interviewed in Project 4

Code	Role in project	Organisation at time of project
P4.1	Principle investigator	ExperiCo
P4.2	Original principle investigator (left)	ExperiCo
P4.3	Hortgro representative	Hortgro
P4.4	Research participant	Forelle Producers Association

Project 4 is the case study that provided the clearest example of problem solving or so-called ‘applied’ research. In this case, a problem was identified by industry, and researchers applied their minds to solving the problem. Unlike the other projects, this project was run by a research company that profits from successful research. The company in question, ExperiCo, is partnered with Hortgro and frequently does research for the stone fruit industry as commissioned by them. The theory of change for Project 4 is presented on the next page in Figure 6.14.

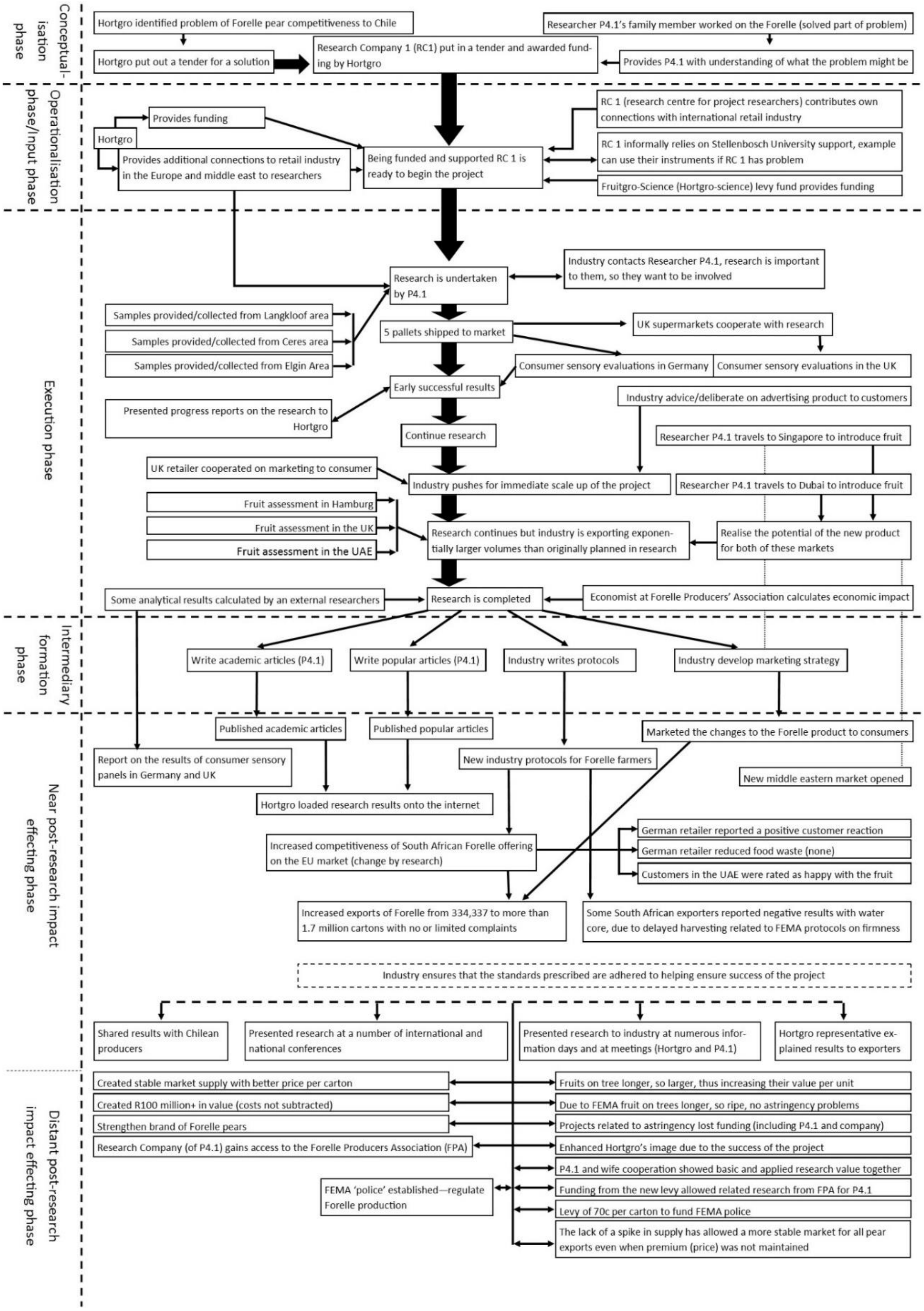

Figure 6.14 Project 4: Theory of change

Source: Author's own compilation

Project 4 showed what would generally be viewed as a flagship project. The results of the project increased industry profits, helped the local industry to access new international markets, it solved a longstanding problem that had reduced the competitiveness of the industry, and the contribution of the project can be quantified in monetary value, with the financial impacts already being felt during the research process.

6.8.1 The conceptualisation phase

The research was conceptualised in terms of a problem that required a solution. The problem was identified by Hortgro who put out a tender to solve the issue of how to get Forelle pears to the market faster (see Figure 6.15 for an overview of the conceptualisation and operationalisation phases). In addition, a possible solution (that had to be researched), came about at the same time from P4.1, who in contact with his wife (a researcher at the Stellenbosch University), had done research on the topic of astringency in Forelle pears.

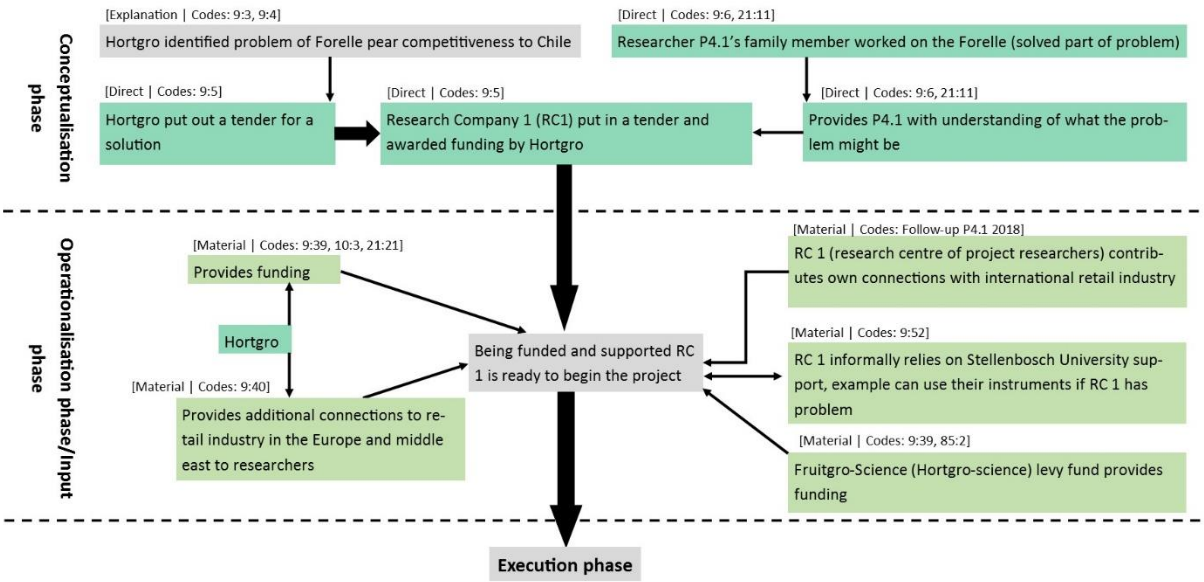

Figure 6.15 Project 4: Conceptualisation and operationalisation phases with supporting interaction codes

Source: Author's own compilation

> Interviewee P4.1: *What happens every year, is that the industry identifies critical areas of research, problems in industry. So, what goes out there is a questionnaire to all the producers, to the pack houses, to the exporters, you know, what are critical areas of quality, economic loss. In other words, as an industry body, which this came through Hortgro. […] And that's where the industry was saying that we need to do something about bridging this gap*.

ExperiCo then put in a tender in response to the call for projects.

> Interviewee P4.1: *Look, I mean we've got an alliance as a company, ExperiCo, with Hortgro, as being their postharvest service provider. So, we've got a contract in place to really try and meet their needs.*

In this case, however, P4.1 had already been interested in the topic of astringency in Forelle. At the time, none of the tests to try and limit it had yet been successful. However, P4.1's wife had had a breakthrough in her research, which also looked at astringency in Forelle.

> Interviewee P4.3: *He had the idea, and if you go back, it was actually his wife who showed the reasons for mealiness in Forelle. And if you understand that, it is clear why the other solutions did not work.* (Translated from Afrikaans)

With the understanding of what causes the astringency (linked to the research on mealiness), P4.1 was able to tender successfully for the Hortgro funding with a new idea of how to prevent it.

6.8.2 Operationalisation phase

In the operationalisation phase, the funding agreement with Hortgro was formalised and additional funding from the Forelle Producers Association was sourced. The additional funding was processed through Hortgro.

> Interviewee P4.1: *And also, as I've mentioned earlier from the levy fund that came through the … through the Forelle producers association. But that was also handled through Hortgro.*

This was confirmed by a Hortgro employee who worked with the funding at the time. He also explained the process of how funding was distributed.

> Interviewee P4.3: *It went through my hands. Everything, we are facilitators for research, in other words we find out with which problems industry has to cope. Then we direct the research funding which we get, which is what the grower pays on a per kilo basis. And we place money at research institutions.*

In addition to funding the project, Hortgro also assisted the project in getting into contact with the right industry players. ExperiCo was already well connected in Europe so this was an additional role that Hortgro played beyond ExperiCo's own networks.

> Interviewee P4.1: *No, it was mainly funding and maybe market access you know, putting us in touch with the right people, that type of thing. It was, you know, if you have to go see let's say [UK retailer], you know, then they will help set up the meetings and put us in touch with the right people.*

Informally, ExperiCo was also supported by Stellenbosch University.

Interviewee P4.1: *We help each other [ExperiCo and Stellenbosch University]. Their … one of their equipment instruments break down, you know, they've got us to fall back on, we've got them.*

Although the interactions between the university and ExperiCo were mentioned and captured in the interviews, no evidence of such direct co-operation was found, except for the sharing of ideas.

6.8.3 Execution phase

As can be seen from previous quotes, an environment existed conducive for conducting the research of the Forelle project, based on the reported support and co-operation between Stellenbosch University, and ExperiCo (Figure 6.16 provides an overview of the productive interactions in the execution phase).

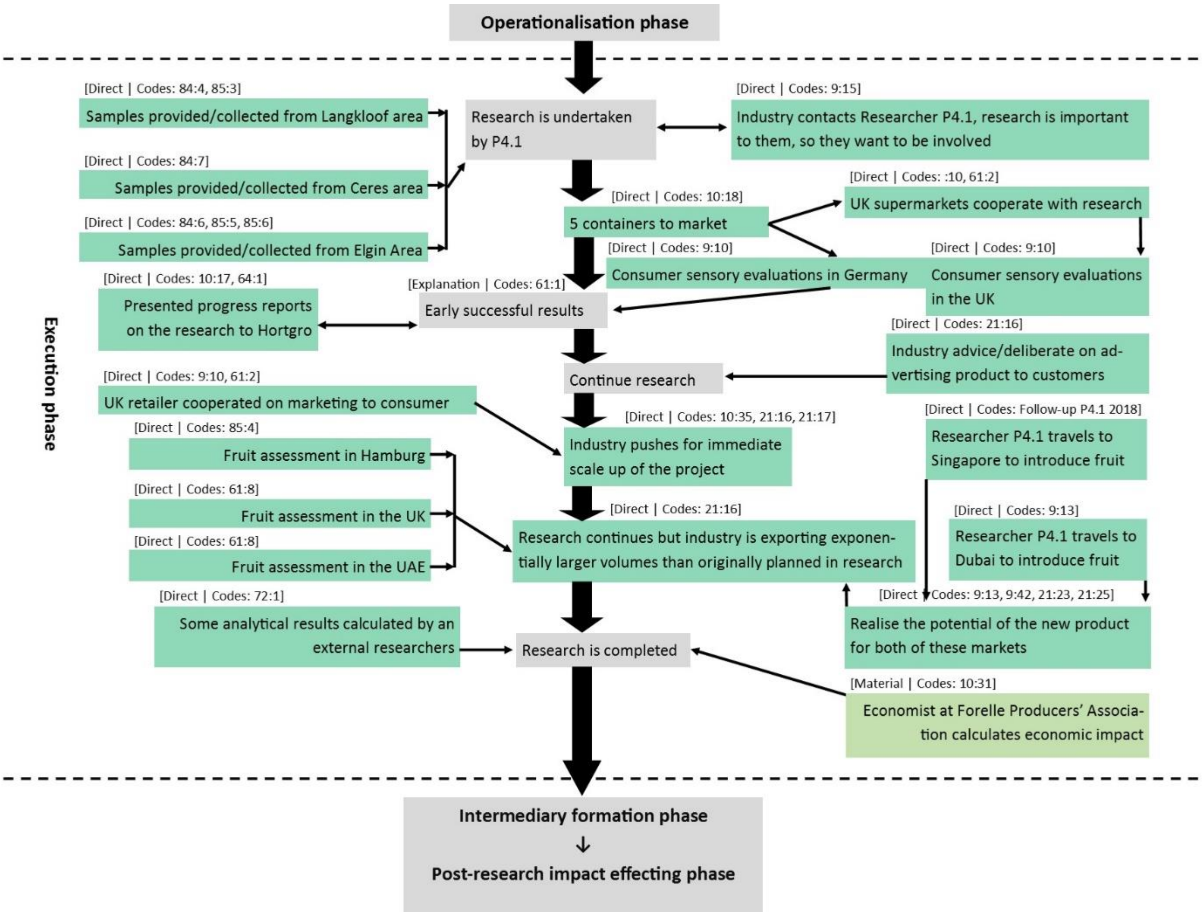

Figure 6.16 Project 4: Execution phase with supporting interaction codes

Source: Author's own compilation

In addition, P4.1's wife, who works at the university, provided him with the scientific background to understand better how astringency works in Forelle pears. Hortgro assisted by ensuring that the researchers from ExperiCo gained access to relevant role players in the industry, such as international retailers where the Forelle pears were sold.

Samples of treated Forelle pears were collected from different farms in three regions of South Africa, namely from the Langkloof, Ceres and Elgin areas. Throughout the research period, fruit were tested at various institutes around the world, for example in Germany, the Netherlands, the United Kingdom and the United Arab Emirates (P4_Document_Information_Sheet_08; P4_Document_Final_Report_01].

In addition to testing the fruit, consumer taste tests were also organised by the project researchers. P4.1 travelled to Europe to do the tests.

> Interviewee P4.1: *I went overseas and I did taste tests […], I think I had five or so trips overseas […], I went to Germany, I went to the UK, we organised taste panels and I've actually added that for you in here as well. […] I went to [*UK-based retailers*], I went to all of them, you know.*

The first part of the research was 'conservative', as it was unclear whether the research had solved the problem of astringency.

> Interviewee P4.1: *So, in the first year, those five containers were distributed but they were brought into some of the consumer programmes, you know, where they were, had proper consumer panels in Germany and the UK […].*

During the research execution phase, P4.1 also delivered yearly progress reports to Hortgro.

> Interviewee P4.3: *Yes. Yes, we do. We have a formal interaction. Once a year they've got to submit a progress report. So then we evaluate that to see that it's, you know, meeting the … there are milestones which I said in the beginning. It's meeting milestones and that kind of thing. […] Then they speak to us or once a year we get the report, and we look at it and advise on perhaps a way forward or we're happy with it whatever the case may be.*

The industry was very interested in the project from as soon as they were made aware of it. They were fully aware of the need to address the competition issue with the Chilean exporters. The Forelle industry is highly regulated in South Africa, with a very active industry body.

> Interviewee P4.1: *They were … they were … they came in, when they … well once they knew about it, they came in because you know they have to protect the brand. The Forelle is a South African pear brand you know and because of that you know, they likewise, they police, you know they are involved with the regulations and stipulations and the harvest release dates and all of that … it all goes through this Forelle Producers Association because it is such a challenging pear.*

Once the industry saw that the results for the study seemed to be positive they immediately pushed for large-scale adoption. This created excitement in the research team, but also some anxiety due to the risk of failure.

> Interviewee 4.1: *So, obviously, they had to get involved and so the biggest influence for me was the excitement and the fact that they wanted to move on it.*

The Hortgro employee (P4.3) spoke of this anxiety.

> Interviewee P4.3: *I mean [P4.1] nearly had a heart attack when people said they wanted to do this.*

Industry wanted to go 'all in' as they needed to get a solution to their problem quickly, with the risk of losing the market. Instead of following P4.1's suggestion of increasing the research sample from five containers to ten containers, industry decided to export 300 000 cartons.

> Interviewee P4.4: *He wanted, he wanted … typically researcher … now we have to check it just a bit more. And the industry said, "no, we do not see a downside to it, 300 000". And then it was 1.1 million, I think. From a commercial … from a marketing side, we thought there was very little downside to what he did. How could anything go wrong with 300 000 cartons? It's in the market with Chile, what is the worst that can happen?* (Translated from Afrikaans)

With Chilean products already on the market reducing the quality and brand of Forelle, the SA Forelle industry decided that there was little to lose. A full 300 000 cartons, even if a failure, would not do more damage than the Chileans were already doing (the Chilean Forelle export market is not regulated). Luckily for them, the research was a success – in this case, the success was part of the research study. There was however still the need to sell the 'new product' to consumers. Unlike what might be expected from a red blush fruit, the Forelle pears resulting from the research are sweet and crispy, similar to apples. The consumer had to be aware of this or would be confronted with a product that behaved in a way they did not expect.

> Interviewee P4.4: *Crisp and sweet. And interestingly enough, the only country that had a problem with it was England. And after the first year that it had been rolled out, they were the country with the most complaints.* (Translated from Afrikaans)

The most complaints originated from the United Kingdom ['England' is often used in South Africa to refer to the whole of the United Kingdom] where some of the retailers did not want to follow the advice of the research. Instead of clearly marking the products as crisp and sweet, they only attached small stickers to the back.

> Interviewee P4.4: *But the English said no, no … they do not want it, because they have their own bag. So, they printed, something along the line of 'Best enjoyed firm' or whatever, on the back of the packet, in a small font. And they had the most comebacks.* (Translated from Afrikaans)

This showed the need to communicate with the consumer. The 'new' crisp and sweet Forelle also turned out to have a large market in the United Arab Emirates (UAE).

> Interviewee P4.1: *Other thing [is], I went to the Middle East and Far East and I spoke to them. I remember landing in Dubai, it was 49 degrees outside. It was incredibly hot. They want things that are not going to be one day and be unsellable. So for them this was a gift from god, you know. And likewise, Singapore, Malaysia, they need something that can handle that high temperature and humidity. So, they, this programme was a perfect fit for them, so it opened up new markets like the Middle East and Far East for these pears.*

The research concluded by having shown that the new way of treating Forelle pears was a success (more of which is described in the post-research impact-effecting phase). As it became clear that the Forelle project was a success, an economist at the Forelle Producer's Association began to track the financial contribution of the project.

> Interviewee P4.3: *At the Forelle Producers Association annual general meeting, we have an economist [name] looking at the economies of Forelle, where it's doing well and where it's not doing well. And at the time that the FEMA project came on board and somewhere after a while it was separated in the distribution chain through a different marking, a different code, so it could be identified separately.*

The separate identification allowed for later economic calculations on the contribution of the Forelle project.

6.8.4 Intermediary formation phase

No interactions were captured for the Intermediary formation phase. This is not strange, since as has previously been said, this phase is not a real phase, but more 'something that must happen somewhere'. Articles must be written, and this only happens after the research has been completed (or admittedly, for some, article during research). It only happens once there is something to capture or present. From later interactions, we know that this phase included:

- the writing of popular articles by P4.1;
- the writing of academic articles by P4.1;
- the writing of protocols by the Forelle industry (incorporating research recommendations); and

- the development of marketing strategies by the Forelle industry (incorporating knowledge from the research).

6.8.5 Post-research impact-effecting phase (near)

It was somewhat difficult to distinguish whether the research produced any academic articles or only popular ones. The *South African Fruit Journal* is the preferred magazine for many commodity companies in the SA fruit industry. The magazine is however not an academic journal, but rather a publication similar to the *Wineland*. It publishes 'popular articles', as opposed to academic peer-reviewed articles. From the interviews, it was clear that some articles were published in the *South African Fruit Journal*, but due to the confusion of the use of the word 'journal', it is not clear whether the research was also published in academic journals. When making use of the information in the final report for Project 4, there were no mention to academic journal articles. However, research is often only published in academic journals after these reports had been compiled.

> Interviewee P4.3: *Ja. Look, this is published in the* South African Fruit Journal*.*

The primary investigator agreed.

> Interviewee P4.1: *Yes. Ja, look there were two or three publications that came from this in the* Fruit Journal*, ok.*

From the quote below, it seems that the information might also have been published in an academic journal. There are none listed in the final report. It is however not uncommon for researchers to publish articles on their work only after specific research projects had been completed.

> Interviewee P4.1 *So, I mean the information is certainly out there. Once you publish something in a journal in South Africa, you know, within an hour, everything is digital.*

The information was also made available online.

> Interviewee P4.1 *All of this information is on Hortgro's website and anyone from around the world can access Hortgro's website.*

From follow-up anecdotal evidence it became clear no academic articles were published. Figure 6.17 below shows the post-research impact-effecting phases for Project 4.

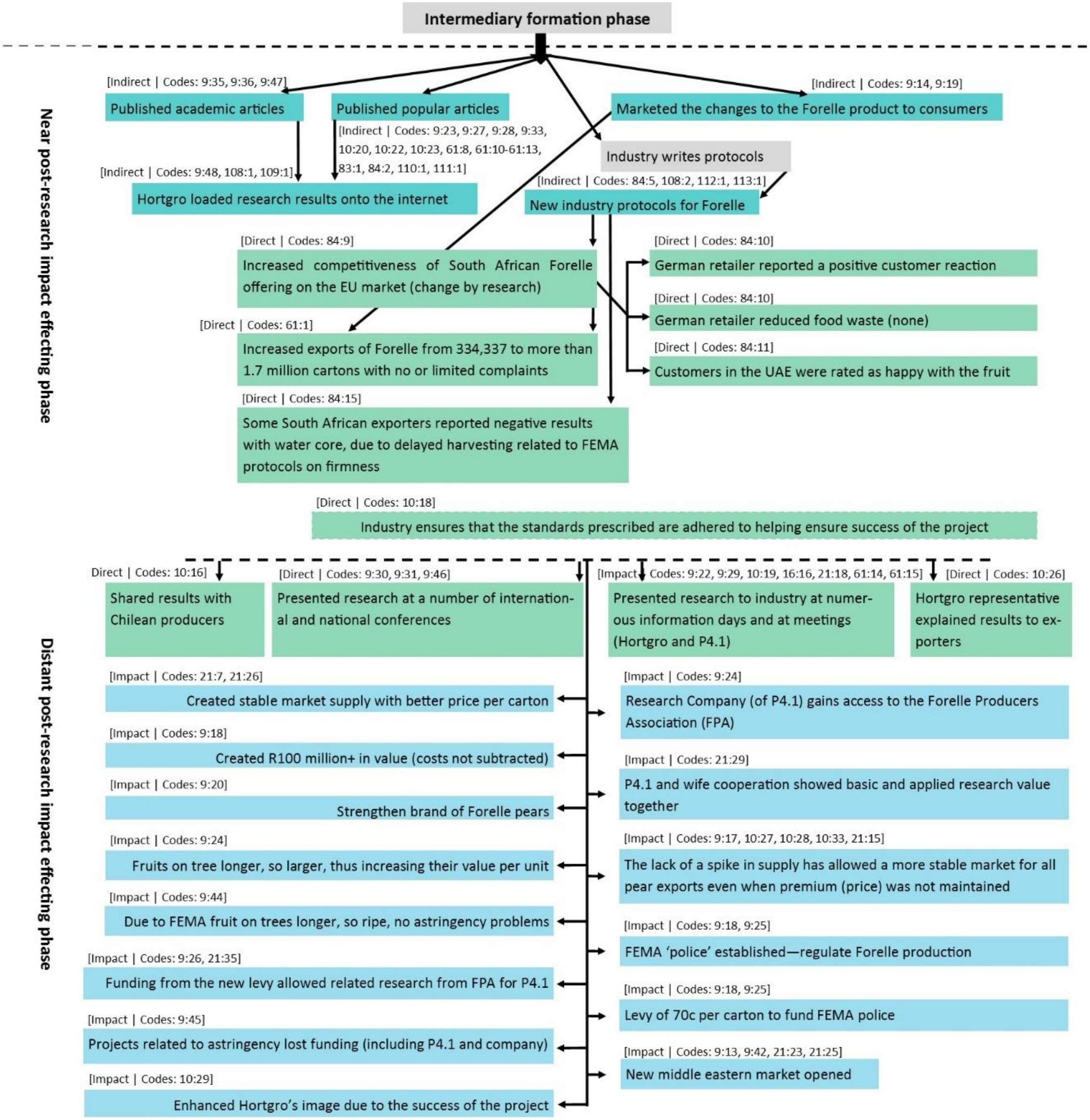

Figure 6.17 Project 4: Post-research impact-effecting phases with supporting interaction codes

Source: Author's own compilation

The research was also spread directly (in addition to the popular articles). P4.1 presented at national and international conferences.

> P4.1: *So I think I've spoken about it at a couple of … two or three international conferences.*

Industry was engaged through 'traditional' information days, but also through engagement through meetings.

Interviewee 4.1: *So that's come out of it. In terms of industry feedback, I've probably given maybe half a dozen talks around this.*

Interviewee P4.3: *[P4.4], ja. [P4.4]. So, I sit on that Forelle committee, that producers association meeting. I attend them and at times we bring [P4.1] into the meeting to discuss aspects surrounding the protocols or procedures or whatever.*

The 'new type Forelle' also had some unplanned advantages. Researcher P4.1 travelled to Dubai where he realised that the crisp property of Forelle, the result of the treatment prescribed by the research, made it a perfect fit for very warm countries.

Interviewee P4.1: *This programme was a perfect fit for them so it opened up new markets.*

The research therefore created a new market for Forelle that had not previously been explored fully. With the lucrative new export potential and having gained the upper hand over the Chilean exporters, the Forelle Producers Association drafted new industry protocols based on the research.

The success of the FEMA programme was largely attributed to strict guidelines and controls being adhered to, ensuring that only fruit of correct harvest maturity and acceptable eating quality arrived in offshore markets, in compliance with the initial research recommendations (P4_Document_Information_Sheet_07).

As a Hortgro representative describes, once industry knew the project was a success, they took over to ensure implementation of the research findings.

Interviewee P4.3: *In fact, once this was commercialised it started off, I think [P4.1] started off with five containers and he was responsible for getting the treatment done in the containers loaded. Then the industry is responsible for making sure that the protocols surrounding this fruit are monitored.*

The push from industry forced the scale of the project to increase exponentially. Without the pressure from the industry, implementation would have been much more gradual.

Interviewee P4.1: *Next year, they went, I think 150 containers or something like that. Now it doesn't sound like a lot but it, in terms of value it's like it's maybe a million rand per container, I'm not sure you know. […] And they wanted to go. And then the next year, I think it went up to 750 containers or 700, no I think then it went up to 750 000 cartons and then the next year it went up to 1.2 million cartons and then it went up to 1.4 million cartons. And I think we are now sitting, depending on the volume, this programme is about one, let's say between 1.5, 1.6 maybe 1.7 million cartons on an annual basis. […] So, and that went very quickly you know, so from five*

> *containers to 150 containers to 750 000 cartons to one million two hundred thousand cartons, that is rapid growth, but we got such positive feedback from industry.*

Hortgro also played its part in spreading the results of the study, even going to Chile to explain the problem of mealiness in Forelle to the Chilean farmers. Part of the reason for going to Chile was to try and protect the Forelle brand.

> Interviewee P4.3: *Yes. We actually tested some of theirs [Chilean Forelle] in the UK and found it was mealy. So, they weren't aware of it. […] We've spoken to them. We've actually been there [to Chile] and we told them what to do, because if they do this protocol [with cold storage] they'll be even later than they are now [in getting to the market]. […] We want the cultivar to have a good name, so it's in the interest of the cultivar actually for them to do the right thing.*

Hortgro additionally gathered feedback on the financial impact on the export industry. They found that the new protocol was delivering financial benefits to the industry.

> Interviewee P4.3: *[An unrelated researcher and P4.3] in fact, visited a lot of researchers specifically on this, ag so sorry, exporters. And we went to one in Port Elizabeth. […] They are exporting a lot through Port Elizabeth so we went to the exporter there. They told us their stuff is getting R50 a carton. So they are very happy, everyone's very happy.*

Feedback was also received from clients in Europe. According to them, the new protocols greatly benefitted the Forelle brand. The text below is a quote from P4_Document_Information_Sheet_07.

> [European client]: *Based on the condition and quality of the fruit upon arrival, we can clearly state that the treatment with [commercial product] was absolutely no problem and even a success. The better freshness and more shiny appearance definitely helped to create a good market with the right prices. Not only the better quality, but also the earlier arrival helped […] without the normal gap of arrivals between Rosemarie and Forelle. More retail will reserve space because of this. We see that we can be more competitive towards the Chileans because of the earlier arrivals of [commercial product] Forelle, and again because we see no gap between the arrivals of the different varieties* (quoted in P4_Document_Information_Sheet_07).

As mentioned, the project included a component of marketing the changes in Forelle to consumers. Although Forelle pears are blushed, they are firm and sweet.

> Interviewee P4.1: *We had to find a way to actually market it. So, there were stipulations that every box had to have this 'crisp and sweet' so wherever the consumer looked they could actually see this and then they knew, hang on.*

The response from customers from Germany, United Kingdom and the United Arab Emirates were all positive. The quality and colour of the fruit were rated highly, and there was a reduction in elimination of waste (pears spoiling).

> *On the overall good quality of the fruit on arrival and the fact that there was absolutely no waste. Texture and firmness were rated as very good, appearance as very fresh, and taste as sweet, rich and moderately juicy. Customer reaction was positive with no claims reported* (P4_Document_Information_Sheet_07).

Forelle also did well in the new expanded Middle Eastern market.

> *The containers of Forelle received under the FEMA Programme were very well received. Fruit were reported as having an attractive blush colour and a creamy sweet flavour once ripened. Customers were very happy with the pears* (P4_Document_Information_Sheet_07).

Due to the nature of the study, Project 4 showed much clearer commercial value. The return on investment for the project, if calculated, will probably be very high, due to the limited cost of the research and the exponential growth of application after the research had shown positive results.

There was also one negative result, which emerged from the coded interactions. SA exporters reported to the researchers that the delayed harvesting as a result of the new protocols (FEMA) was leading to an increase in water core.

> *The delayed harvest had the negative effect of advancing skin ground colour, and also evidently resulted in an increase in both the incidence and severity of water core during storage* (P4_Document_Information_Sheet_07).

6.8.6 Post-research impact-effecting phase (distant)

As could have been expected, the main impacts identified by stakeholders and researchers were related to commercial value for industry (see table 6.13). This can be expected because, from the start, the aim of the project was to create commercial value for the SA Forelle pear industry. Some aspects already reported on in the previous section with productive interactions were captured again in the impact codes. It was, for example, mentioned how the FEMA programme opened new markets, especially in the Middle East, and how the project strengthened the Forelle brand. Just as in the previous section, some negative results were also reported.

Table 6.13 Most common impact codes in Project 4

Impacts	Count
Impact – Commercial value for industry	44
Impact – Created industry-relevant knowledge	23
Impact – Influenced own future research	4
Impact – Leading to research/researched by others	3
Impact – Success unlocked funding	2
Impact researcher – Network expanded	1
Impact researcher – Professional advantage	1

Part of the FEMA protocol is that fruit remain on the trees for longer, before being sprayed with a commercial product. This allows fruit to grow bigger (increasing revenues) and solving the problem of astringency.

> Interviewee P4.1: *It's taken the pressure off the farmers now to get into the market as early as possible. And because of that, the normal Forelle is being harvested at the right time and so that has kind of almost eliminated the problem with astringency.*

With the success of the project, more research funding has been unlocked. The Forelle Producers Association collects a levy for all Forelle pears exported.

> Interviewee P4.1: *The other thing that came out of this programme is that the Forelle Producers Association decided to charge a levy per carton. I think it was about 70c depending on … between 50 and 70c per carton. So, to become part of this programme you had to … there was that levy which is, I mean if you are making R20 on a carton …*

Some of this funding has been used to fund research at ExperiCo.

> Interviewee P 4.1: *Additional research came out of this, which was funded directly from the levy, which I think was a good thing.*

The negative aspect for ExperiCo is that the astringency problem has now been solved. There is no further demand for research on astringency.

> Interviewee P 4.1: *That's one of many projects and more projects were born from funding through the FEMA fund than we lost through it, and obviously you know, no one likes to lose work but in the same sense there's a certain professional pride to knowing that the problem has been solved.*

The project resulted in market stabilisation, increasing the size of the market and reducing price spikes. This has been calculated to have translated into significant financial gains for the industry.

> Interviewee P4.3: *Existing markets have increased their uptake because of the more consistent supply.*

> Interviewee P4.4: *[And] our farmers earned a good premium for a while out of FEMA.*

> Interviewee P4.1: *The worth of this project is over a 100 million [ZAR] [€6.3 million] now, just in the last few years*.

A final impact that was identified related to the idea of basic and applied research. The research indicated a direct link between what some see as valueless or less valuable 'basic research' and the valuable 'applied' research that makes a visible difference.

> Interviewee P4.4: *I think it is probably the best example of research where it was implemented on a large scale, where you can say, 'that research was used there'. With all the other research … also it was more applied research. It wasn't basic research. I would say if you take [P4.1's wife's] research … normal farmers in the industry would ask you, 'what do we get from it?'* (Translated from Afrikaans)

According to P4.4, it shows why basic research, which, although it may seem pointless, if seen from an industry perspective in search of quick solutions in the short term, should still be done. Similar to Project 3, Project 4 also showed the coming together of different networks in a single research study. In this project, the world of private research, exporters, the retail industry and academia came together.

6.8.7 Impact pathways in Project 4

In Project 4, the impact pathways focussed on the use of research to address and overcome a specific problem. In addition to the problem that it addressed, the research resulted in unplanned benefits, such as the development of new markets.

6.8.7.1 Protecting market share for South African fruit exports

Description of the impact

The SA Forelle pear industry was losing market share in Europe to Chilean Forelle pears due to a cold storage period needed for SA fruit to lose their astringency. The research reduced the cold storage period by introducing a new protocol for the harvesting and treatment of Forelle. This resulted in a faster time to market, overcoming the problem with Chilean producers getting into the European market before the SA producers.

Description of the productive interactions that constitute the impact pathway

In Project 4, P4.1's personal connections made him aware of new research on astringency in Forelle (in fact, his wife had done research on the topic). This shows that a productive interaction can be completely unexpected. It would not have been possible to plan for an encounter such as this (between husband and wife, working on a related topic by chance).

Forelle as a product needed to be changed to make it fit for the demands of the market. It needed to be ripe and on the European market sooner. Hortgro identified the problem of getting Forelle to market faster, and put out a call for research to address the issue. P4.1, as a researcher at a private research centre, received funding to undertake research based on new data of which he had become aware (which his wife had researched).

P4.1, with the new knowledge on treating astringency and his own professional background, was able to find a possible solution to the Forelle problem, which he tested successfully on a small scale.

However, he was not allowed to follow the normal 'slower' scientific process in testing the new product. Crucially, the industry body responsible for Forelle decided that the early results were conclusive enough and immediately implemented the findings at a larger scale. The interaction of industry with the early results proved instrumental. Early tests with exports of small quantities of treated Forelle showed that it overcame the problems experienced by the fruit. The push from industry meant that the research was implemented on a large scale much faster than would otherwise have been the case.

Within a few years of the project starting, around 30 per cent of the SA Forelle pear industry was adhering to the new protocol, exporting millions of cartons annually.

Description of other contributing factors and/or elements of contexts

The research progressed much faster than the principle investigator would have let it progress if he had full control of the research.

> Follow-up P4.1: *It's my name. And … It's an expensive commodity. You know … a container of Forelle is going to cost you a million rand, or whatever … you know … you work it out per carton … per … uhm. So it's … it's a high risk if something goes wrong.*

However, it was exactly the fact that the industry took ownership of the outcomes of the research that allowed it to be as successful as it ended up being. The industry made use of the research to write a new protocol for the production of Forelle and introduced a levy to fund oversight of the implementation of the protocol through the 'FEMA police'.

> Follow-up P4.1: *It's what we call the FEMA police. […] So, that is coming from the levy. […] It is important, because you know without the police … people would take chances … and then it would probably crash the system.*

Adoption by the industry and the introduction of a levy to 'police' the new protocol allowed the implementation of the research results to be sustainable. The research would also not have been possible without the possibility of exchange of research between husband and wife. This type of interaction shows the range of research interactions captured by SIAMPI beyond data included in final research reports.

6.8.7.2 New markets for South African Forelle

Description of the impact

Although it was not the aim of the Forelle research, the 'new' type of Forelle pear that had been developed had qualities that made it a perfect fit for fruit markets in warm countries in the Middle and Far East. Once these markets became aware of the new type of SA Forelle pears they started to import it, creating a new market for SA Forelle pear exports.

Reflection on the productive interactions that constitute the impact pathway

The primary researcher of Project 4, P4.1, travelled to Dubai and Singapore while the Forelle pear research was being undertaken. Arriving in Dubai on a very hot day, he quickly realised the market potential of a fruit that does not ripen (a problem in warm climates). The product used to treat Forelle pears in Project 4 stops the ripening process.

> P4.1 Follow-up: *I think when I arrived it was 49 degrees [in Dubai]. So … it's incredibly hot, so any fruit […] has got the potential to ripen. Their requirement from us as a country … exporting fruit, is always to have things on the firm side … on the green side. […] So … so, it made sense for a product like this to go to Dubai.*

When P4.1 returned to South Africa, he contacted fruit exporters and made them aware of the potential. Fruit exporters in South Africa then began exporting the treated Forelle pears to the Eastern markets. The opening up of new markets for the fruit again contributed back to the perceived success of P4.1's research (probably an additional impact that builds on the success of both protecting the European market and opening new markets). An interesting observation (since it is not always the case) for this project was that the researcher was a central figure along the entire impact pathway – P4.1 did not rely on non-linked researchers to facilitate broader impact. He acts almost like the researcher-as-entrepreneur, which is probably a reflection of the fact that he works in a commercial context and not within academia.

6.9 Conclusion

This chapter presented the results of the data on research interactions (or productive interactions) and the theories of change. It also presented impact pathways that were constructed from the interactions. The research was able to build theories of change from the interactions captured and expand on these by looking at some of the impact codes that were also captured. Productive interactions have been shown to be useful in the construction of programme theory through theories of change. These interactions also capture impact pathways. The next chapter presents the results of the survey of funders on impact literacy.

Chapter 7

Results: Research funders' understanding of the societal impact of research

7.1 Introduction

This chapter presents the results of the third phase of the research, specifically the results of a survey on impact literacy that was conducted among members of the expert funding committees at Winetech and Hortgro. These two organisations are commodity companies that funded the four agricultural research projects discussed in the previous chapter.

In the previous chapter, theories of change were used to illustrate how research impact was effected in the four projects, and who played a role in enabling the undertaking of the research along with effecting this impact. However, the productive interactions identified in the previous chapter (and their representation in theories of change and impact pathways) mainly reflected the perspective of researchers with reduced focus on the funders of research. A survey was therefore developed to expand on the 'what' of impact as viewed by funders, along with some insights into 'who' the funders see as responsible for effecting research impact. This survey was informed by the concept of impact literacy, which looks at impact in terms of *how* it is effected, *who* is involved and *what* the impacts are (Bayley & Phipps, 2017).

This chapter also introduces the SoIR classification scheme, whose development was discussed in 5.5.1. The classification scheme plots research impacts in terms of their scale of benefit and the relationship with beneficiaries. The first part of the chapter therefore uses the SoIR classification scheme to plot the impact codes that were identified in the previous two phases of the research (presented in Chapter 6). This provides an overview of impacts as captured in the four agricultural research projects. The second part of the chapter focusses on the survey of research impact. These different foci provide insights into the impact codes of the previous chapter and how these possibly relate to the way in which research funders, specifically, view the impact of research.

After a general overview of survey respondents, the sections in the second part of the chapter follow the logic of the survey. One section considers 'what' research funders view as impact. Ideal research impact results and reasons for a lack of research impact are presented in this section, together with the responses to the impact scenarios that are plotted on the SoIR classification scheme. Another section presents the results on whom the different funders identified as important in the process of effecting SoIR. These responses show how the research effecting environments (in relation to 'who' is responsible for achieving research impacts) differs between Winetech and Hortgro.

7.2 Plotting impact codes on an impact classification scheme

The impact codes captured from the data in the first two phases of the research, for Project 1, are presented in Table 7.1 below. The codes are listed in order of most to least identified in the data.

Table 7.1 Project 1: impact codes and descriptions

Impact (codes)		Description	Example from Project 1
W1.1	Impact researcher – job or professional opportunity	P1.2 was employed based on her experience gained during the project.	P1.2: I think this is why I was appointed. This is why my boss approached me; it was because I had this background [from Project 1].*
W1.2	Impact – influenced own future research	P1.2 continued with related research after the project had ended.	P1.1: And so she continued with her post-doc and she added more cellars and wine [to test].*
W1.3	Impact researcher – network expanded	P1.2 and P1.1 are now part of each other's professional networks.	P1.1: I am sitting with a client, and I have asked [P1.1] if he has any ideas. I would not say I am lost, but it is sometimes nice to get input from other people.*
W1.4	Impact – created industry-relevant knowledge	Created an understanding of the importance of previously unexplored research.	P1.1: And since then, the wine industry also started to target these components as very important for more research.*
W1.5	Impact researcher – skills development	P1.2 obtained a PhD and new analytical skills.	P1.2: I know the importance of sampling, how to sample correctly, how important it is that sampling can affect your results, […] what to analyse for, what to look out for.*
W1.6	Impact – commercial value for industry	Winemakers can use the results of the research to make better wine.	P1.4: Yes, if we could improve the quality of the wines [through the project] you will be able to be more competitive.
W1.7	Impact researcher – professional advantage	The PhD P1.2 obtained in the project has given her professional recognition.	P1.2: Yes, I think so, [name of P1.2's boss], my boss, will refer people to me and say, "listen, she has a PhD and she will help you."*
W1.8	Impact – leading to research/researched by others	Researchers who were not part of the project are requesting information on how the research was done.	P1.4: We have had a few questions, yes, on my records. […] Other academics. Not from the industry.
W1.9	Impact – research institution – new equipment	Stellenbosch University gained access to new analytical capabilities through new equipment bought during the project.	P1.1: In the meantime we have brought the analysis here and can now do it 'in-house', which is great, and it is a consequence of the project, indirectly, which was not really part of the aims of the project.*

*Translated from Afrikaans.

To some extent, the codes in the above table replicate those reported for Project 1 in Table 6.7. However, these impact codes listed above also include a description of relevance to the project together with an example of a code quotation from the case study material.

Figure 7.1 plots the nine impact codes for Project 1, taken from Table 7.1, on the SoIR classification scheme. The impact codes are concentrated mainly at the level of the researchers who undertook the research and the industry (as a whole) for whom the research was undertaken.

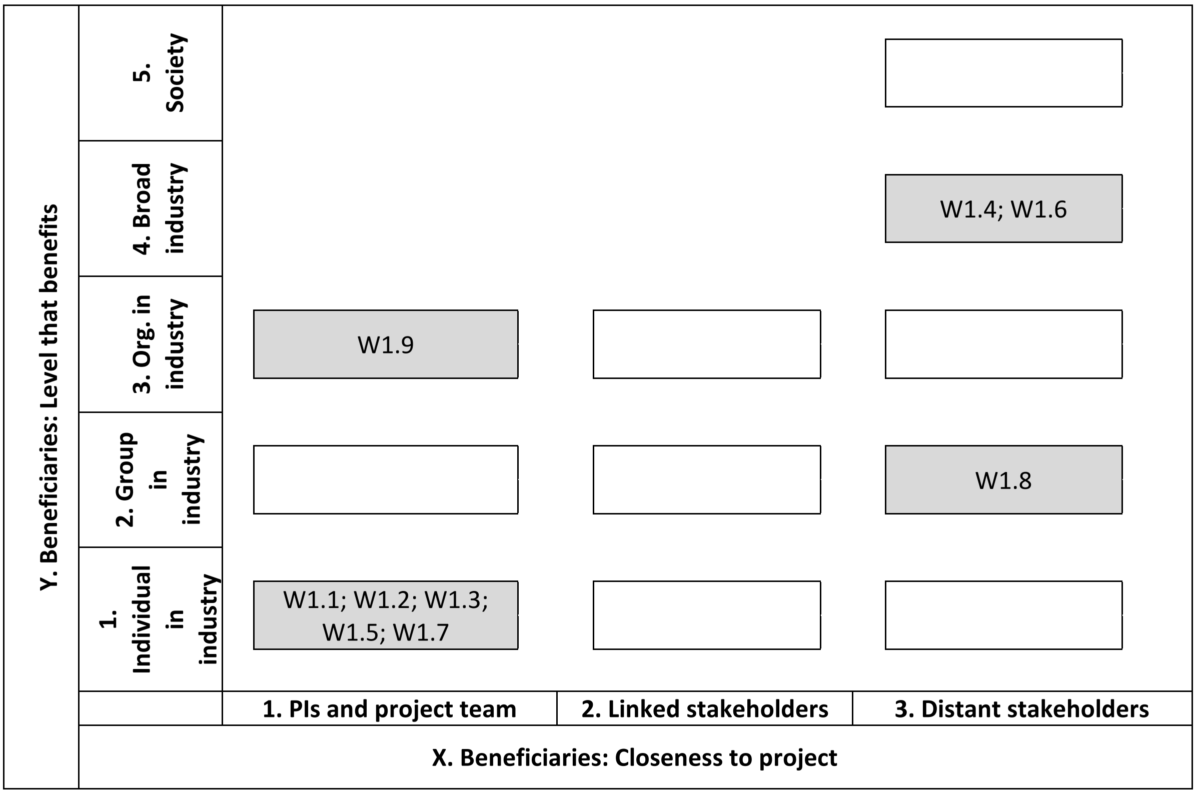

Figure 7.1 Winetech Project 1 impact classifications scheme

W1.8 is placed in cell X3Y2 because the quote refers to 'non-project researchers'. These researchers are requesting information on how the research was undertaken in order to do their own related research. If a single un-linked researcher or an un-linked organisation requested the same information, W1.8 could also have been placed at X3Y1 or X3Y3.

The same reporting structures for Project 1 (i.e. a summary table with impact codes followed by a graph which plots the same impact codes on the SoIR classification scheme) were also used for sense making in the case of the other three projects. The respective outputs are reflected in Table 7.2 and Figure 7.2 (for Project 2), Table 7.3 and Figure 7.3 (for Project 3) and Table 7.4 and Figure 7.4 (for Project 4).

The impacts codes and descriptions for Project 2 appear in Table 7.2 below. Again, there were nine impact codes.

Table 7.2 Project 2: impact codes and descriptions

Impact (codes)		Description	Example from Project 2
W2.1	Impact – created industry-relevant knowledge	Created knowledge on how to identify DNA	P2.1: So, we take the DNA out, and then we have a tool with which we can test it [the DNA] to immediately see what it is. […] As part of the project, it was, well, an outflow of the project*
W2.2	Impact – expanded science	Produced new knowledge in the field	P2.2: The outputs of this project were very academic, it was like, unknown stuff that are now known.*
W2.3	Impact researcher – network expanded	Created a collaboration opportunity for P2.1	P2.1: So out of this project, I also got a collaboration project from the NRF with Germany*
W2.4	Impact – influenced own future research	P2.1 continued with related research after the end of the project	P2.2: And this specific project is continuing. […] He is getting a post-doc again and everything*
W2.5	Impact researcher – skills development	P2.2 obtained a degree (PhD)	P2.2: I got a PhD, and we still have to publish the last chapter of the PhD*
W2.6	Impact – success unlocked funding	The project led directly to additional research funding for P2.1	P2.1: So, out of this project I also got a collaboration project from the NRF with Germany*
W2.7	Impact researcher – professional advantage	Students from the project were able to find employment based on their specialisation	P2.1: Obviously, [researcher] and P2.2 both started working in the fruit industry afterwards [after Project 2]*
W2.8	Impact – commercial value for industry	Highlighting the problem of Esca allowed the industry to begin understanding how to manage it	P2.4: It shed a lot of light on the subject. […] It is very valuable that it has been exposed*
W2.9	Impact researcher – job or professional opportunity	The project assisted P2.1 in achieving his job performance targets	P2.1: It was the criteria, well some of the main criteria* [P2.1, referring to training students in Project 2 to keep his position as extraordinary professor]

*Translated from Afrikaans.

In Figure 7.2 below W2.2 from Table 7.2 above is placed in the broad industry cell. It fits the best in the cell since an expansion of science takes place (in this case) in one industry or field. It does not affect society as a whole. Additionally, although the expansion of science can have an impact on the researchers in the project that produced the results, scientific findings can have a much broader impact than only one researcher's work. Based on the quotation provided the impact is suggested as broad rather than limited to the project researchers.

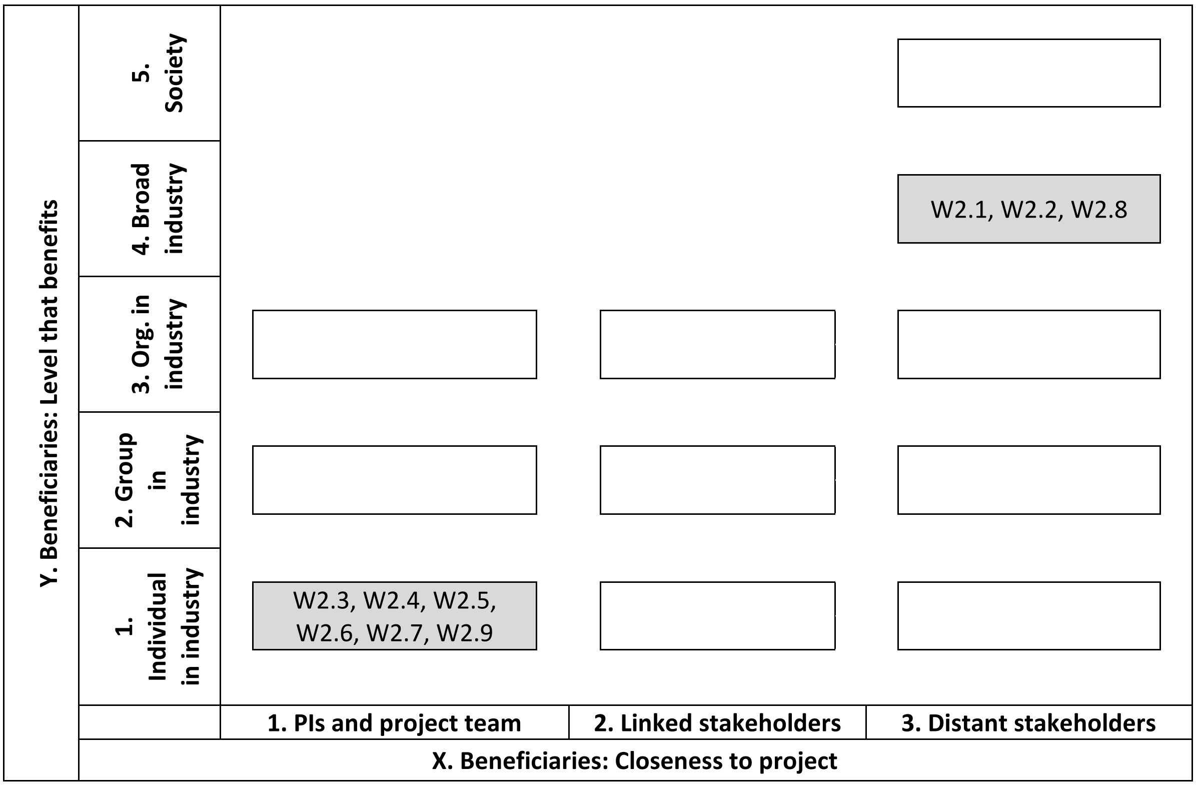

Figure 7.2 Winetech Project 2 impact classifications scheme

Turning to the two projects that were funded by Hortgro, the first of these (Project 3) generated six impact codes. The details appear in Table 7.3 below.

Table 7.3 Project 3: impact codes and descriptions

Impact (codes)		Description	Example from Project 3
H1.1	Impact – created industry-relevant knowledge	The project produced the knowledge that the thinning machine works	P3.1: Yes, I am aware of a number of people who started making use of the machine.*
H1.2	Impact – commercial value for industry	Knowing that the machine works allowed farmers to invest in it and save on labour costs	P3.3: No, I would say 100 per cent. It is new technology with which you can save on labour without losing on anything. So yes, it is a big asset.*
H1.3	Impact researcher – skills development	A researcher gained a new qualification (master's degree)	P3.1: There was one M student who completed his studies and produced a thesis.*
H1.4	Impact researcher – network expanded	P3.2 networked with producers in the industry	P3.2: Yes, I met a lot of people, which was good for me and gave me a lot of exposure.*
H1.5	Impact – influenced own future research	P3.1 continued with related research after the project	P3.1: The other two machines I decided to test on apples and pears and other planting styles or tree forms.*
H1.6	Impact – leading to research/researched by others	P3.3 (a researcher at a major producer at the time) took part in further research related to the project	P3.3: Yes, afterwards there was a lot of follow-up work as a result of it [Project 3].*

*Translated from Afrikaans.

In Figure 7.3, the six impact codes for Project 3 are plotted in the impact classification scheme.

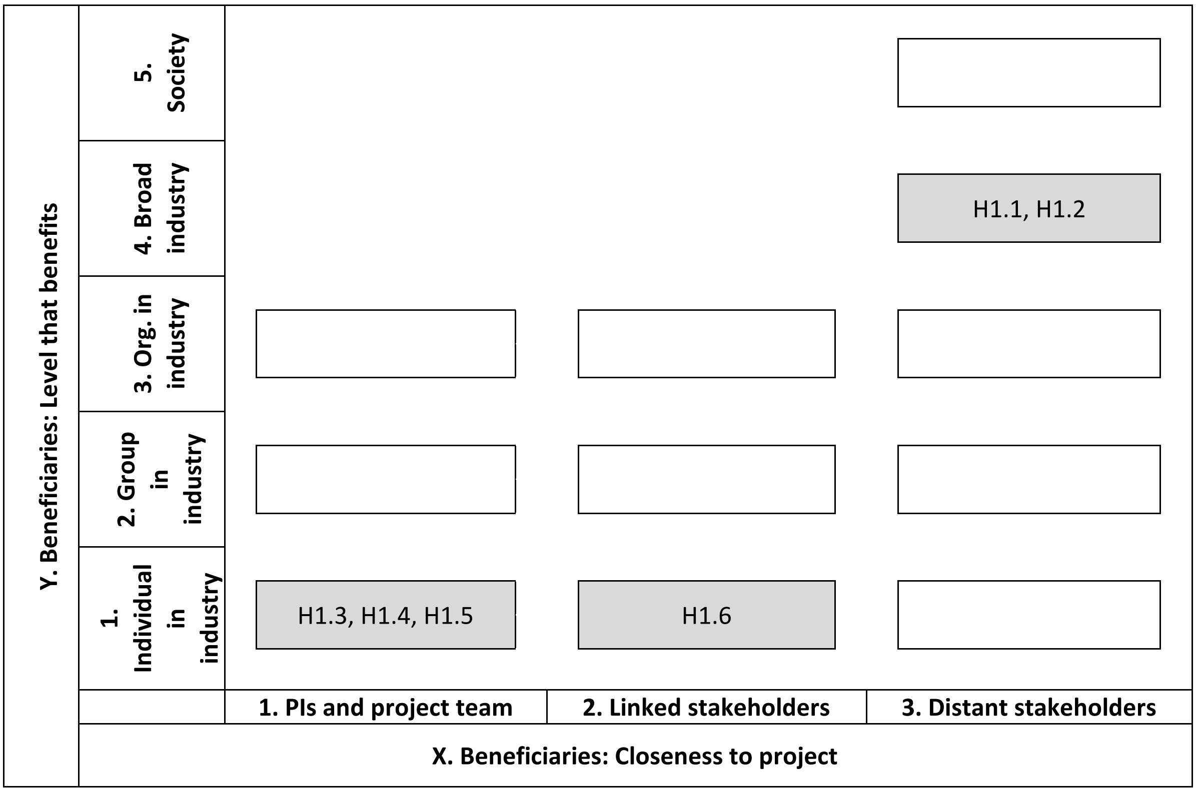

Figure 7.3 Hortgro Project 3 impact classifications scheme

H1.6 is plotted at X2Y1 since it refers to a linked stakeholder doing new research based on the results of the research done in Project 3. If this research were done in a group or an organisation, H1.6 could also have been plotted at either X2Y2 or X2Y3.

Finally, Table 7.4 provides descriptions of the impacts that were identified in Project 4.

Table 7.4 Project 4: impact codes and descriptions

Impact (codes)		Description	Example from Project 4
H2.1	Impact – commercial value for industry	Research protected the price of Forelle pears	P4.1: It stabilised. There are not huge peaks and troughs. […] That's what they want. And that keeps the price stable and high.
H2.2	Impact – created industry-relevant knowledge	Produced research that has changed practice in industry	P4.1: It has taken the pressure off the farmers now to get into the market as early as possible. And because of that, the normal Forelle is being harvested at the right time and so that has kind of almost eliminated the proper astringency.
H2.3	Impact – influenced own future research	Researcher continues with related research	P4.3: Yes, [P4.1] has actually come up with an idea on other pears. We use [commercial product] on apples, but that's fine 'cause it stays crispy; you eat it crisp.
H2.4	Impact –	Non-project-related	P4.1: And then there are other outputs that I haven't been

	leading to research/researched by others	researchers do research based on or related to project research	involved with. People like yourself have contacted us, [research organisation] has contacted us, you know.
H2.5	Impact – success unlocked funding	Research led to an increase in funds available for research from industry	P4.1: The other thing that came out of this programme is that the Forelle Producers Association decided to charge a levy per carton. […] So, additional research came out of this, which was funded directly from the levy, which I think was a good thing.
H2.6	Impact researcher – network expanded	The researcher gained access to a new industry body	P4.1: I think maybe the one benefit was we got to be part of the Forelle Producers Association which we wouldn't normally have and through that it was a good platform that we could start building that relationship.
H2.7	Impact researcher – professional advantage	Reputation of researcher gave his institution an advantage in gaining access to future funding	P4.1: More projects were born from funding through the FEMA fund than we lost through [the research project], and obviously you know, no one likes to lose work but in the same sense, there's a certain professional pride to knowing that the problem has been solved.

Similar to the other projects, Project 4 showed a concentration of impacts or effects at the level of the individual project researcher and at the distant industry level (Figure 7.4). Impacts were thus consistently captured for these areas of the classification scheme, across all four projects.

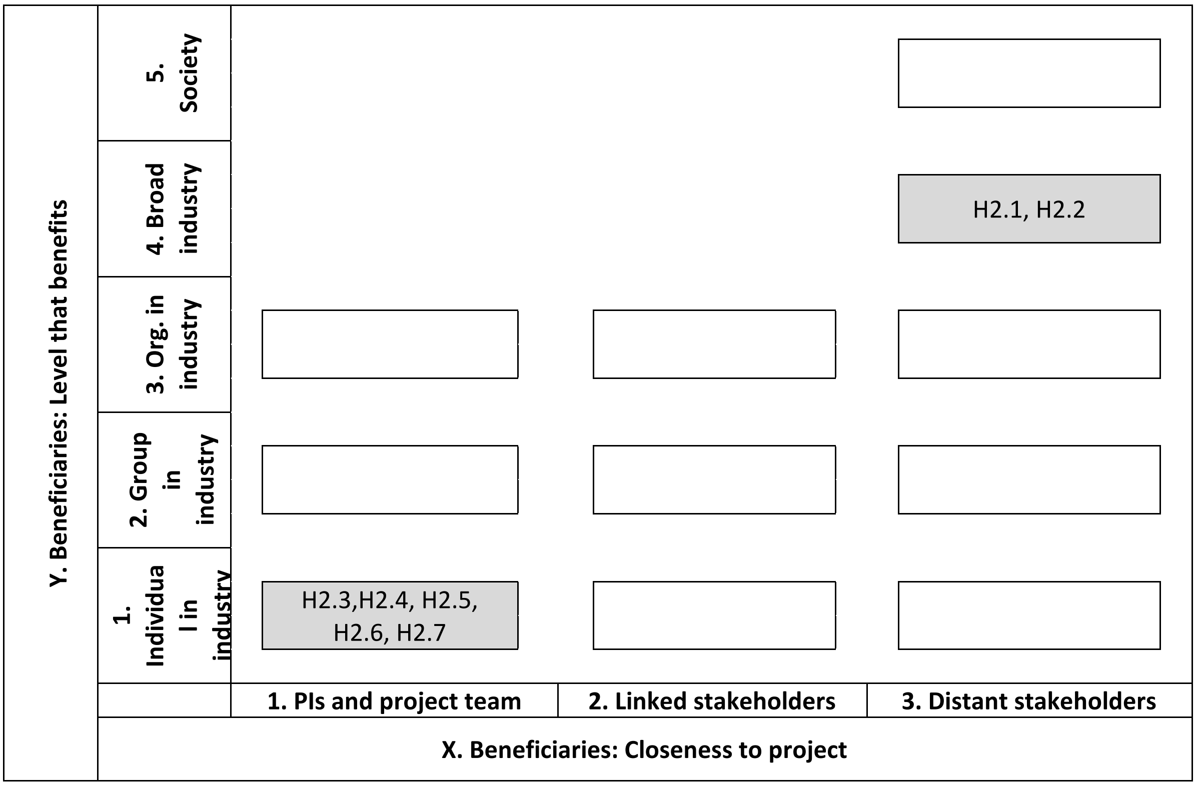

Figure 7.4 Hortgro Project 4 impact classifications scheme

The impacts presented in Figures 7.1 to 7.4 above were captured from the first two phases of the research that mainly focussed on the identification of possible productive interactions close in time and space to the researchers and the research process.

It is interesting that impacts from the research projects are mainly seen as those that either affect the project researchers themselves, or the broader industry (unlinked from the actual research project). It also shows that the understanding of impact is mainly focussed on final types of benefits derived from the research results of projects. The next sections present the results of the survey of research impact that was undertaken on funders of research (Winetech and Hortgro).

7.3 Results of the survey of research impact literacy of two funders

The survey response rate for Winetech was 72 per cent, with 43 completed surveys out of a population of 60 expert committee members. All the Winetech surveys were completed online on a survey platform. For Hortgro, 23 completed surveys were received out of a population of 30, giving a 77 per cent response rate. This provided a combined response rate of 73 per cent, or 66 out of 90.

The relability of responses on the scenarios of research impact (the scope of understanding of research impact by research funders) (see 5.5.2) were tested through Cronbach's Alpha for Winetech (separately), Hortgro (separately) and combined responses. For Winetech the coefficient was .85, with no scenarios below .834. For Hortgro the coefficient was .77, with no scenarios below .733. For Winetech and Hortgro combined the coefficient was .825, with no scenarios below .811. Since all of these figures are above .7, no scenarios were excluded from the analysis.

Not all the questions in the survey were answered by all 66 respondents. The respondents who completed a question was provided with each table and figure. For the responses where a mean score was calculated, unanswered responses were discarded and not included in the calculations. In these cases, the number of responses was made clear. This was never a major issue since, as will be shown, and questions where a mean score was calculated were generally well answered.

The respondents, although all expert committee members, were drawn from different occupations. This allowed for various views to be considered when deciding on the allocation of funding. See Figure 7.5 on the following page for a breakdown of respondents' occupations. The most common occupation for Winetech respondents was 'Industry consultant', followed by 'Farmer/producer' and 'Public researcher'. Public researchers mainly included individuals who work as academics at universities. For Hortgro, the order was different with the largest number of committee members being 'Technical advisors', followed by individuals in different managerial roles in the industry and 'Public researcher' (again in third place).

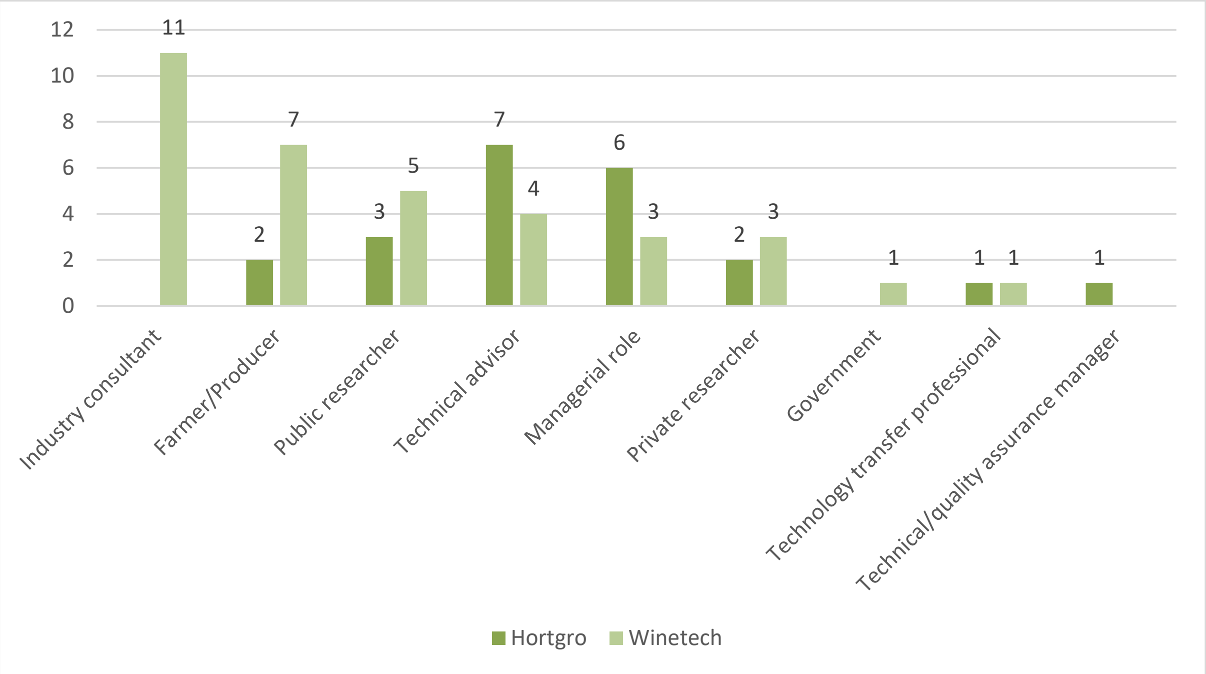

Figure 7.5: Distribution of Hortgro and Winetech respondents according to occupation (Hortgro n=22; Winetech n=35)

The next section discusses results for the first part of the survey, which – from the point of view of impact literacy – highlights the funders' understanding of the 'what' component of impact.

7.3.1 The 'what' of societal impact of research according to funders

The first section of the survey on research impact literacy among funders focussed on 'what' researcher funders view as research impact. Respondents were asked to rate the importance of 22 specific scenarios in terms of whether these were examples of research impact that Winetech or Hortgro projects should have (see again 5.5.2). The scale ranged from 1 ('Very important impact of Winetech/Hortgro research') to 4 ('Unimportant impact of Winetech/Hortgro research'). In analysing the responses, the scores were reversed so that the highest value (4) indicated a 'Very important impact' and the lowest value (1) an 'Unimportant impact'.

The responses for Winetech, Hortgro and both funders combined are presented below in three tables (Tables 7.5, 7.6 and 7.7). For each of the tables the first column refers to the position where the scenario, as described in the second column of the table, would be plotted on the research impact classification scheme. The number next to the X in the first column refers to the position of the impact on the X-axis and the number next to the Y to its position on the Y-axis of the scheme. As explained in Chapter 5, two scenarios were presented for each the 11 plot-points of the impact framework. Any two scenarios within the same plot point (e.g. X1Y1) are indicated by means of 'a' and 'b' respectively (e.g. X1Y1a and X1Y1b).

In Tables 7.5 and 7.6, the total number of respondents per scenario can be viewed in the second column. The remainder of each table presents the counts per response category, as well as the response percentage. The final column provides the mean for the scenario. The following scale was used to interpret the mean for each scenario:

- 3.50–4.00 = Very important impact
- 2.50–3.49 = Moderately important impact
- 1.50–2.49 = Slightly important impact
- 1.00–1.49 = Unimportant impact

The order of the scenarios in the tables follows the order of the cells in the impact classification scheme (starting with X1Y1a and ending with X3Y5b).

Table 7.5 Ratings of 22 scenarios by Winetech in terms of how much each reflects an example of research impact

Location in scheme	Scenario		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X1Y1a	A researcher in the Winetech-funded project receives external (non-Winetech) funding to undertake similar research in a different industry based on the success of the Winetech project (N=42)	**Count**	4	12	18	8	2.71	.891
		Percentage	10%	29%	43%	19%		
X1Y1b	A researcher in the Winetech-funded project becomes more skilled (e.g. acquires a higher qualification) (N=42)	**Count**	3	7	17	15	3.05	.909
		Percentage	7%	17%	40%	36%		
X1Y2a	The researchers involved in a Winetech-funded project have forged strong professional ties with each other, resulting in their continued research cooperation in other projects (N=42)	**Count**	0	12	14	16	3.10	.821
		Percentage	0%	29%	33%	38%		
X1Y2b	The researchers involved in a Winetech-funded project create their own consultancy based on the expertise they gained from the project (N=42)	**Count**	20	17	0	5	1.76	.958
		Percentage	48%	40%	0%	12%		
X1Y3a	The university centre/department that housed the Winetech-funded project can undertake more complex research for the wine industry (e.g. because its analytical capacity has improved), because of the funding received under a Winetech project (N=42)	**Count**	0	1	19	22	3.50	.552
		Percentage	0%	2%	45%	52%		
X1Y3b	A research institute that housed a Winetech-funded project subsequently attracts more research grants than before because of the success of the Winetech project (N=41)	**Count**	0	6	22	13	3.17	.667
		Percentage	0%	15%	54%	32%		

Location in scheme	Scenario		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X2Y1a	A winemaker who took part in a Winetech-funded project as a research participant has improved the quality of the cellar's wine based on knowledge gained during the study (N=41)	**Count**	0	6	13	22	3.39	.737
		Percentage	0%	15%	32%	54%		
X2Y1b	A farmer who took part in a Winetech-funded project as a research participant has cut input costs by reducing water usage based on insights gained from the project (N=41)	**Count**	0	2	12	27	3.61	.586
		Percentage	0%	5%	29%	66%		
X2Y2a	An international research team that assisted the researchers involved in a Winetech-funded project has joined the Winetech-funded researchers in an international research network that regularly co-publishes (N=41)	**Count**	1	9	18	13	3.05	.805
		Percentage	2%	22%	44%	32%		
X2Y2b	A group of farmers from a single district who assisted in a Winetech-funded project as research participants have implemented a pest control strategy in their area based on lessons learnt from the project (N=41)	**Count**	0	0	11	30	3.73	.449
		Percentage	0%	0%	27%	73%		
X2Y3a	Based on the results of a Winetech-funded project, Winetech has become aware that a vine disease thought to be uncommon is prevalent in South African vineyards (N=41)	**Count**	0	2	8	31	3.71	.559
		Percentage	0%	5%	20%	76%		
X2Y3b	An industry body has implemented a new protocol for the cultivar it oversees, which was based on the results of a Winetech-funded research project in which the industry body had cooperated (N=41)	**Count**	0	4	12	25	3.51	.675
		Percentage	0%	10%	29%	61%		

Location in scheme	Scenario		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X3Y1a	A sales agent experiences a rise in sales because of the published findings of a Winetech-funded project confirming the properties of the product sold by the agent (N=41)	**Count**	6	14	15	6	2.51	.925
		Percentage	15%	34%	37%	15%		
X3Y1b	A farmer who has no knowledge of the Winetech-funded research project experiences a reduced prevalence of pests, because a neighbour who participated in the project has applied the project findings on pest control successfully (N=41)	**Count**	0	3	19	19	3.39	.628
		Percentage	0%	7%	46%	46%		
X3Y2a	Researchers abroad use the published results of a Winetech-funded project to inform their research methodology for a replication study in their own context (N=41)	**Count**	2	7	20	12	3.02	.821
		Percentage	5%	17%	49%	29%		
X3Y2b	A group of farmers sharing an irrigation system benefit from increased river water supply that has resulted from reduced water use on a farm upstream, where the owner introduced water-saving strategies based on the published findings of a Winetech-funded project (N=41)	**Count**	0	2	9	30	3.68	.567
		Percentage	0%	5%	22%	73%		
X3Y3a	A wine cellar produces wines of higher quality by using new analytical capacity at a university, which had been developed during a Winetech-funded project and of which the winemaker at the cellar learned at an industry information day (N=41)	**Count**	1	3	10	27	3.54	.745
		Percentage	2%	7%	24%	66%		
X3Y3b	A public sector laboratory working in the wine industry recruits an employee who obtained a qualification by means of a Winetech-funded project (N=41)	**Count**	2	15	17	7	2.71	.814
		Percentage	5%	37%	41%	17%		

Location in scheme	Scenario		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X3Y4a	Producers across different wine regions implement the recommendations of a practice guideline informed by a Winetech-funded project (N=41)	**Count**	0	3	10	28	3.61	.628
		Percentage	0%	7%	24%	68%		
X3Y4b	A previously untapped market opens for the wine industry because of a Winetech-funded project (N=41)	**Count**	1	5	8	27	3.49	.810
		Percentage	2%	12%	20%	66%		
X3Y5a	Public health improves because of reduced use of chemical pest control in the agricultural sector since bio-control strategies have been adopted that are based on Winetech research (N=42)	**Count**	0	5	10	27	3.52	.707
		Percentage	0%	12%	24%	64%		
X3Y5b	The living standard of the general population rises because of lower food prices associated with the introduction of mechanisation in agriculture, which mechanisation process is partially informed by Winetech research (N=42)	**Count**	3	11	17	11	2.86	.899
		Percentage	7%	26%	40%	26%		

Table 7.6 Ratings of 22 scenarios by Hortgro in terms of how much each reflects an example of research impact

Location in scheme	Scenario		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X1Y1a	A researcher in the Hortgro-funded project receives external (non-Hortgro) funding to undertake similar research in a different industry based on the success of the Hortgro project (N=23)	**Count**	3	8	9	3	2.52	.898
		Percentage	13%	35%	39%	13%		
X1Y1b	A researcher in the Hortgro-funded project becomes more skilled (e.g. acquires a higher qualification) (N=22)	**Count**	1	5	8	8	3.05	.899
		Percentage	5%	23%	36%	36%		
X1Y2a	The researchers involved in a Hortgro-funded project have forged strong professional ties with each other, resulting in their continued research cooperation in other projects (N=23)	**Count**	0	6	9	8	3.09	.793
		Percentage	0%	26%	39%	35%		
X1Y2b	The researchers involved in a Hortgro-funded project create their own consultancy based on the expertise they gained from the project (N=23)	**Count**	13	7	0	3	1.70	1.020
		Percentage	57%	30%	0%	13%		
X1Y3a	The university centre/department that housed a Hortgro-funded project can undertake more complex research for the deciduous fruit industry (e.g. because its analytical capacity has improved), because of the funding received under a Hortgro project (N=23)	**Count**	1	4	8	10	3.17	.887
		Percentage	4%	17%	35%	43%		
X1Y3b	A research institute that housed a Hortgro-funded project subsequently attracts more research grants than before because of the success of the Hortgro project (N=23)	**Count**	2	3	11	7	3.00	.905
		Percentage	9%	13%	48%	30%		

Location in scheme	Scenario		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X2Y1a	A farmer who took part in a Hortgro-funded project as a research participant has improved the yield of an orchard based on knowledge he gained during the study (N=23)	**Count**	1	3	8	11	3.26	.864
		Percentage	4%	13%	35%	48%		
X2Y1b	A farmer who took part in a Hortgro-funded project as a research participant has cut input costs by reducing water usage based on insights gained from the project (N=23)	**Count**	0	2	8	13	3.48	.665
		Percentage	0%	9%	35%	57%		
X2Y2a	An international research team that assisted the researchers involved in a Hortgro-funded project has joined the Hortgro-funded researchers in an international research network that regularly co-publishes (N=23)	**Count**	0	6	7	10	3.17	.834
		Percentage	0%	26%	30%	43%		
X2Y2b	A group of farmers sharing an irrigation system benefit from increased river water supply that has resulted from reduced water use on a farm upstream, where the owner introduced water-saving strategies based on the published findings of a Hortgro-funded project (N=23)	**Count**	0	1	7	15	3.61	.583
		Percentage	0%	4%	30%	65%		
X2Y3a	Based on the results of a Hortgro-funded project, Hortgro has become aware that a disease previously thought to be uncommon is prevalent in South African orchards. (N=23)	**Count**	0	0	6	17	3.74	.449
		Percentage	0%	0%	26%	74%		
X2Y3b	An industry body has implemented a new export protocol for the cultivar it oversees based on the results of a Hortgro-funded research project in which the industry body had cooperated (N=23)	**Count**	0	3	5	15	3.52	.730
		Percentage	0%	13%	22%	65%		

Location in scheme	Scenario		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X3Y1a	A sales agent experiences a rise in sales because of the published findings of a Hortgro-funded project confirming the properties of the product sold by the agent (N=23)	**Count**	8	6	7	2	2.13	1.014
		Percentage	35%	26%	30%	9%		
X3Y1b	A farmer who has no knowledge of the Hortgro-funded research project experiences a reduced prevalence of pests, because a neighbour who participated in the project has applied the project findings on pest control successfully (N=23)	**Count**	1	5	9	8	3.04	.878
		Percentage	4%	22%	39%	35%		
X3Y2a	Researchers abroad use the published results of a Hortgro-funded research project to inform their research methodology for a replication study in their own context (N=23)	**Count**	4	6	11	2	2.48	.898
		Percentage	17%	26%	48%	9%		
X3Y2b	A group of farmers from a single district who assisted in a Hortgro-funded project as research participants have implemented a pest control strategy in their area based on lessons learnt from the project (N=23)	**Count**	0	2	8	13	3.48	.665
		Percentage	0%	9%	35%	57%		
X3Y3a	A farming group introduces a successful pest control strategy in a district, based on the research results of a Hortgro-funded study that was presented to them at their study group (N=23)	**Count**	0	1	5	17	3.70	.559
		Percentage	0%	4%	22%	74%		
X3Y3b	A public sector laboratory working in the deciduous fruit industry recruits an employee who obtained a qualification by means of a Hortgro-funded project (N=23)	**Count**	5	8	8	2	2.30	.926
		Percentage	22%	35%	35%	9%		

Location in scheme	Scenario		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X3Y4a	Producers across different regions implement the recommendations of a practice guideline informed by a Hortgro-funded project (N=23)	**Count**	0	2	3	18	3.70	.635
		Percentage	0%	9%	13%	78%		
X3Y4b	A previously untapped market opens up for a cultivar in the deciduous fruit industry because of a Hortgro-funded project (N=23)	**Count**	0	0	6	17	3.74	.449
		Percentage	0%	0%	26%	74%		
X3Y5a	Public health improves because of reduced use of chemical pest control in the agricultural sector since bio-control strategies have been adopted that are based on Hortgro research (N=23)	**Count**	0	2	11	10	3.35	.647
		Percentage	0%	9%	48%	43%		
X3Y5b	The living standard of the general population rises because of lower food prices associated with the introduction of mechanisation in agriculture, which mechanisation process is partially informed by Hortgro research (N=21)	**Count**	3	4	8	6	2.81	1.030
		Percentage	14%	19%	38%	29%		

Table 7.7 Funders combined: ratings of 22 scenarios by Winetech and Hortgro in terms of how much each reflects an example of research impact

Location in scheme		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X1Y1a (N=65)	**Count**	7	20	27	11	2.65	.891
	Percentage	11%	31%	42%	17%		
X1Y1b (N=64)	**Count**	4	12	25	23	3.05	.898
	Percentage	6%	19%	39%	36%		
X1Y2a (N=65)	**Count**	0	18	23	24	3.09	.805
	Percentage	0%	28%	35%	37%		
X1Y2b (N=65)	**Count**	33	24	0	8	1.74	.973
	Percentage	51%	37%	0%	12%		
X1Y3a (N=65)	**Count**	1	5	27	32	3.38	.700
	Percentage	2%	8%	42%	49%		
X1Y3b (N=64)	**Count**	2	9	33	20	3.11	.758
	Percentage	3%	14%	52%	31%		
X2Y1a (N=64)	**Count**	1	9	21	33	3.34	.781
	Percentage	2%	14%	33%	52%		
X2Y1b (N=64)	**Count**	0	4	20	40	3.56	.614
	Percentage	0%	6%	31%	63%		
X2Y2a (N=64)	**Count**	1	15	25	23	3.09	.811
	Percentage	2%	23%	39%	36%		
X2Y2b (N=64)	**Count**	0	1	18	45	3.69	.500
	Percentage	0%	2%	28%	70%		
X2Y3a (N=64)	**Count**	0	2	14	48	3.72	.519
	Percentage	0%	3%	22%	75%		
X2Y3b (N=64)	**Count**	0	7	17	40	3.52	.690
	Percentage	0%	11%	27%	63%		
X3Y1a (N=64)	**Count**	14	20	22	8	3.38	.968
	Percentage	22%	31%	34%	13%		
X3Y1b (N=64)	**Count**	1	8	28	27	3.27	.740
	Percentage	2%	13%	44%	42%		

Location in scheme		Unimportant impact (score of 1)	Slightly important impact (score of 2)	Moderately important impact (score of 3)	Very important impact (score of 4)	Mean score	SD
X3Y2a (N=64)	**Count**	6	13	31	14	2.83	.883
	Percentage	9%	20%	48%	22%		
X3Y2b (N=64)	**Count**	0	4	17	43	3.61	.607
	Percentage	0%	6%	27%	67%		
X3Y3a (N=64)	**Count**	1	4	15	44	3.59	.684
	Percentage	2%	6%	23%	69%		
X3Y3b (N=64)	**Count**	7	23	25	9	2.56	.871
	Percentage	11%	36%	39%	14%		
X3Y4a (N=64)	**Count**	0	5	13	46	3.64	.627
	Percentage	0%	8%	20%	72%		
X3Y4b (N=64)	**Count**	1	5	14	44	3.58	.708
	Percentage	2%	8%	22%	69%		
X3Y5a (N=65)	**Count**	0	7	21	37	3.46	.686
	Percentage	0%	11%	32%	57%		
X3Y5b (N=63)	**Count**	6	15	25	17	2.84	.937
	Percentage	10%	24%	40%	27%		

The three tables presented above raise the question of why two impact scenarios referring to the same plot-point in the impact classification scheme, do not necessarily have similar results? Where two impact scenarios refer to the same plot-point one would expect a similar rating for those two scenarios. For example, both X1Y1a and X1Y1b refer to impact at the level of an individual (X-axis), where the individual is either the principal investigator or member of the project team (Y-axis). However, though scenarios of the same kind were mostly rated in a similar way by funders, there are cases where scenarios of the same impact plot-point are rated very differently. One example is X1Y2a and Y1X2b in the case of Winetech (Table 7.5).

The first had a mean score of 3.10 (X1Y2a), which would make it a 'Moderately important impact', whereas the second (Y1X2b) had a mean score of 1.76, making it only a 'Slightly important impact'. It is interesting that, when looking at the scenarios as responded to in the Hortgro survey (Table 7.5), they are again dissimilar, this time with a first mean score of 3.09 (X1Y2a) and a second of 1.70 (Y1X2b). Both scores for Hortgro are very similar to the Winetech scores. A dissimilarity is also seen in the Winetech survey (Table 7.4) in the case of X3Y3a (mean score of 3.54), making it a 'Very important impact' and X3Y3b (mean score of 2.71), making it 'Moderately important'. Once again these are also dissimilar in the Hortgro responses (Table 7.5) with X3Y3a (mean score of 3.70) and X3Y3b (mean score of 2.30), a pronounced difference between a 'Very important impact' and a 'Slightly important impact'. The discussion on the responses in the three tables (7.5, 7.6 and 7.7) will take the form of a mapping exercise (7.3.1.1). The various impacts will be plotted similar to Figures 7.1 to 7.4.

Table 7.8 below provides an explanation for these differences by presenting two elements from each of the 22 impact scenarios. The first element, seen in the 'beneficiaries' column, shows the individual, organisation or group that purportedly benefitted from the impact or effect. The second element appears in the next column, and highlights the type of benefit that these beneficiaries derived from the impact, based on the account provided in the impact scenario. A third element was also added, which indicates whether the beneficiaries identified in the 'beneficiaries' column are either the funders themselves, or represented by the funder (in other words a producer, or someone paying levies to the funder). The different scenario elements are presented in order of most to least important to both funders combined based on the combined mean score.

Table 7.8 Scenarios of research impact analysed in terms of beneficiaries and types of benefit

Location in scheme	Scenario elements			Mean score		
	Beneficiaries	Type of benefit	Beneficiary is the funder or is represented by the funder	Winetech	Hortgro	Both
X2Y3a (N=64)	Winetech/Hortgro	Created new knowledge	Yes	3.71	3.74	3.72
X2Y2b (N=64)	Group of farmers	Improved pest control	Yes	3.73	3.61	3.69
X3Y4a (N=64)	Producers	Developed industry-wide practice guideline	Yes	3.61	3.70	3.64
X3Y2b (N=64)	Group of farmers	Improved water management	Yes	3.68	3.48	3.61
X3Y3a (N=64)	Wine cellar/Farming cooperative (Hortgro)	Increased/improved product quality or pest control	Yes	3.54	3.70	3.59
X3Y4b (N=64)	Wine industry or deciduous fruit industry	Opened new market(s)	Yes	3.49	3.74	3.58
X2Y1b (N=64)	Farmer	Reduced cost	Yes	3.61	3.48	3.56
X2Y3b (N=64)	Industry body	Developed new export protocol	Yes	3.51	3.52	3.52
X3Y5a (N=65)	General public	Improved public health	No	3.52	3.35	3.46
X1Y3a (N=65)	University centre/department	Expanded research capacity	No	3.50	3.17	3.38
X3Y1a (N=64)	Sales agent	Increased sales	No	2.51	2.13	3.38
X2Y1a (N=64)	Winemaker or farmer (Hortgro)	Improved or increased production	Yes	3.39	3.26	3.34
X3Y1b (N=64)	Farmer	Improved pest control	Yes	3.39	3.04	3.27
X1Y3b (N=64)	Research institute	Attracted more work	No	3.17	3.00	3.11
X1Y2a (N=65)	Researchers	Built network	No	3.10	3.09	3.09
X2Y2a (N=64)	International research team	Built network	No	3.05	3.17	3.09
X1Y1b (N=64)	Researcher	Received external funding	No	3.05	3.05	3.05
X3Y5b (N=63)	General public	Increased living standards	No	2.86	2.81	2.84
X3Y2a (N=64)	Researchers	Allowed replication study	No	3.02	2.48	2.83
X1Y1a (N=65)	Researcher	Gained skill	No	2.71	2.52	2.65
X3Y3b (N=64)	Public sector laboratory	Qualified an employee	No	2.71	2.30	2.56
X1Y2b (N=65)	Researchers	Created own consultancy	No	1.76	1.70	1.74

From the results as presented in Table 7.8, it seems clear that the responses of the funders not only depended on the position of the impact plot point on the research impact classification scheme, but also on the relationship between the funder and the beneficiary. In other words, the level of benefit and the closeness of the beneficiary to the project team were important in determining how impact scenarios were rated. There are 22 impact scenarios. Out of the top 11 only three beneficiaries are not a funder or a beneficiary that is represented by a funder. Out of the bottom 11 impact scenarios, only two are beneficiaries related to a funder. From the table, it does not seem as if the type of benefit influenced the outcome; however, this is explored in detail later in the chapter under 7.3.1.2 (Ideal impacts of research and reasons for failure).

7.3.1.1 Plotting survey funder impact responses on the impact classification scheme

Each of the 22 impact scenarios in Tables 7.5 and 7.6, for Winetech and Hortgro respectively, corresponds to a particular plot point on the impact classification scheme. A plot point is located at the intersection of the beneficiary's proximity to the research project (X-axis) and the level of organisation of the beneficiary, or scale of benefit (Y-axis). The funders' responses to the impact scenarios can thus also be visualised on the impact classification scheme. To visualise the responses, two figures are presented for each of Winetech and Hortgro, as well as for the funders combined.

The first figure provides an overview of the responses based on the mean scores per scenario. The scale used to interpret the means is the one that was introduced in section 7.3.1. However, colour is now used to ease pattern identification.

3.50–4.00 = Very important impact	2.50–3.49 = Moderately important impact	1.50–2.49 = Slightly important impact	1.00–1.49 = Unimportant impact

The second figure presents the percentage of respondents who rated each scenario as a 'Very important impact'. Scenarios where more than 50 per cent of respondents indicated that they viewed that scenario as very important are shaded in a dark grey.

The responses for Winetech are presented first (Figures 7.6 and 7.7), followed by Hortgro (Figures 7.8 and 7.9) and finally the combined responses of funders (Figures 7.10 and 7.11). In each cell, the left-hand side represents scenario 'a' and the right-hand side, scenario 'b', as per Tables 7.5 to 7.7. The six impact schemes should therefore always be read in conjunction with Tables 7.5 to 7.7.

The responses of the Winetech respondents (Figure 7.6) were relatively diverse in that most impact plot points were either rated as moderately important or very important impacts.

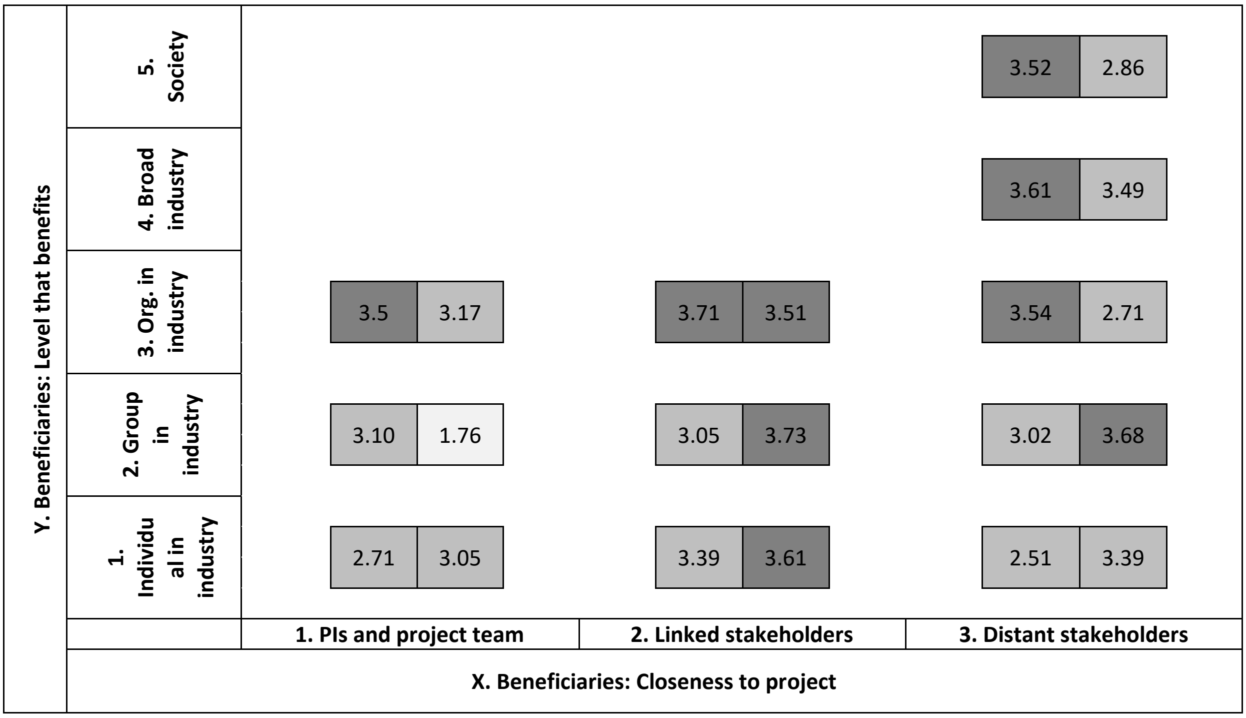

Figure 7.6: Impact according to Winetech technical committee members: mean rating scores (N=42)

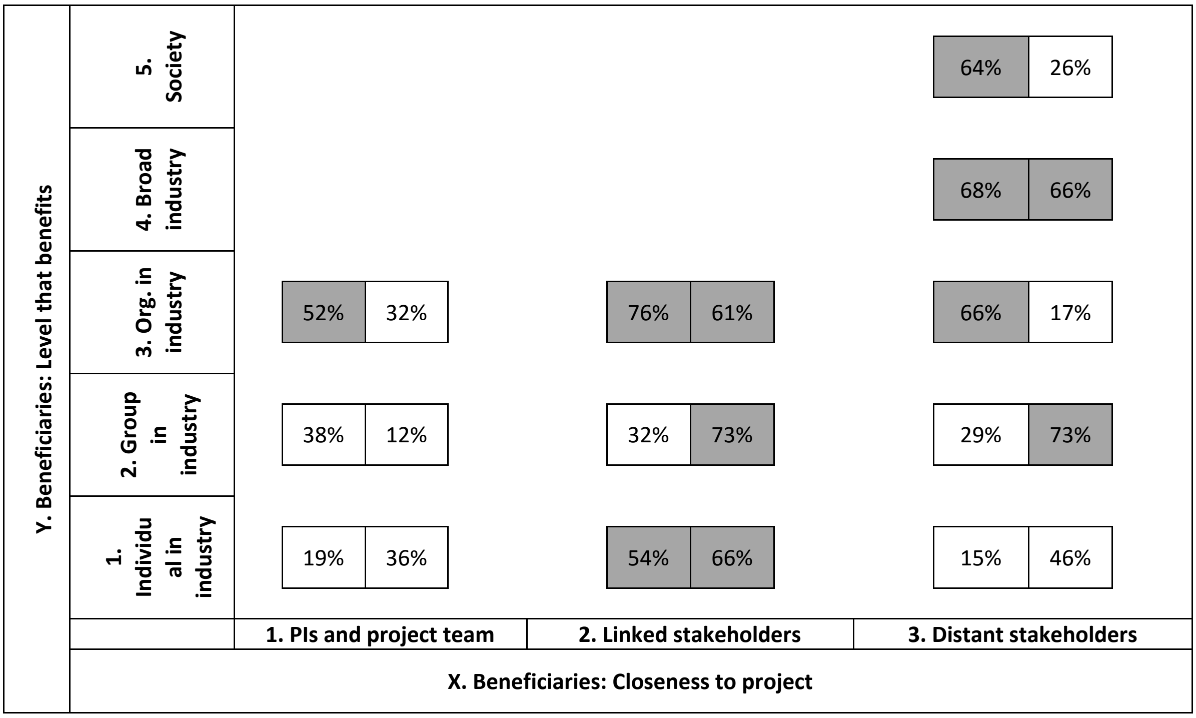

Figure 7.7: Impact according to Winetech technical committee members: percentage ratings of "Very important impact" (N=42)

One of the two exceptional cases discussed earlier (see 7.3.1) can also be seen clearly in X1Y2 and X3Y3 where there were very different responses to the two scenarios in the same impact point.

Another example clearly showing the difference between stakeholders linked to Winetech and those not linked can be seen in X3Y3. In X3Y3a, the scenario relates to a wine cellar, while X3Y3b refers to a public sector laboratory. Even though both scenarios have impact at the same level, the type of stakeholder means that they are scored very differently.

When comparing Figure 7.6 (mean scores) and Figure 7.7 (percentage indicating 'Very important impact'), a similar pattern emerges. Impacts benefitting linked stakeholders and distant higher-level stakeholders seem to be regarded as the most important impacts for Winetech research. These types of stakeholders would include (as seen in Table 7.8) numerous stakeholders or beneficiaries linked to Winetech (not just to the research project). Any impact on a farmer (often research participants in X2) is seen as an important impact for Winetech.

With Hortgro (Figures 7.8 and 7.9), the results were somewhat different in terms of where the focus of impact should be. It could be argued that the results seem to be more concentrated than in the case of Winetech.

For Hortgro, it seems that cells X2Y3 and X3Y4 are the most important (Figures 7.8 and 7.9). This focus could be explained by the fact that the boxes relate to impacts on Hortgro itself (X2Y3) and to the industry as a whole (X3Y4). Similar to Winetech, it is clear that the relationship of the stakeholder with Hortgro plays a role (as shown in Table 7.8). In X3Y1 and X3Y2, there is a marked difference between farmers benefitting, and stakeholders further removed from Hortgro (for example the foreign researcher) benefitting from an impact or effect.

Cell X3Y3 in the Hortgro results and somewhat less in the Winetech results also show that these stakeholders are mainly directly related to Hortgro and Winetech levy payers. Scenario 'b' of cell X3Y3 is one where a private laboratory in the wine or deciduous fruit industry recruits an employee trained through a Winetech or Hortgro project. However, for neither Winetech nor Hortgro is this 'building capacity scenario' rated as 'very important'. For Hortgro, this is rated as 'slightly important'.

Again similar to Winetech, the X2 column is most important for Hortgro. As stated, this would include individuals and organisations, such as individual producers or larger corporations in the industry, which took part in the research of a project.

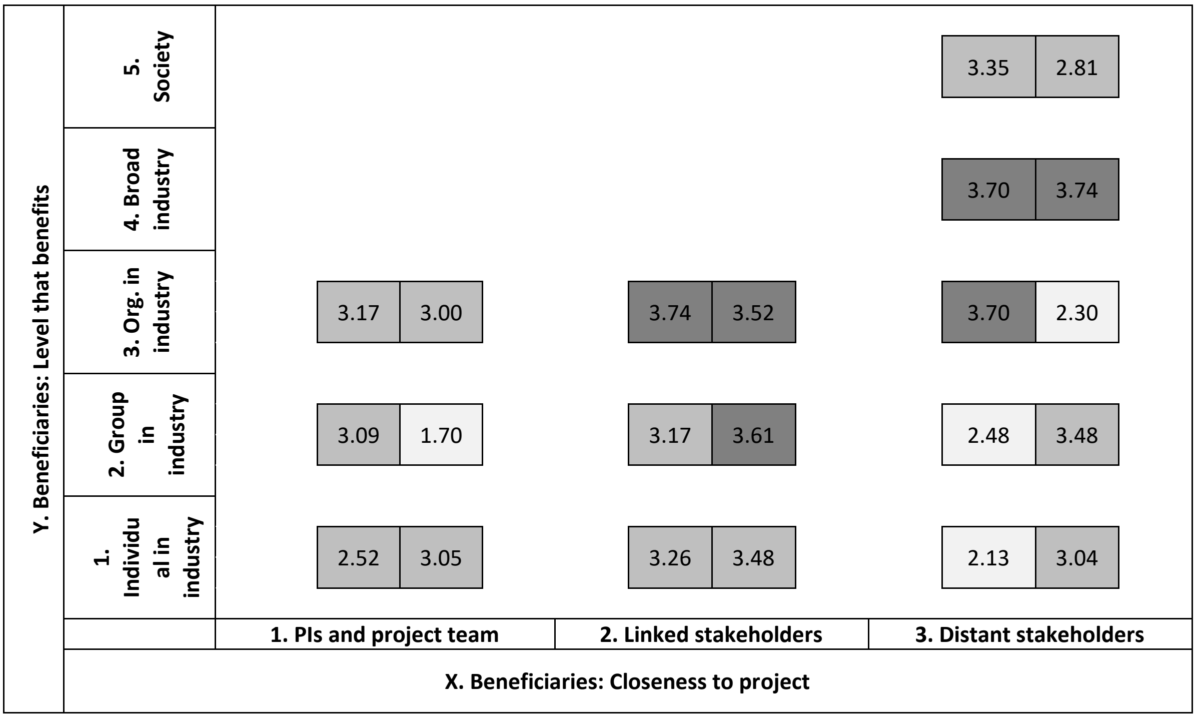

Figure 7.8: Impact according to Hortgro technical committee members: mean rating scores (N=23)

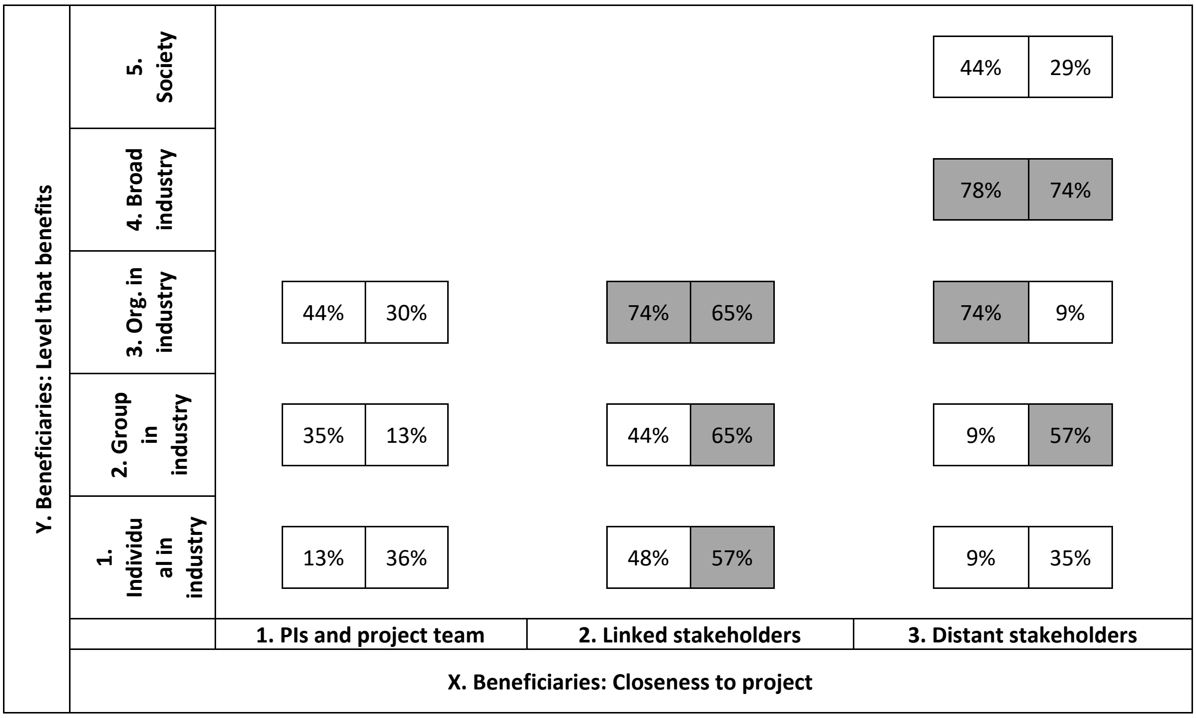

Figure 7.9: Impact according to Hortgro technical committee members: percentage ratings of "very important impact" (N=23)

The researchers in Hortgro projects (column X1), were more important to Hortgro (funding committee members) than the lower-level distant stakeholders (only those not represented by the funder). Distant stakeholders only seem to become important when they are organised at a higher level, and/or linked to Hortgro (for example the deciduous fruit industry as a whole). The Hortgro committees did not view impacts on society as 'very important', showing a decrease in importance when the impact is again too broad (as opposed to focussed on the industry). The two figures (7.10 and 7.11) below show the amalgamated results of Winetech and Hortgro.

Y. Beneficiaries: Level that benefits	1. PIs and project team		2. Linked stakeholders		3. Distant stakeholders	
5. Society					3.46	2.84
4. Broad industry					3.64	3.58
3. Org. in industry	3.38	3.11	3.72	3.52	3.59	2.56
2. Group in industry	3.09	1.74	3.09	3.69	2.83	3.61
1. Individual in industry	2.65	3.05	3.34	3.56	2.38	3.27
	X. Beneficiaries: Closeness to project					

Figure 7.10: Impact according to Winetech and Hortgro technical committee members: mean rating scores (N=65)

Y. Beneficiaries: Level that benefits	1. PIs and project team		2. Linked stakeholders		3. Distant stakeholders	
5. Society					57%	27%
4. Broad industry					72%	69%
3. Org. in industry	49%	31%	75%	63%	69%	14%
2. Group in industry	37%	12%	36%	70%	22%	67%
1. Individual in industry	17%	36%	52%	63%	13%	42%
	X. Beneficiaries: Closeness to project					

Figure 7.11: Impact according to Winetech and Hortgro technical committee members: percentage ratings of "Very important impact" (N=65)

In the combined results, the same trends seen in the results for the two funders re-emerge. In all the different figures plotting research impact, the only impact plot point where both scenarios were always selected as 'very important' impacts were for X2Y3 (both X2Y3a and X2Y3b fall in this category). Similarly, both X3Y4a and X3Y4b were also mostly scored highly.

After the funding bodies and the broader industry, stakeholders that were linked to Winetech or Hortgro (not necessarily the different research projects) were rated as most important. This was followed by the researchers who worked on the projects. The least important groups were distant stakeholders not linked to Winetech or Hortgro. However, as X1Y2a above shows, any impact that does not seem to have a direct effect on Winetech or Hortgro (in this case, researchers starting their own consultancy after the success of a project) was rated low.

7.3.1.2 Ideal impacts of research and reasons for failure

This section presents the results on what funders identify as 'ideal impacts' of Winetech- or Hortgro-funded research. It also presents the results on the reasons why funders believe some projects (which they funded in the past) failed to achieve optimal impact. In total, the research was able to collect

- Ideal impacts: 89 answers from 32 Winetech respondents
  54 answers from Hortgro 20 respondents
- Impact failure: 60 answers from Winetech 24 respondents
  30 answers from Hortgro 15 respondents

Figure 7.12 presents the ideal impacts identified by each of the commodity companies.

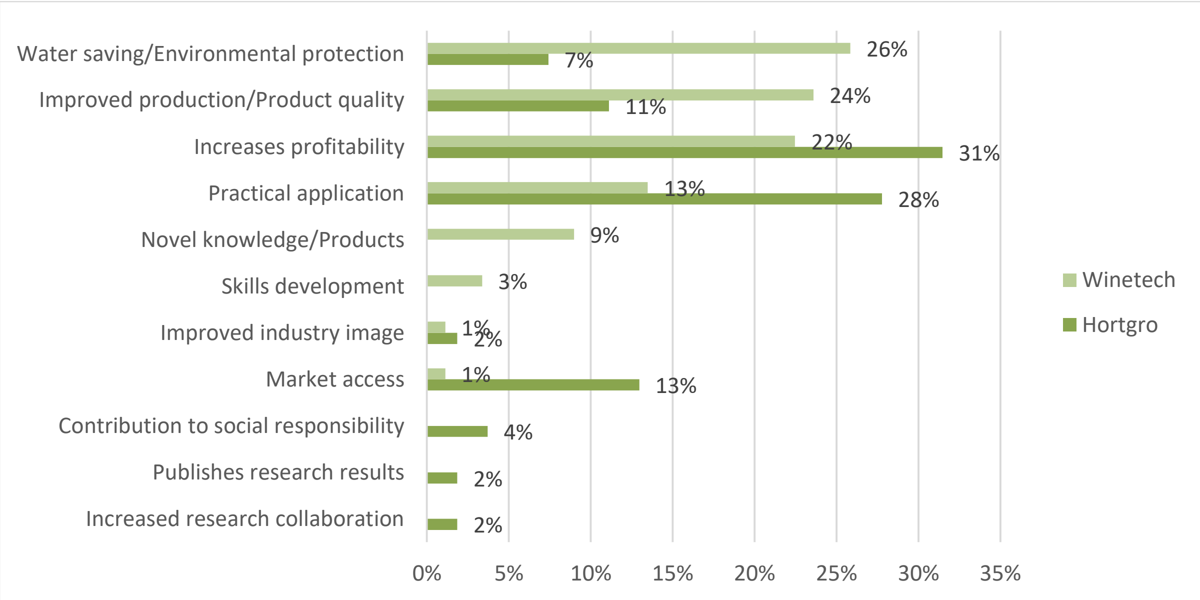

Figure 7.12 Ideal impacts of research as identified by Winetech and Hortgro

Each respondent could provide three ideal impacts (an open question), and the responses were then coded into 11 categories. The distributions in Figure 7.12 reflect the percentage breakdown of answers across all 11 categories, per funder (all the responses for Winetech, for example, will add to 100 per cent). The data are sorted from the most common Winetech response to the least.

For Winetech, the most important ideal impact was "Water saving/Environmental protection", as mentioned by 26 per cent of respondents (Figure 7.12). This focus is probably the result of a drought that has been affecting the Cape Town region, close to which most of the wine farms in South Africa are situated. The SA government has forced industries and farms in the area to reduce water usage by up to 60 per cent. The second most important ideal impact is "Improved production/Product quality" (24 per cent), followed by "Increases profitability" (22 per cent). These impacts seem of logical importance to Winetech as they directly benefit the producers who partially fund Winetech through levy payments.

For Hortgro, the most important impacts were "Increases in profitability" (31 per cent), followed by research that has a "Practical application" (28 per cent) and, interestingly, research that increases or maintains "Market access" (13 per cent). These impacts seem to suggest a business or corporate focus from Hortgro, reducing costs, improving aspects in the industry through implementable (practical) results and ensuring there are customers to whom to sell.

Figure 7.13 below shows the percentage distribution of answers, by funder, with regard to impact failure.

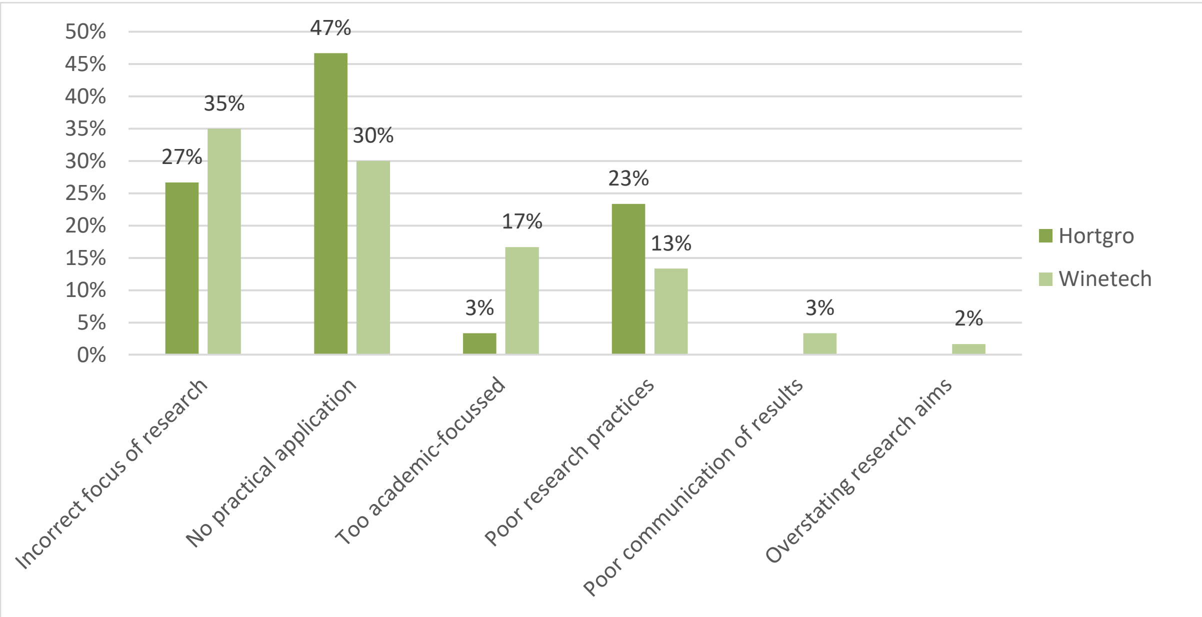

Figure 7.13 Reasons for research failing to have an impact, as provided by Winetech and Hortgro

Respondents could provide up to three reasons for impact failure, and the answers were coded in six categories. The most common reasons for a lack of impact showed some overlap between Winetech and Hortgro. For both, the issue of research having no practical application were important (most important for Hortgro; second most important for Winetech). The incorrect focus of research projects was the most reported reason for failure according to Winetech funders and the second biggest reason for failure according to Hortgro funders. This seems to be an interesting result since the focus of research and the projects funded are decided by the Winetech and Hortgro funding committees themselves.

The third problem for Winetech was research that was too academic-focussed (somewhat related to the problem of research not having a practical application or being incorrectly focussed). The fourth problem for Winetech, and third for Hortgro was "Poor research practices". It is interesting that this topic was raised by both Winetech and Hortgro, which suggests that poorly executed research is a problem at some level in both industries. Poor research practices comprise complaints such as research that was done without keeping samples from getting contaminated, poor management of researchers by PIs, which led to slow or limited progress, and mention is even made of poorly designed studies with untrustworthy results.

7.3.2 'Who' are the main role players effecting research impact?

The previous section looked at responses from the survey on impact literacy regarding 'what' funders view as research impact. This section presents the results seen by Winetech and Hortgro as the most important in effecting research impact ('who'). The respondents were presented with a list of organisations that potentially play a role in knowledge and technology transfer-related activities. Each funder received a list of organisations specific to the industry that they represent but there were also some communalities. The lists were drawn up with input from the management of both Winetech and Hortgro on the respective important organisations. Respondents were asked to rate the organisations in terms of their importance for knowledge and technology transfer, ranging from 'very important' to 'not important at all'. 'Do not know' was included as an option.

The responses for Winetech and Hortgro are presented in Tables 7.9 and 7.10 below. The tables are organised according to the number of times an organisation was rated as a "Very important organisation". The tables also include a number of organisations not previously introduced elsewhere in this dissertation:

- *Council for Scientific and Industrial Research (CSIR)*: The CSIR was established through an act of parliament, with the SA Parliament as its only shareholder. According to the CSIR (CSIR, 2019), its aim is to improve the quality of life for South Africans through research and technology development. It undertakes research that is in line with priorities set by the SA government.

- *Industry representative bodies*: An example is Shiraz South Africa (bodies representing specific cultivars of agricultural produce or products).
- *Private corporations in South Africa*: Examples of these are fruit importers and exporters.
- *Institute for Grape and Wine Sciences (IGWS)*: The IGWS at Stellenbosch University is built on a collaboration between the university and the wine and table grape industries. The aim of the IGWS is to undertake research and stimulate technology development in viticulture and oenology (IGWS, 2019).
- *South African Wine Industry Information and Systems (SAWIS)*: SAWIS is a not-for-gain company that administers the South African Wine of Origin system (the system used to indicate where wines originate from, example: "Wine of origin: Stellenbosch"). It also aims to collect and distribute information relevant to the wine industry (SAWIS, 2019).
- *South African Plant Improvement Organisation (SAPO)*: The SAPO trust works to develop and supply SA agriculture with virus-free plant material (SAPO, 2019).
- *Culdevco*: A joint venture between the SA deciduous fruit industry and the ARC that aims to commercialise all ARC-bred fruit varieties (Culdevco, 2019).

Table 7.9 Most important organisations in effecting research impact, as identified by Winetech

Organisation	Unimportant organisation		Slightly important organisation		Moderately important organisation		Very important organisation		Do not know	
	Count	%	Count	%	Count	%	Count	%	Count	%
Winetech (N=35)	0	0%	1	3%	2	6%	32	91%	0	0%
Universities (N=35)	0	0%	2	6%	4	11%	29	83%	0	0%
VinPro (N=34)	1	3%	0	0%	6	18%	27	79%	0	0%
IGWS (N=35)	1	3%	0	0%	6	17%	27	77%	1	3%
Industry-focussed 'popular' magazines (N=35)	1	3%	1	3%	7	20%	26	74%	0	0%
Agricultural training institutes (N=35)	1	3%	3	9%	9	26%	22	63%	0	0%
SAWIS (N=35)	0	0%	6	17%	9	26%	20	57%	0	0%
Industry representative bodies (N=35)	1	3%	2	6%	12	34%	20	57%	0	0%
ARC (N=34)	4	12%	4	12%	7	21%	19	56%	0	0%
SA academic journals (N=35)	1	3%	2	6%	14	40%	18	51%	0	0%

International academic journals (N=36)	1	3%	4	11%	14	39%	17	47%	0	0%
Private corporations in South Africa (N=35)	1	3%	9	26%	13	37%	12	34%	0	0%
Department of Agriculture, Forestry and Fisheries (N=35)	6	17%	10	29%	7	20%	11	31%	1	3%
Private/independent laboratories/research centres (N=35)	2	6%	9	26%	13	37%	10	29%	1	3%
CSIR (N=35)	6	17%	7	20%	9	26%	9	26%	4	11%

Table 7.10 Most important organisations in effecting research impact, as identified by Hortgro

Organisation	Unimportant organisation		Slightly important organisation		Moderately important organisation		Very important organisation		Do not know	
	Count	%	Count	%	Count	%	Count	%	Count	%
Hortgro (N=22)	0	0%	0	0%	6	27%	16	73%	0	0%
Universities (N=22)	0	0%	2	9%	6	27%	14	64%	0	0%
Private/independent laboratories/research centres (N=22)	2	9%	0	0%	6	27%	14	64%	0	0%
CULDEVCO (N=22)	0	0%	1	5%	8	36%	13	59%	0	0%
Industry representative bodies (N=22)	2	9%	2	9%	10	45%	7	32%	1	5%
Agricultural training institutes (N=22)	2	9%	6	27%	7	32%	6	27%	1	5%
Industry-focussed ‘popular’ magazines (N=22)	2	9%	10	45%	5	23%	5	23%	0	0%
SA academic journals (N=22)	2	9%	6	27%	7	32%	5	23%	2	9%
International academic journals (N=22)	1	5%	8	36%	7	32%	5	23%	1	5%
CSIR (N=22)	2	9%	7	32%	6	27%	5	23%	2	9%
Private corporations in South Africa (N=22)	5	23%	6	27%	7	32%	4	18%	0	0%
ARC (N=22)	2	9%	3	14%	13	59%	4	18%	0	0%
SAPO (N=22)	1	5%	10	45%	5	23%	3	14%	3	14%
Department of Agriculture, Forestry and Fisheries (N=19)	5	23%	9	41%	3	14%	2	9%	3	14%

When looking at the Winetech results, there is a focus on Winetech and university-related organisations. Winetech and its partner organisation, VinPro, were selected the most and third most often as “Very important organisations”. Universities (in general) and the Stellenbosch University-related IGWS were second and fourth respectively. This might indicate that research in the Stellenbosch area is seen as vital to the wine industry. “Industry-focussed ‘popular’ magazines” was selected fifth most. This most likely refers to the *Wineland* magazine that has a very strong following among wine producers. Another interesting observation is that SA academic journals were rated (just) above International academic journals. Research has shown that SA winegrowers are prone to rely on research results in their wine making, with academic journals being of importance, but with the *Wineland* magazine (a popular magazine mentioned earlier) being particularly well known (Boshoff, 2014a). Government organisations were not seen as very important, with the Department of Agriculture, Forestry and Fisheries receiving 31 per cent “Very important” responses, and the CSIR even less at 26 per cent.

In general, Hortgro responses rated the importance of most organisations as less important, except for “Private/independent laboratories/research centres” which Hortgro respondents viewed as more important than Winetech respondents (64 per cent “Very important” for Hortgro, compared to 29 per cent in the Winetech responses). This is due to the importance of a private research institution, ExperiCo, which has a cooperation agreement with Hortgro (as discussed in Chapter 6 and depicted below in Table 7.11). Only four organisations received a rating of more than 50 per cent for “Very important”, namely Hortgro, Universities, Private/independent laboratories/research centres (probably ExperiCo) and Culdevco. Similar to Winetech, there seems to be a strong reliance on the research infrastructure in the Stellenbosch area. It is interesting that Culdevco is rated as one of only four organisations with a “Very important” rating above 50 per cent, since the ARC was mainly rated as “Moderately important” (59 per cent) with only 18 per cent of respondents viewing it as “Very important”. This is somewhat surprising since the ARC is the second largest recipient of Hortgro research projects, with 24 projects out of 116 in 2015/2016 (see Figure 3.1 Number of Hortgro Science projects per research institute 2015/2016) (Hortgro Science, 2018).

The survey also allowed respondents to indicate whether there were any organisations that had not been included in the list of possible important organisations. Seven Winetech and eight Hortgro respondents suggested 24 possible additions (12 in the wine industry and 12 in the deciduous fruit industry). These suggestions were however mainly different commercial companies, such as chemical companies, distributors or suppliers. No new additions therefore emerged because the category of ‘Private corporations in South Africa’ already included the suggested organisations.

Reasons for importance of top important organisations

The respondents were also asked to specify the five most important organisations (from the lists in Tables 7.9 and 7.10) that they viewed as most important in effecting research impact in their industries. The respondents provided responses on:

- Which organisations are most important
- Why these organisations are important (the roles they play in effecting impact)
- Who the employees (in terms of occupation) are that are important within these organisations in effecting impact.

Tables 7.11 and 7.12 present the results for each funder. The number of respondents who mentioned an organisation, role or employee are indicated in brackets next to the responses.

Table 7.11 Most important organisations, roles and employees in effecting research impact in the wine industry, as specified by Winetech

Organisation	Roles	Employees
Universities (23)	• Training students in latest research (11) • Undertakes research (7)	• Lecturers/Researchers (12)
Winetech (15)	• Provides research funding (5) • Coordinate industry research priorities (4) • Technology and knowledge transfer activities (2)	• Management (4) • Technology transfer/Extension officers (4)
VinPro (14)	• In direct contact with producers (4) • Technology and knowledge transfer activities (4) • Practical on-farm experience ('know how') (3)	• Extension consultants (9) • Technology transfer/Extension officers (2)
ARC (7)	• Technology and knowledge transfer activities (3) • Undertakes research (2)	• Researchers (6)
IGWS (6)	• Technology and knowledge transfer activities (4)	• Technology transfer/Extension officers (4)

The obvious difference between Table 7.11 and the list of all organisations in Table 7.9 is that the ARC overtakes the agricultural training institutes, SAWIS and industry representative bodies and even the IGWS to become the fourth most important organisation for Winetech. It might be that respondents viewed the larger list of organisations as one effecting research impact in the industry as a whole, with the organisations in Table 7.11 being more focussed on Winetech's own projects. Universities were the most important organisation for Winetech respondents. It is also possible that not all respondents who answered the previous question answered this question. Their main function was identified as training students who are conscious of the latest research and who could work in the wine industry later. Winetech was identified as a source of research funding and as important in directing research funding. VinPro was seen as an important link, both with producers (linking back to Winetech with their concerns) and between research and producers, introducing producers to relevant results and knowledge. The IGWS seems to have a similar role to VinPro, while the ARC is important in producing research.

Table 7.12 Most important organisations, roles and employees in effecting research impact in the deciduous fruit industry, as specified by Hortgro

Organisation	Roles	Employees
Hortgro Science (12)	• Technology and knowledge transfer activities (3) • Coordinate industry research priorities (2) • Provides research funding (2)	• Technology transfer/Extension officers (3)
Universities (12)	• Undertakes research (4) • Aware of current international research trends (2) • Training students in latest research (2)	• Lecturers/Researchers (8)
ExperiCo (6)	• Undertakes research (2)	• Researchers (6)
Hortgro (6)	• Technology and knowledge transfer activities (2)	
Popular media (4)	• Technology and knowledge transfer activities (4)	

The Hortgro results looked somewhat different; however, again there was a difference between the most important organisations and those listed in Table 7.10 (possibly due the smaller number of respondents who opted to answer this question). Hortgro has both a main body and a research-focussed body (Hortgro Science). These were combined in the results for Table 7.10. However, respondents could rate both Hortgro and Hortgro Science separately (this was done on recommendation from Hortgro). Hortgro (the main body) is seen as important in technology and knowledge transfer, while Hortgro Science (as could probably be expected) is seen as important in commissioning and coordinating research along with technology and knowledge transfer. Universities were also identified as important, but in this case, as sources of research first and training of students second. ExperiCo was mentioned as the third most important organisation, again unsurprisingly with a focus on research, since it is a private research organisation. Culdevco and industry representative bodies were not selected by any respondents even though they were the fourth and fifth most important organisations in Table 7.10. Again, it is possible that these types of organisations are seen as important in research impact in the industry in general, but that other organisations are prominent when it comes to Hortgro-specific research projects.

7.4 Conclusion

The survey of research impact was able to capture a wide range of opinions of two agricultural research funders, namely Winetech and Hortgro, as represented by their expert committee members. The survey was able to enlarge the understanding of 'what' impact is from the perspective of the research funders.

Making use of a research impact classification scheme, the chapter showed that the impact identified through the impact codes from the mainly self-reported data in the first two phases of the research focussed on two areas of impact. The first was a strong focus on impact related to researchers who formed part of the research projects (the cases). The second focus was on impacts within the broader wine and deciduous fruit industries. In other words, there was a focus on the direct effects of research on researchers, and secondly, on longer-term or more distant impacts (in relation to the researchers) to industry.

The funder responses (from the survey on research impact in the third phase) showed that the impacts related to researchers were less appreciated by funders. Funders focus on the impacts that relate to them directly, but they also attach importance to impacts on the broader industry. Additionally, it was shown that the most important consideration for funders is in achieving any research impacts that relate to stakeholders whom they represent (Table 7.8). When the funder is the beneficiary, or when the beneficiary is represented by the funder, the impact is rated as more important.

Lastly, it was found that Winetech and Hortgro operate in similar research-effecting environments in relation to 'who' is responsible for achieving research impacts. Although the responses were different for Winetech and Hortgro both:

- identified an organisation responsible for funding of research and research coordination (Winetech and Hortgro/Hortgro Science);
- identified an organisation that produces research only (ARC or ExperiCo);
- identified universities as important in research and in training of students; and
- relied on specialised technology and knowledge transfer organisations (VinPro/IGWS and Hortgro/Hortgro Science themselves).

The next chapter provides a discussion of the results of Chapters 6 and 7, along with the conclusion for the dissertation.

Chapter 8

Towards a deeper understanding of the mechanisms that drive the societal impact of research

---

8.1 Introduction

In this final chapter of the dissertation, the researcher discusses the results presented in the previous two chapters in relation to the three research objectives of the dissertation along with the research questions. The aim of the study reported in this dissertation was to increase the understanding of the SoIR towards the goal of improving research evaluation, through the use of the SIAMPI approach with productive interactions, influenced by the logic of realist evaluation. The use of SIAMPI allowed the researcher to overcome some obstacles that have hindered the development of SoIR evaluation methods, especially the problem of attribution and a lack of expertise (understanding of what research impact is).

The current research was able to show that research interactions (possible productive interactions) identified through the SIAMPI approach provided sufficient data for the construction of theories of change for the case studies (for visualisation of the research process), showing the productive nature of these interactions. From the theories of change, the research was able to identify impact pathways that arguably represent theories of how research impact is effected. These theories of change show that SIAMPI with its focus on productive interactions could theoretically be used as a method within realist evaluation. The alignment of productive interactions and CMO configurations are related to the theories of change, and will be expanded on in the chapter (see 8.3.3). It will be argued that CMOs could provide SIAMPI with the tools needed to build transferable and generalisable theories on effecting SoIR.

Having collected research interactions, combined these into theories of change and impact pathways, the research needed to understand to what extent it had explored the concept of SoIR. The problem with definitions of SoIR is that impact by its nature cannot be captured in a single definition; there will probably always be numerous definitions highlighting different aspects and views of impact, either within different disciplines or with different stakeholders (Bayley & Phipps, 2017:2).

To overcome this problem, the research relied on the concept of impact literacy, which states that the understanding of impact (also research impact) requires an understanding of who causes it, how it is caused and what it effects (‘who’, ‘how’ and ‘what’). This is not a definition, but provides a lens with which to look at the research undertaken in the study, which showed a need to explore the ‘what’ element further in terms of how funders view impact. From this last research endeavour, the research was able to capture not only the views of ‘how’, ‘what’ and ‘who’ research impact is for those directly involved in the research process (phases one and two of the research), but also for the funders of research.

An enabling element in this process was the development of a SoIR classification scheme. This ‘classification scheme’ is presented in the third section of the current chapter (see 8.4), where it is adapted to a Classification framework for research impact.

The chapter is divided into four main sections. The first looks at the findings surrounding the first and second research questions related to productive interactions and SIAMPI (the research questions are restated at the start of each section). The second focusses on the third and fourth research questions, mainly related to the use of productive interactions in theories of change, the alignment of productive interactions and CMOs and the use of SIAMPI within a realist evaluation. The third section presents the SoIR classification scheme (questions five and six). The final two sections look at recommendations for research evaluation practice followed by recommendations for future research.

8.2 Identifying productive interactions and effects through the SIAMPI approach

The first objective of the research was to study the SoIR through a focus on productive interactions as identified through SIAMPI. The two research questions related to this objective are:

- Question 1: Which *research interactions* (possible productive interactions) are identified through application of the SIAMPI approach in four cases of agricultural research in South Africa?
- Question 2: What do the identified research interactions reveal about the *SIAMPI approach* – in other words, what are possible strengths and weaknesses of the approach in capturing and understanding research impact?

In Chapter 6, an in-depth overview was provided of which types of research interactions were identified in which data sources. These findings will not be repeated here in detail. Interactions were identified from all the different types of interactions (direct, indirect and material). Additionally, the distribution of interactions by case fell into a repeated pattern with direct interactions being most common, followed by indirect and material interactions (see Tables 6.1 and 6.2, also Figure 6.1). The prevalence of direct interactions was expected since SIAMPI's productive interactions focus on the time and space close to the researcher and research. Indirect interactions take place through intermediaries and are thus most likely found at a level more removed from the researcher or research.

The results in Chapter 6 also showed that a number of different productive interactions and data on these interactions are already being captured in research project documentation. However, it is clear that, at least in the case of the two commodity companies that formed part of the current research, it is presently not possible to do a study on productive interactions without the use of interviews. More specifically, it showed that current reporting categories in research reports do not capture all the interactions needed to build *ex post* theories of change as was done in the current research.

8.2.1 An overview of productive interactions

The SIAMPI approach was developed to explore the process of how SoIR occurs and to assist with the development of a method that can be used to assess and identify the SoIR (Spaapen & Van Drooge, 2011b). SIAMPI is *process-oriented* and moves the focus away from final impacts to the actions within which research and researchers engage that leads to societal impact. This was illustrated by the different interactions identified in different stages of the research process for the cases (see Figures 6.2, 6.6, 6.10 and 6.14). Access to funding, the securing of a relevant supervisor and the completion of research exchanges all have effects on different stakeholders long before traditional academic outputs are produced (for example journal articles and PhD dissertations) (see Figure 6.3 for an example).

To continue, SIAMPI is thus contextual since it looks at the different contributions into the research process and the uptake along the way. SIAMPI believes that by focussing on the process of research in this way that it has the potential to identify shorter-term impacts that would otherwise be missed, as it would not be possible to theorise these impacts before the research is undertaken. Research can be iterative, with steps being added or changed as required by the research. In Project 1, the researchers realised that they needed additional expertise to complete the project successfully and they were able to recruit P1.4 as a co-supervisor to address this need. Additionally researchers from outside the research project, for example the researchers from New Zealand, assisted in developing the analytical capacity required by P1.2, which eventually introduced new analytical capacity in the testing of molecules in wine to Stellenbosch University. None of these 'inclusions', which proved instrumental to achieving the outcomes produced by the research, were included or mentioned in the original project proposals. The SIAMPI approach highlighted these interactions. Researchers themselves are experts in the fields in which they specialise, not necessarily in foreseeing the impacts of their research. By requesting information about productive interactions, a funder would be in a better position to see how different research projects, for example, combine to contribute to a larger impact as they will be able to understand the interworkings between projects

The use of productive interactions then show the 'non-linear' nature of the research process. Although the research process has been portrayed as linear, research can be influenced, or disseminated into "many directions" (De Jong *et al.*, 2014:100). Productive interactions can capture all these different influences and outcomes of research. The theories of change used in the current research were therefore only chosen to represent the research process (which of course also has a chronological order) in a more linear fashion (similar to the payback framework) for ease of understanding.

Finally, SIAMPI is oriented towards making formative contributions rather than summative judgements with the aim of improving the interactions that take place between researchers and stakeholders thus facilitating the achievement of SoIR (Spaapen & Van Drooge, 2011). SIAMPI's impact mechanisms, the productive interactions (or research interactions) showed how research impacts formed and how the research processes in the different cases developed as presented in the different impact pathways (see 6.5.7, 6.6.7, 6.7.7 and 6.8.7). This aspect of productive interactions is expanded on in the second section of this chapter (8.3), which looks more closely at the theories of change and impact pathways.

8.2.2 Productive interactions as indicators of impact

Productive interactions provided enough data to reconstruct the research processes of the cases on how research impact formed and who was involved in enabling the different outcomes and outputs of a research project. The research would be more than cautious to try and identify specific productive interactions as anything close to a process indicator. There are possibly countless different 'finer' types of direct, indirect or material interactions still. Making lists of possible process indicators would lead to the same problem as experienced by previous SoIR assessment approaches where there were too many possible indicators to generalise. The value of productive interactions as 'indicators of impact' however lies in their ability to construct impact pathways, discussed in the second section of the chapter (see 8.3.2). Nonetheless this is a clear strength of productive interactions, being useful in the development of coherent visualisations of the research processes for the case studies (Chapter 6).

Some of the outcomes and outputs identified by productive interactions are used in determining scientific impact, and not the SoIR. For example, the production of journal articles with citation counts and journal impact factors are a standard area of focus for scientific impact. Beyond the number of journal articles or conference presentations delivered, productive interactions contribute the ‘bread crumb trail’ of how these articles and presentations were enabled by the coming together of different networks of actors all contributing (since the interactions are productive) to the research process. This supports the notion that the focus on contribution as opposed to attribution has merit. For examples, again see the various impact pathways discussed in Chapter 6 under 6.5.7, 6.6.7, 6.7.7 and 6.8.7. Additionally, it shows how and where these artefacts fit in a larger system of research or knowledge spread. Similar processes that allow for the writing of journal articles give rise to new oxygen probes, trained employees, or the identification of diseases unknown to industry.

In the examples of the case studies, portrayed through the theories of change, the productive interactions show impacts, albeit with most interactions at a very low level of impact (see Figure 7.1 to 7.4). Nonetheless, by definition, these interactions have at the very least had an effect, something changed or someone tried to make use of the knowledge received in some way. These are effects or impact, even if they do not traditionally count as such. The interactions between a supervisor and his or her students, who are provided with funding or conceptualisations of research topics, are direct and material interactions that are very low-level impacts, or arguably immediate outcomes (when considered in terms of programme evaluation).

For a funder, these interactions, if presented in a progress report, will have very little value. Funders of research might not even care about the production of a PhD as was shown from some of the results from the survey of research impact, so there is little chance of having the funding of a PhD candidate count as impact (Tables 7.5–7.8). Yet, for the PhD candidate, if the project is seen from his or her view, the funding is of critical importance. Similarly, funders did not view additional funding for researchers, sourced on the successful completion of research projects as important (see Table 7.7 Funders combined: the societal impact of research). However, for the researcher or arguably the research field, this is essential for future research. These productive interactions are showing small enablers of research, and although research alone is not enough to have a societal impact, without research there is logically no chance of an impact either.

It is then unsurprising that so many interactions are not included in research reports, probably because these interactions are not seen as important. Table 6.1 showed that research interviews identified 176 researcher interactions compared to research reports with 135 interactions (out of 426). This was also shown in Table 6.4, which looked at finer coding categories, where the widest range of research interactions (types of interactions) were coded from researcher interviews followed by research reports in second place. While research reports had much higher mentions of articles, conference presentations and other 'traditional' research outputs, interviews included more information on the industry taking part in the research process (where producers for example provide free products or expertise). Data from interviews also provided information on other researchers sharing expertise with project researchers, where funding from projects came from and the relationships and/or interactions between supervisors and students who took part in the research projects. The additional information provided by productive interactions identified from the interviews did not show as much that interviews are critical for SIAMPI, but rather that additional information is required from researchers, and this is not currently being captured. This information is typically not included in their progress or final progress reports. To capture interactions that are not currently present in the reports, a change in reporting requirements is needed.

There are limits on the reliability of impacts as reported by case study researchers. For impacts taking place in time and space closer to the researchers, or impacts at a lower level, the interviews provided supporting evidence because those benefitting are also the individuals or groups linked to the project. The interviews in addition to identifying productive interactions simultaneously served as sources of evidence for these low-level impacts. For impacts at a higher level, interview data, from the perspective of the case study researchers, were mainly opinionated, if not vague and idealised with less supporting evidence (see Figure 7.1 to 7.4). The exception here being Project 4 on Forelle pears, where the researcher in the project, due to the involvement of industry from the early stages of the project, could follow the success of his research. Generally, this is not the case. The primary researcher in Project 1, for example, knew more farmers were using an oxygen probe that the project had (accidently) proved to be useful; however, he could not provide any evidence. It remained anecdotal. He could however clearly provide evidence on how P1.2 gained critical skills needed in the wine industry (an industry he knows very well).

In Project 3, the primary researcher thought it probable that some producers had bought the thinning machine as a result of her research; yet, she was not certain. She could however talk confidently about future research that followed from the project (since she was doing it). Researchers are experts on their research and discipline, not necessarily on wider impacts and they can also not be used as primary sources for research impacts that take place removed from them (distant in time and space).

Productive interactions through the focus closer to the research show that impact is something very specific to time, place and actors involved. This is not just to say that the context is important in the traditional realist evaluation sense where the historical and social context of an intervention affects the 'firing' of impact. However, what is meant here is that the SoIR is not something that exists beyond the demands of those interested in a specific impact. The view of this research, based on the working definition of the SoIR, has been that the SoIR is not something concrete that exists in the natural world. This type of impact is a construct that relies solely on the view of an individual, group, organisation, industry or even society of what is desired, one reason why the classification scheme for research impact focusses on the beneficiaries of impact. In the natural world, impacts only exist in a latent potential form in that they are effects of anything that takes place, but only become impact once the effect is valued by a grouping or entity. Impact is an effect that has become valued, and that value is specific to a certain individual, group or grouping.

8.2.3 Impact at a low level, but building to a nuanced overview

It might seem that productive interactions look at the process of impact at a far too low level to contribute to the understanding of SoIR. However, the example of the researcher in the Esca project (Project 2) showed that a researcher might be the one to push for the implementation of an important project. For a researcher, a low-level productive interaction is often accessing funding. Thus, although this type of interaction is insignificant on a larger scale, P2.1 spotted the problem and pushed for the implementation of Project 2. Access to funding was crucial for the researcher to continue his research. The point here is that the value of impact or of a specific outcome is very reliant on from whose view one is looking, and productive interactions provide the tools with which to explore these views. This is similar to what was found by Molas-Gallart and Tang (2011), who reported that productive interactions collect data on parts of the research process that are often overlooked. Productive interactions helped to "legitimise activity [that is] valuable for [researchers and] research users, but which traditionally are given little weight in academic schools" (Molas-Gallart & Tang, 2011:224).

When identifying productive interactions, an evaluation or monitoring method will identify a variety of different interactions that are probably important only for very limited audiences - not necessarily even for all the stakeholders involved in a specific part of a project. This shows that a nuanced overview and understanding of the research process is important. The different stakeholders are all experts in limited parts of impact. The funder, the researcher, the extension agent and the producer are all experts in their own rights, but none of them on their own will achieve a desirable impact without the others. Productive interactions on their own do not have an innate importance to all of the desired impacts in a project in terms of monitoring all of them, but they do show cases of different types of impact flaring up in specific contexts. In this way productive, interactions definitely capture 'impacts' that would otherwise have been overlooked or ignored.

Funders, researchers and even stakeholders, such as producers providing levies to fund the research of funders, have to possess a level of impact literacy that sensitises them to the importance of different productive interactions. Alternatively, the research found that both Hortgro and Winetech are seen as important in managing research; both are funding it and determining which research to commission. This supports the notion of impact literacy as important for those commissioning research. To achieve their research goals, funders must understand how the research process works and with whom, and how these contribute to what their industries need.

8.2.4 Contribution and attribution

The theories of change show that the productive interactions sketch a general overview of how the SoIR forms. Productive interactions do overcome the problem of attribution, since, as seen in the theories of change, SIAMPI identifies productive interactions close to the research, where those providing proof of interactions are knowledgeable on how the research process (thus early effects and outcomes) works. For example when P3.1 (the primary investigator in Project 3) said that it helped her in her research to be able to test the results against those of the developer of the machine she was testing, we can be fairly confident that the interaction contributed to ensuring reliable results. The researcher's research was being impacted and she was providing the evidence.

Although productive interactions show small effects, outcomes or impacts, the connections between different interactions might at times seem more implied than concrete in terms of showing how much each contributed to certain outcomes. This is a problem also experienced by realist evaluation, where it is not always clear that a certain mechanism or group of mechanisms is undoubtedly responsible for a particular change. The realist response is 'to make sense of' the mechanism based on the outcomes, or in other words to make use of logic to determine whether certain mechanisms contributed to an outcome. Once this has been done, the CMO configuration can be tested (Pawson & Tilley, 2004:16). This is discussed in more detail in section 2 (section 8.3.3). Even if it is not necessarily clear exactly how important each interaction was in the larger research project, we can be confident that all the interactions did contribute as seen in the theories of change.

8.2.5 Building impact stories from otherwise undocumented interactions

A researcher who gains funding for new research based on the success of a previous research project is an example of a productive interaction linking to an impact. There is such an example from the case studies that illustrates it better. P1.2, the PhD candidate in Project 1, gained her PhD from the research in the project. The aim of the project, for which funding was provided, was to understand the effect of oxidisation on white wine better. From the view of the funders, the fact that she became better qualified through the project had no effect on the importance or relative success of the project. However, arguably one of the most import impacts of Project 1 was that P1.2 acquired the capacity to undertake very skilled and highly technical analyses of components in wine. Her new skill is extremely rare, especially in South Africa. Until 1995, the Department of Viticulture and Oenology at Stellenbosch University, arguably the leading university department on viticulture in South Africa, had produced only one PhD (Boshoff, 2005). The analytical capacity P1.2 acquired made her one of only two researchers at the department who could do the type of analyses (component analyses on wine). It was this skill that helped her secure a job in the wine industry as a researcher at a private laboratory that does analytical work for the industry.

The project provided her with her new skills, and productive interactions can trace the process through which her skills were developed. There was also little chance of external interference as P1.1 and P1.2 were both extremely knowledgeable on the skill P1.2 acquired and on what is needed to become skilled in the field. The productive interactions in this case might not capture all factors playing a role in P1.2 becoming skilled, but there is a very high level of certainty that all the main causal interactions were captured.

The funding from Winetech acquired by her supervisor (P1.1) was provided to her (P1.2) along with her supervisor's conceptual understanding of the research that needed to be done (both of these are material direct interactions). She engaged with researchers in New Zealand where, through more material direct interactions, she gained the skills needed to do the technical analyses. Through the direct interaction of her supervisor, a Portuguese supervisor was brought into the project. Through further direct interactions of supervision, which included her travelling to Portugal, he (P1.4) enhanced her analytical capacity. The funding from Winetech further contributed to the purchasing of instruments required to do the analyses at Stellenbosch University successfully. These interactions combined to give her a rounded understanding of her topic needed to become fully skilled in the scare ability. This impact pathway is not in the final reports of the project and is only mentioned in the report as a quick reference to a PhD being produced from the project. This example shows that, at times, productive interactions do allow for the reconstruction of a very plausible explanation with concrete examples of contributions on how an impact was achieved. Missing the data in the impact pathway above means losing an opportunity to construct a better understanding of how the SoIR takes place.

8.2.6 Summarising the value of productive interactions

The 'productiveness' of an interaction is determined by its context. Although productive interactions generally do what they claim to do, that is, show the process of impact taking place, they are tied to the reality that impact (an effect with value for someone) changes along the process of being effected. This means that SoIR is not a linear process, and not only just a process of different stakeholders coming together (for example the export company, Hortgro and the researchers in Project 3). It is also the result of different types of impact or interactions overlapping and coming together (for example acces to funding, personal networks, and even self-determination such as what was required to launch Project 2).

An impact that is viewed as a research success both develops out of a trajectory and emerges out of favourable conditions, created by the coming together of stakeholders and their unique contexts. Productive interactions show contributions of different actors that can be verified, although the impact to which they are contributing might only have an impact on the research side of the project, or it may influence the research and produce impacts desired by funders.

Productive interactions have less value as lists of indicators that can be identified to create evaluations and much more value in understanding how research works. Productive interactions contribute in understanding the building blocks that construct the research networks from which the SoIR emerges (as shown in the theories of change). The interactions capture aspects of research that would otherwise have been overlooked (Molas-Gallart & Tang, 2011). The approach also reduces the need for stakeholders of research projects and researchers themselves to have to understand impact completely for the productive interactions to be identified. None of the interviewees were knowledgeable on research impact. Although productive interactions highlight the importance of networks in the effecting of SoIR, the SIAMPI approach itself does not provide enough tools with which this understanding can be taken further. A pure focus on productive interactions also runs the risk of only focussing on short-term impacts and missing the longer-term impacts. The list below provides an overview of strengths and weaknesses idenitified in SIAMPIs productive interactions.

- [Strength] Can be used to develop coherent visualisations of research processes (see 8.3).
- [Strength] Can show how specific impacts are effected through a research process (see 6.5.7, 6.6.7, 6.7.7 and 6.8.7)
- [Strength] Can be used to overcome the problem of attribution through their inherent focus on contribution (see theories of change in Chapter 6).
- [Strength] Can show the nature of impact(s), for example that impact is something specific to time, place and the actors involved. Productive interactions can be used as a tool to explore

how these impacts are effected (visible through the different phases of the theories of change as presented in Chapter 6).

- [Strength] Collect data on parts of the research processes that are overlooked or undervalued.
- [Weakness] Due to their focus on the research process productive interactions are limited in their ability to capture higher level impacts (see figures 7.1 to 7.4).
- [Weakness] Connections between different interactions might at times seem more implied than concrete in terms of showing how much each contributed to certain outcomes.
- [Weakness] Are not necessarily captured by current research reports, making it a more labour intensive process to identify the research interactions (see 5.3.2.4 Challenges experienced in the interview process).

Having looked at productive interactions (or the research interactions from which they were identified), the next section of the chapter focusses on the use of these interactions in constructing theories of change and impact pathways.

8.3 Using the logic of realist evaluation to assign value to productive interactions

The second objective of the research was to use the logic of realist evaluation (particularly impact-generating mechanisms through which realist evaluation suggests theory construction) to assign value to these productive interactions (research interactions) identified through the SIAMPI approach, by building theories of change and impact pathways.

- Question 3: Which value do the *theories of change* provide to the research interactions (possible productive interactions) that are identified through application of the SIAMPI approach?
- Question 4: What do the identified, if any, productive interactions reveal about impact-generating mechanism and the associated context(s) in which research takes place as captured by the *impact pathways* in the theories of change?

In the previous section, the possibility of making use of the productive interactions of SIAMPI to build CMO configurations was mentioned briefly. This section discusses the value of making use of productive interactions in theories of change (often part of the initial phase of a realist evaluation), which could theoretically allow the use of the SIAMPI approach as a method within realist evaluation. This section also discusses the topic of productive interactions and their relation to CMOs. The use of productive interactions in constructing CMO-type configurations for the SoIR could therefore be a second consequence of the use of SIAMPI in relation to realist evaluation.

An answer to Question 3 is provided in 8.3.2, where the building of theories of change is discussed. The theories of change showed the productive nature of the research interactions. Question 4 is mainly answered in section 8.3.3, where the use of productive interactions in the development of CMO configurations is presented. The use of productive interactions in theories of change with identified impact pathways, provide the needed insight into the research process (related to Question 3) to develop CMOs that are based on a factual understanding of the research process. Though CMO construction is ad hoc (Pawson & Tilley, 1997:80), productive interactions give contextual substance to these configurations. Research interactions used in theories of change become productive interactions from which impact pathways can be identified. From this visualisation of the research process (and impact pathways) CMO configurations can be developed for research (Question 4). Before discussing productive interaction in theories of change and use in building CMOs, the use of the logic of realist evaluation in relation to SIAMPI is deliberated.

8.3.1 The logic of realist evaluation applied to cases of productive interactions

Traditional evaluations (see Salter & Kothari, 2014) which preceded realist evaluation generally focussed on measuring outcome criteria. This is referred to as the black-box approach to evaluation since there is little focus on how an outcome is produced (Salter & Kothari, 2014). It is argued that the black-box approach provides an oversimplification of reality as it does not provide insight into how different types of interventions operate in varying contexts. Theory-driven evaluation in contrast to the black-box approach takes into account the different ways in which programme mechanisms cause change. Theory driven evaluations have the benefit of being both formative and summative.

Realist evaluation is a ‘species’ of theory-based evaluation. Scientific realism, the realism which the ‘realist’ in realist evaluation references (Pawson and Tilley, 1997), seeks to identify repetitive or regular patterns that exist in nature. Though reality cannot be captured in any one theory or explanation, the understanding of something can be increased over time as knowledge is built-up on a topic (Salter & Kothari, 2014).

Realist evaluation is not an approach that describes the use of methods, but a logic of enquiry. Realist evaluation seeks to understand ‘what works, for whom, in what circumstances…and why’ (Pawson *et al.*, 2005:25). CMOs are used as an entry point into understanding the different underlying mechanisms of programmes. Whereas the components of a programme can be captured in an impact pathway, showing which interactions built up to the impact, CMOs are theories of how people react to the resources (choices or capacities) delivered by a programme (Salter & Kothari, 2014).

Throughout this dissertation, it has been suggested that SIAMPI should embrace the logic of realist evaluation when approaching the assessment of SoIR. Two elements of realist evaluation are primary in this assertion, which could allow the SoIR to embrace the idea of developing assessment methods that are good enough to be used in the real world, even when they might not overcome all theoretical obstacles (for example attribution). Firstly, realist evaluation focusses on what it calls the 'middle ground' of evaluation and, secondly, it uses the concept of 'middle ground' to do something it labels 'make sense of' (see Pawson & Tilley, 2004:18). These two (at first seemingly confusing) terms are discussed below.

The middle range of findings: Realist evaluation does not pretend to look for an ultimate defensible truth in how programmes work. Instead, it focusses on the middle range between describing universal theories and specific cases (Pawson & Tilley, 2004). This means that evaluation theory cannot be built based on too specific particulars. As an example, although P1.2 was offered employment after being noticed at a conference, this particular was circumstantial and too context-specific to be transferable, thereby making it a non-transferable finding in terms of evaluation. The concept of a middle range can provide SIAMPI with a level of operation, based on an established theory-based evaluation approach. "The methodological point here is that by operating at the middle-range, there is a much greater opportunity for realising and transferring the findings of evaluations" (Pawson & Tilley, 2004:18).

By not focussing on the minor details, but also by not focussing on a too abstract level, the transferability of 'lessons' learned from one case study to the next is increased. If the focus of a study was on trying to understand how a research project influenced the health of society at large, it was operating at a too high level. The focus would move the interactions required to affect the population beyond the time and space of the research, bringing in additional possible stakeholders who will have to set off a chain of events that would lead to this large impact. Focussing on something such as the smaller interactions that led to the recruiting of students in, for example, Project 1 and Project 3 is again at a too low level. There were productive interactions that led to the student being enrolled; yet, are these emails and conversations worth mentioning? More than likely not. Examples of productive interactions used in 'the middle ground' are provided under the discussion on CMOs in 8.3.3 later in the chapter.

The focus of a realist theory of how impact occurs should also be careful to concentrate on the real underlying mechanisms and not the context that might obscure these mechanisms. CMO configurations are the main focus of realist evaluation, and these show how capacities and choices affect the target audience of a programme (Pawson & Tilley, 1997; 2004).

'Make sense of': Secondly, SIAMPI should accept that the findings of an evaluation might be somewhat equivocal, while still remaining useful. This is explained in the manner in which realist evaluation addresses the problem of attribution. Since there is more than one mechanism or more than a single productive interaction in a programme or project, it is not necessarily possible to determine exactly which mechanisms or interactions were responsible for a particular change. For example, in Project 3, the researcher and a producer reported that the research led to thinning machines being sold. The importer of the machines said that the sale of the machines was due to the research *and* due to his sale representatives. It also emerged that the developer of the machine had scientific data available on tests he had done on the effectiveness of the machine. In this case, there are therefore more than one possible cause for the sale of the machines in South Africa. To 'make sense of' this scenario would entail accepting that there are other possibilities for machines being sold (additional research data beyond Project 3 and the skill of the sales representatives). However, based on the producer's feedback and the researcher's knowledge of the industry it can be assumed that Project 3 played an instrumental part in the machines being sold. The producer is one of the largest deciduous fruit producers in South Africa. He had insight into what other producers were thinking when buying the machines. It would arguably make sense to value his opinion and accept the importance of Project 3.

Realist evaluation encourages the development of 'rival explanations' for outcomes (if there is a problem of attribution). Any number of alternative explanations can be suggested and tested in time (Pawson & Tilley, 2004).

By using the logic of realist evaluation, SIAMPI can buy into an established approach to evaluation which accepts that it cannot perfectly understand programmes (or projects in SIAMPI's case), but it can understand them well enough to make recommendations and improvements. Realist evaluation gives SIAMPI guidance on where to aim its assessments, for example by focussing on the middle ground. A third element in realist evaluation is of even greater possible value – the development of CMO configurations. This is discussed in section 8.3.3. The following section explores how productive interactions and SIAMPI could be used within a realist evaluation.

8.3.2 Building theories of change with productive interactions and using the theories in realist evaluation

The concept of using the SIAMPI approach in an evaluation is based on the possibility that the process of a realist theory-based evaluation could attribute value to 'value-free' productive interactions. Though exploring this topic was one of the interests of the dissertation, the current research does not include the use of SIAMPI in realist evaluation as a recommendation. It was found that the value of testing different productive interactions in an evaluation would not contribute to transferability or generalisation of findings since the number of possible productive interactions are too extensive to isolate important interactions. Instead the research recommends the use of productive interactions to develop an understanding of research processes from which possibly generalizable CMO configurations can be constructed (Question 3). With that said, the focus now shifts to the use of SIAMPI within a realist evaluation, since it is nonetheless possible to make use of SIAMPI as a method in realist evaluation and it might have value for research that desires to test the 'productivity' of different productive interactions.

Although productive interactions are 'productive', this productivity does not refer to it being positive or negative, big or small, as previously discussed (see 5.4.1). It only indicates that something changed during the interaction.

Realist evaluation is a suitable approach to look at in the context of research as it recognises that social interventions take place at different levels with interwoven variables (Pawson & Tilley, 1997). Realist evaluation takes the understanding of how a programme works beyond the level of cause–effect and takes into account the social context in which an intervention is launched.

In the current research, the research interactions (potential productive interactions) were used to build the theories of how the research process unfolded (visual representations of which can be seen in Chapter 6). The data produced by the SIAMPI approach was dense enough (meaning detailed enough or it provided sufficient information) to build theories that were then presented to and verified by the primary investigators of the case studies. The data used to build the theories of change were collected from various sources (as discussed in 6.2), not just from the project researchers. The follow-up interviews led to small changes being made to the theories of change, but nothing that affected the general flow of the projects.

The creation of the theories of change showed that productive interactions can be used to understand and create a comprehensive theory of how a research project functions. Once used in the theories of change, the research interactions identified in the first phase of the research became or were proved to be productive interactions. This is based on the logic that the different interactions in the theories of change represent different steps in the research (of the case studies). From the theories of change, the research identified different pathways to impact.

If it is desirable to determine how productive individual productive interactions are in research, it can feasibly be tested through the use of logic models and the development of indicators of impact. In other words, productive interactions lend themselves and the SIAMPI method to be used in a realist impact evaluation. The steps below describe such an evaluation. This process is purely hypothetical and it is not the intention of the research to move beyond suggesting the possibility of the process.

A. Undertake an *ex-post* assessment of research interactions in a project through the SIAMPI approach.
B. Develop a theory of change based on the identified productive interactions.
C. In consultation with funder, identify relevant productive interactions. (Productive interactions with positive outcomes will be tested. Productive interactions with negative outcomes must be recorded for context.)
D. Through consultation with project funder:
    a. Determine desirable effects of selected productive interactions.
    b. And, note scope of relevant negative impacts. The expertise of the funder should determine the scope.
E. Set criteria of success for each positive productive interaction.
F. Develop a logic model with impact indicators for selected positive productive interactions. Effect of negative impacts can be measured separately.
G. Test the productive interactions according to impact indicators.
H. Produce report detailing the results, including reference to any negative productive interactions.

One example of a possible relevant productive interaction with a positive impact, is the presentation of a project's results at a conference. The interaction could be 'conference presentation to industry producers' (this is an example). It will be relevant based on the spreading of new findings to industry. Using the terminology of logic modelling, an outcome for the presentation would be either increased knowledge of producers with an impact of increased use of new research (maybe a technique) by producers. An indicator for increased knowledge could be (improved) scores obtained in a questionnaire by conference attendees before and after presentation (indicating increased understanding). An indicator for use can be related to the percentage increase in queries a researcher receives from producers wanting to implement, or purely a percentage of producers indicating implementation based on a survey (in other words, an indicator of success would for example be the adoption rate with a target of 80 per cent).

The sources of evidence for the first example is the pre- and post-test (before and after the conference presentation) and the source of evidence of the second is the survey itself. The level of success, in other words what would count as a successful outcome is determined by the funder, for example '50 per cent of producers indicate increased knowledge', or 'a 20 per cent increased score for producers on test results'. Similarly success for adoption can be linked to the number of producers using results, '400 producers indicate use of results', or it can be context specific for example 'used by 50 per cent of ten largest producers' and so on. These targets are all context specific and depend on the aims of the funder. It is theoretically possible to use productive interactions in an impact evaluation, if required.

In summary, research interactions are proven to be productive when captured in a theory of change. The theories of change developed in the current research were shown to be reflections of how the projects developed. Theories of change provide a coherent way of visualising a myriad of interactions. The theories of change show that productive interactions are a feasible starting point for an impact evaluation which aims to add value to these interactions. The following section answers the question of what productive interactions reveal about impact-generating mechanisms and the contexts in which these are found (Question 4).

8.3.3 Aligning productive interactions with the CMO configurations of realist evaluation

Theories of change display the productive nature of productive interactions. These theories of change provide a means through which to visualise research interactions (productive interactions) to ease analysis. This section builds from these findings and answers the question of what productive interactions reveal about possible impact-generating mechanisms and the contexts in which these take place (Question 4). The research found that productive interactions form part of impact generating mechanisms on a project component level. Productive interactions can also be used to understand impact generating mechanisms in a realist evaluation CMO sense, where actors react to mechanisms based on the choices and capacities provided by a programme (or research in the case of the current study). Mechanisms as understood by SIAMPI and realist evaluation have an important distinction. For SIAMPI the mechanism is the action (the interaction) and the reaction of someone to the knowledge that they acquire. In realist evaluation the mechanism, though also based on an action, is purely defined in terms of the response of someone to that which they were introduced to. In other words, the mechanism for realist evaluation is the thought process in someone's mind.

The first finding, that productive interactions are part of impact generating project components, is the most evident when looking at the results of the research. The research narrative that emerged from analysis of the research interactions led to the development of the different phases used in the theories of change (Conceptualisation phase, Execution phase and so on) (see 6.5, 6.6, 6.7 and 6.8). These formed logical groups related to specific timeframes in the projects. The theories of change showed how the research processes (for the different case studies) developed and how research impact was effected in the near post-research impact effecting phase and the distant post-research impact effecting phase. Since the theories of change relied almost exclusively on the use of productive interactions in their construction, the productive interactions themselves are proven to be low level project components. Productive interactions are and can be combined into impact mechanisms (in this case project components), and the different combinations of interactions presented in each phase of the theories of change visualise the context within which these interactions take place.

Productive interactions as possible building blocks of impact mechanisms is one result that Spaapen *et al.* (2011) had in mind when they conceptualised productive interactions, as they state SIAMPI involves two central tasks: "To enlighten the mechanisms by which social [read societal] impact occurs and to develop methods to assess social impact" (Spaapen *et al.*, 2011:2) (emphasis added).

The reference almost certainly refers to the use of productive interactions as discussed above. However, the process of developing theories of change and the creation of impact pathways can also provide the needed understanding of research or the research process from which to build CMO configurations.

The use of realist evaluation in research, specifically making use of CMO configurations is not necessarily new, but its systematic use and introduction into a larger theory building context is. A study by Salter and Kothari (2014) found numerous references to CMO configurations being used in research impact assessment. However, they also reported that there is: "A tendency to begin the realist evaluation cycle with the collection of data, omitting the initial phase that includes articulation of program theory, and development of conjectured CMO configurations" (Salter & Kothari, 2014:16).

This tendency to omit the articulation of theory was the due to the challenges of developing CMO configurations. Salter and Kothari (2014:2) suggest that "rich and detailed accounts may improve feasibility" of using realist evaluation in research impact assessment. Realist evaluation has gathered the most traction within the field of knowledge translation (Cambon, Petit, Ridde, Dagenais, Porcherie, Pommier, Ferron, Minary & Alla, 2017; Haynes, Rowbotham, Redman, Brennan, Williamson & Moore, 2018; Kreindler, 2018).

For the current study the question is however what the relationship is between productive interactions and CMO configurations and what it is that the use of productive interactions can reveal about impact mechanisms in research projects. There are numerous similarities between the SIAMPI approach (impact mechanism is productive interactions) and realist evaluation (impact mechanism is CMOs).

- In both, there is a desire to learn from the evaluation beyond just making judgments.
- Both of the approaches focus on the context in which research takes place, or a programme is implemented.
- Both also seek to take evaluation beyond the black box of linear models.

Realist evaluation has a central question that asks, “what works for whom in a set of given circumstances?” (Pawson *et al.*, 1997:86). Productive interactions answer this question but arguably at a lower level of impact (in realist evaluation terms, possibly at an ‘outcome’ rather than ‘impact’ level). The difference between productive interactions and CMOs lies in the fact that productive interactions are or can be programme (or research project) components. CMOs however are hypothesis of the way in which actors react to that which is introduced by a programme. Productive interactions then are the useful tools in developing an understanding of how a research works, from which CMOs can be developed. The following section presents the identification of CMO configurations based on the research case studies that formed part of the current study.

CMO configurations in the research case studies: Realist evaluation sees both macro and micro social mechanism as important in creating social reality. The ‘classic’ example of this is suicide rates, where individual choices (micro) and social support (macro) both impact on the very personal choice of committing suicide. The argument is made that there is often nothing intrinsic about what a programme (or in this case research) produces that leads to an outcome (or research impact). Pawson and Tilley (1997) use the example of close circuit television being installed in a car park to prevent crime. If crime in the car park is reduced, it was not because the installation of cameras intrinsically caused crime to fall, but rather it caused ‘a chain of reasoning and reaction’, for example in potential criminals’ minds (Pawson & Tilley, 1997:78).

There is nothing intrinsic about (for example in Project 3) testing a new product that will increase its adoption by industry (impact pathway ‘Creating an evidence base for a commercial product’). Rather, there is some other “reasoning and reaction” that emerges (Pawson & Tilley, 1997:78). We can identify some potential mechanisms for this. These mechanisms show how the deeper understanding of the research projects through productive interactions and the identification of impact pathways based on the theories of change, can help to expand the theory of how the societal impact of research is effected. To continue with the example of Project 3:

a. 'The instrument has scientific merit' mechanism: It is not the fact that a product was tested that gave it credibility, but rather that it has gained academically proved credibility that increased its standing in producers' view leading them to purchase the instrument.
b. 'My neighbours are using it' mechanism: Adoption by neighbours might show the value of the product to a farmer who decides that he or she wants to purchase one for themselves as well.
c. 'The sales company has nothing to hide' mechanism: The willingness of a sales company to allow their products to be tested scientifically might create the impression that they are trustworthy with nothing to hide (meaning their products can be bought with confidence).

These mechanisms are in turn influenced by the context in which they are introduced.

i. *Trust of researcher context*: If the researcher who undertook the test has academic gravitas, his or her positive findings might lead to increased sales of the product due to a favourable impression by producers. If the research is from a less reputable institution, the results might be ignored.
ii. *Importance of first adopters context*: If the neighbour adopting the use of the instrument is an industry leader, his or her adoption might give more credibility to the instrument leading to increased sales, than a neighbour from a less important farm.
iii. *Type of orchards context*: With mechanisation, the product must be suitable for the final conditions where it will be used. If the orchards in a country are not planted according to the required style, adoption will not take place (CMO configurations are discussed by Pawson & Tilley, 1997:55–82).

Examples of CMO configurations can also be constructed from the other research project case studies. One of these examples show that though the identification of productive interactions creates the background and understanding to developing CMOs, not all CMOs have to be *based* on productive interactions. In Project 1, some producers started to make use of an oxygen probe used in the specific research project. Though productive interactions surely led to the adoption of the oxygen probe by the producers, these were not captured by the current research (possibly since it was beyond the scope of the project). However the *instrument has scientific merit mechanism* is once again apparent. Below are additional examples of CMOs from Projects 2 and 4.

a) *The 'environmentally better' mechanism*: In Project 2, the research produced knowledge on fungal control that introduced biological instead of chemical control. The fact that biological controls are more environmentally conscious might convince producers to adopt the results.
b) *The 'early success' mechanism*: The early success in Project 4 meant that the industry joined the project early on in the research process. This led to an escalation of the project with rapid adoption of results and testing of the results on a large scale.
c) *The 'I can make money' mechanism*: In both Project 2 and 4 the results of the projects, if adopted could reduce the input costs or increase the profitability of producers. In Project 2 the research allows for the treatment of a vine disease which, if overcome allows vineyards to age. This reduces the need to cut out a vineyard and plant a new one (cost), or potentially increases the quality of wine produced from older vineyards (profit). In Project 4 adoption of the FEMA requirements by a producer (monitored by the FEMA police and implemented as a consequence of the research results) means that farmers can get a premium for their Forelle pears. In both cases, the ability to make money from the results might prove an incentive.

Different contexts can influence the mechanism discussed above. This further illustrates that though some mechanisms might prove resilient (continuously work) in some contexts, a change in context can affect the effectiveness of a mechanism. Some examples are provided below:

i. *The 'environmental vulnerability' context*: The Western Cape where wine farmers/producers are mainly found in South Africa has experienced a major drought in recent years. These farmers might be more susceptible to looking for environmentally friendly farming practices to increase their resilience. Regions less affected by climate change will be less inclined to adopt a new practice based on environmental friendliness.
ii. *The 'scope of success' context*: The results in Project 4 showed that the new Forelle pears led to no wastage and that it was readily accepted by the market. It is probably easier for industry to push a research result that is clearly as positive as was the case in the project. Though there were still risks in expanding the size of the project, the results to that point (of early success) were 'clear-cut'. More ambiguous results will most likely not have led to the same level of industry involvement.
iii. *The 'alternative sources of income' context*: Though farmers could make money from keeping their vineyards for longer (Project 2), or adopting the FEMA requirements (Project 4), this adoption might be jeopardised if alternative economical uses for vineyard or orchard land became available. Both vineyards and orchards might have been cut out if the farmers could have made more money from another cash crop or husbandry for example. The profit benefit would have to outweigh those alternative sources of income.

These examples above show that it is possible to construct CMO configurations that are applicable to research, based on the information gathered through the SIAMPI method. Further, it has been shown that it is possible to identify similar mechanisms in different projects (for example: 'instrument has scientific merit' mechanism and 'I can make money' mechanism). This illustrates the idea of realist evaluation that theory should be built on evaluation theory, not theory that is discipline (or necessarily industry) specific. For example: we could say 'SoIR evaluation theory' in agricultural industry includes the 'I can make money' mechanism.

Figure 8.1 below illustrates how productive interactions feed into theories of change (detailed accounts of the research process) from which possible impact pathways and CMOs can be identified.

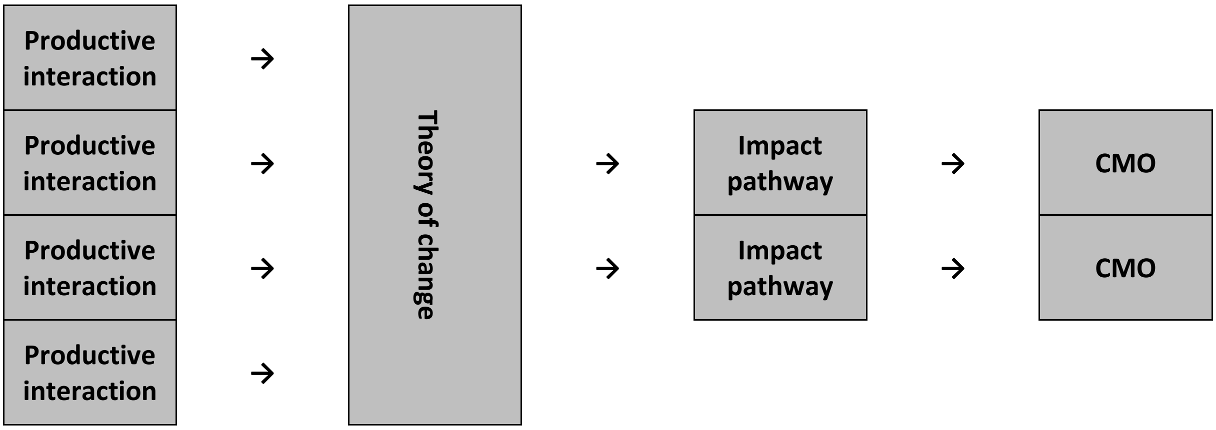

Figure 8.1 Use of productive interactions in developing research theory and possible CMOs
Source: Author's own compilation

To conclude this section, the theories of change prove the productive nature of the research interactions. The identification of the impact pathways and CMO configurations could allow the use of the SIAMPI method within realist evaluation to develop new evaluation 'theory' to assess the SoIR. The next section presents the Classification framework for research impact (from the SoIR classification scheme introduced in Chapter 5) that was developed based on the results of Chapter 7. It also discusses the research environments of Winetech and Hortgro.

8.4 Viewing productive interactions through the lens of research impact literacy

The third objective of the dissertation was to make use of the broad lens of research impact literacy in terms of 'who', 'how' and 'what' of research impact, to look at productive interactions and their effects.

- Question 5: Based on the 'what' element of *research impact literacy*, which kinds of impact are reflected in the effects as identified through the SIAMPI approach and to which extent are these impacts valued by funders?
- Question 6: Based on the 'who' and 'how' elements of *research impact literacy*, how do the impact pathways developed for the four cases of agricultural research align with the funders' understanding of how impact is created?

These two questions focus on the 'impact' in research impact. The 'what' in Question 5 asks in which way impact can be framed to allow for a general way of comparing one impact to another while still looking at impact through one lens. There are many impacts (types of impacts), but how can an understanding of impact be developed to define all these (types of) impacts. This was tested, adapted and achieved through the development of the Classification framework for research impact (based on the SoIR classification scheme), presented below in Figure 8.2. The last part of Question 5 and Question 6 focusses on the topic of whether there is a difference in the way that funders and researchers view impact. This difference, which it was assumed exists, is to be expected since different stakeholders have different desires and needs leading to different views on what impact is. However, in the case of research, especially in the case studies with commodity companies, there is a symbiotic relationship between the researchers and the funders. The funders have their idea of what impact is, but they need the research to achieve these impacts. As was seen in Figures 7.1 to 7.4 in Chapter 7, the research process contains impact and effects needed to achieve later impacts, even when these are not valued by funders (Figures 7.6 to 7.11). This illustrates the importance of impact literacy in understanding not only 'what' is wanted, but also 'who' will need to achieve it 'how'.

Impact literacy is the ability of actors and stakeholders who form part of the research process to understand *how* impact is created, the ability to identify *what* impact is and to comprehend different impact endpoints, and finally to have a nuanced view on *who* the important creators or enablers of research impact are (Bayley & Phipps, 2017). Impact literacy is only achieved when all three of the elements are present. When one of the elements is missing, problems arise. For example, when only 'who' and 'how' are present, a lack of 'what' leads to a lack of what the indicators of the impact endpoints require for an evaluation. A lack of 'how' causes a breakdown that leads to inefficient theory on effecting impact. When the element of 'who' is not present, a project will suffer from not being supported by the right actors.

The theories of change that were constructed out of the productive interactions provided an overview of the projects according to *who* were involved and *how*, through numerous small interactions, impact was effected. A failure in research outputs (the 'what' of impact) according to impact literacy can just as easily be due to the wrong questions being asked (when planning for impact, or when doing an impact assessment) or actual outputs and impacts being missed than due to poor research being undertaken. As Bowen and Graham (2013:5) put it, "[r]ecognition of the importance of organisational context has resulted in a shift from focusing on individuals who broker knowledge between specific individuals to the concept of knowledge brokering as an organisational process".

Impact literacy has the potential to allow funders of research, researchers and other stakeholders to form a uniform understanding of what the desired impacts of research are for the different actors. Making use of the definition of impact literacy (see 4.6), the current research identified a lack of understanding in the research on 'what' research impact is, particularly for research funders.

In response to Question 5, the impact codes and survey responses plotted on the research impact classifications scheme (section 7.2) showed that the main impacts are seen as those affecting the researchers on the research team and 'traditional' (if not idealised) impacts on industry.

From the view of the participating researchers, the most important impacts were mostly the continuation of their research and capacity building initiatives that resulted from the research. The primary drive for P1.1 in Project 1 was continuing research that he had been working on before and after the project. In fact, in the follow-up interview with him, when asked whether he had made use of the project results in his own wine making, he indicated that he already knew what the effects would be before undertaking the research. The project did not produce new information for him.

> Interviewer: *Did you use the results of the study in your own wine making in any way?*
>
> P1.1 Follow-up: *No not really, because I half, I … I know this sounds arrogant, but I actually already knew what the effects of oxygen would be before we started, before we published*.

In Project 2, the primary researcher was continuing his research and interest in Esca. He cared about the industry, saying that it was too large a problem for him to ignore, even after twice being refused funding (P2.1). However, after completion, he continued his research in other industries. His focus was not just on wine research or servicing the industry; his focus was on understanding the diseases in which he specialises no matter where they were found. For P3.1, the reason for starting her research was attending a talk about mechanisation in Europe. She became curious and wanted to know whether it would work in South Africa. The fact that money became available at that stage was a bonus that enabled her to do the research in which she had become interested.

> P3.1: *I also started to think it would be interesting to see whether we would be able to work with the machine, and actually by pure chance, it is funny how these things work, the [farming group] started to pressure Hortgro for research on mechanisation.*

It thus seems that the aims of funders are often used by researchers to fit in with their own interests rather than purely just a process whereby researchers are forced to bend to the will of funders. The first two phases of the study generated dense data on the 'how' and 'who' of these projects but not enough data to understand 'what' the SoIR is, especially according to funders. The research therefore, in phase 3, developed the SoIR classification scheme to be able to plot research impacts that had been identified in the case studies. The framework was essential to bring order to the understanding of whether researchers and funders, as well as different funders, have alternative views on what the SoIR is or should be. These views were tested in the 'Survey of research impact' for both Winetech and Hortgro

From the data on what research funders view as impact, it became clear that funders generally prefer research outputs that have an impact of stakeholders related to them, in other words, related to Winetech or Hortgro. These stakeholders are mostly farmers, but can also be the commodity company itself or the wider industry that the commodity company represents.

The SoIR classification scheme was used in the building of the survey on funders' views on research impact. Based on the results from the survey the research has adapted the classification scheme and presents the *Classification framework for research impact* in Figure 8.2 (below).

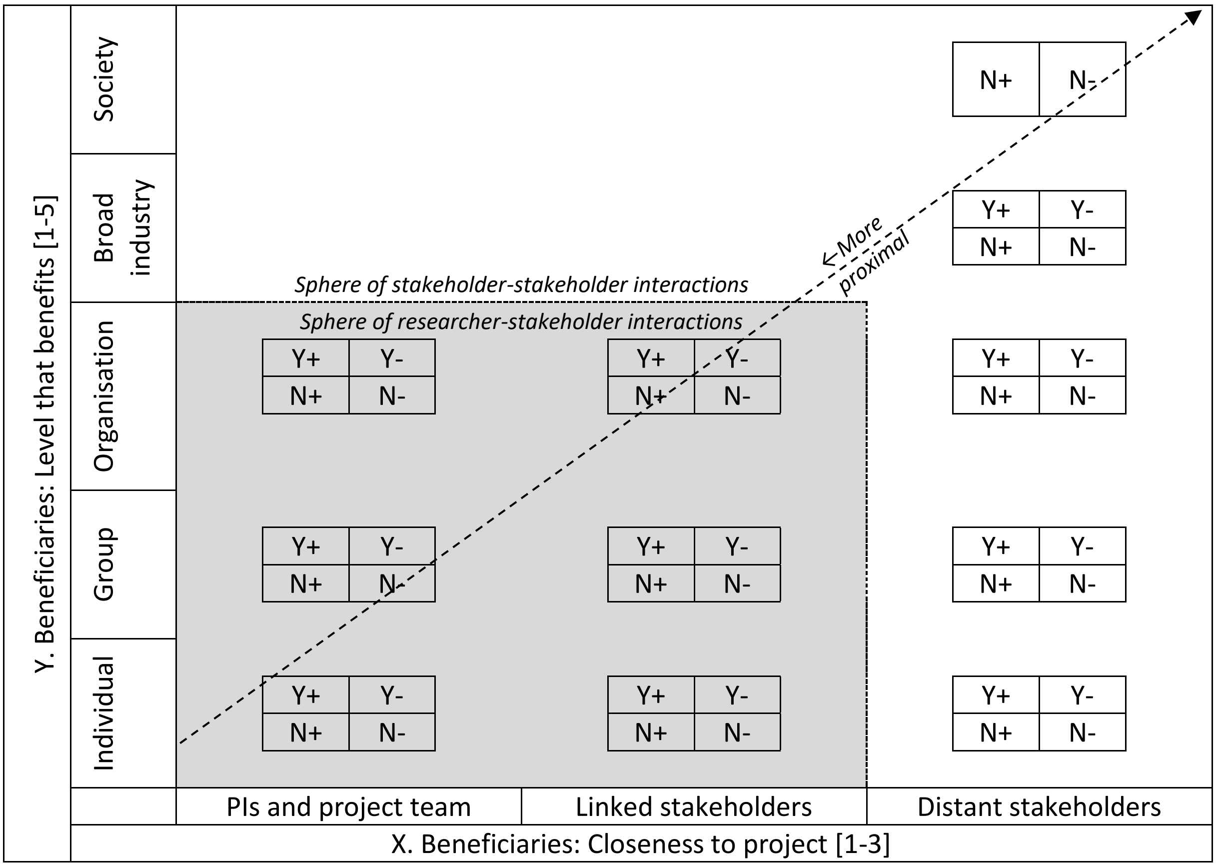

Figure 8.2 Classification framework for research impact

In the modified framework there are still two primary dimensions, the scale of the impact in relation to the number (group) of beneficiaries (Y-axis), and the beneficiaries of impact's distance to the project on the X-axis. The 11 cells in the figure thus represent the cross section of what an impact is in terms of these two axis. However, two additional classifications have been added, the "Relation to 'impact independent'" and "Value of impact". The focus of the Classification framework for research impact remains on the impact (or effect). The framework defines an impact according to (A) who is benefitting (individual, group and so on), (B) the relation of the beneficiary to the original research project, (C) the relation of the beneficiary to the funder of the research (or the entity interested in observing impact) and (D) whether this impact would be viewed as positive or negative. It thus describes who is affected (level, proximity and relation) and in what way (positive or negative). It plots an impact in relation to these elements.

Relation to 'impact independent': The term 'impact independent' is introduced here and refers to the entity for whom an assessment of impact is done. Impacts are effects that have value for someone or something. The impact independent refers to this 'someone' or 'something'. Based on the results of Table 7.8, it was realised that the relationship of the beneficiaries of impact to the entity assessing the importance of impact was just as important, if not more important than the impact scenario itself (all things being equal). The 'Y' in Figure 8.2 indicates that a beneficiary is related to the 'impact independent', and a 'N' indicates that there is no relation ('Yes' and 'No').

Value of impact: The '+' indicates that the impact is seen as a positive impact, and a '-' indicates that it is seen as a negative impact. Since the SoIR classification framework is not intended as a classification framework for only one type of research impact, it was felt that the ability to attach some form of value to impacts needed to be added. This would allow users of the framework to test which impacts a specific *impact independent* views as positive or negative. It can also be used to categorise different impacts, as was required in the survey in the current research. Of course, the value can be adapted as required. It can be replaced by desired- and undesired impacts, planned for and unplanned, or any other type of value that suits the needs of the study using the framework. The use of the word beneficiary seems to exclude negative impacts, however it was felt that changing the term would lead to confusion. The word 'beneficiary' could, if desired, be replaced by for example 'impact affected' or something similar.

Two further elements have been added, namely two spheres of interactions and a line for proximal and distal impacts in relation to the research and researchers.

Two sphere of interactions: The creation of the 'Sphere of researcher–stakeholder interactions' and the 'Sphere of stakeholder–stakeholder interactions' highlights the fact that impacts that take place in the shaded area of the framework, will be based on interactions between individuals or groupings who were part of the original research project. Impacts in the unshaded area will take place further away from the researchers and will be based on stakeholder to stakeholder interactions (i.e. interactions that include individuals or groupings who were not part of the original research project).

Proximal or distal: The proximal–distal line relates to the first point. It shows that impacts closer to X1Y1 takes place proximal to the research and researchers, while impact that takes place closer to X3Y5 will be distal from the researchers and research.

The proposed classification framework with its different elements provide a way of conceptualising research impact. Scientific impact can be portrayed in the framework at different levels. General scientific impact would fall under broad industry. If the impacts were however more localised it will slot in under any other organisational grouping as required.

The classification framework can be used to determine what impacts are desired by a group of stakeholders/a funder and so on, similar to the way in which it was used in the current research. However, the framework can also be used in planning. Knowing that these are the elements that are important in how successful a certain impact will be viewed, it can provide guidance on where to aim for effecting impact. A funder can make use of the framework to express to researchers what it is the producers (who in the case of Hortgro and Winetech ultimately pay for much of the research), would want to see in terms of research impact.

The Classification framework for research impact could also be used in the planning of research projects to assist in understanding who would be responsible for which levels of impact in a research project. Researchers and the stakeholders in a research project mainly have an effect on the “Sphere of researcher-stakeholder interactions”, impacts in the “Sphere of stakeholder-stakeholder interactions” will probably be beyond the scope of most research projects. This answers research Question 6. Final research impacts most often require different impacts or outcomes during a research process where various actors (*who*) are involved, doing (*how*) or being involved in interactions that might at times seem like unrelated activities. Just producing quality research (what researchers care about) does not automatically lead to impact, but without the project linked impacts that funders again care less about, broader industry and impacts in society will not be possible.

8.5 Recommendations on research evaluation practice and future research

This section makes recommendations on the use of the results of the current study within research impact evaluation practice. It also provides some ideas on future research that could add further value to the findings of the dissertation.

8.5.1 Research evaluation practice

The study foresees a number of possible recommendations for evaluation practice, based on the findings of the dissertation. These are presented below.

- *Need to capture more interactions*: The value of productive interactions in understanding the research process has been shown. The reality is that many - if not most - productive interactions are currently being missed by not being captured in research project documentation. It would be feasible to include data collection tools in research project progress- and final reports to capture these interactions without the need for too many additional possibly intrusive data collection methods, such as interviews.
- *Use of Classification framework for research impact*: The framework lends itself to numerous possible uses including:
    - Assisting in understanding and planning which actors will be responsible for which types of interactions or impacts at what level of the research project. The framework can be used to plan the different phases of a research project. For example, research project personnel and stakeholders will be involved in the researcher-stakeholder proximal part of the project, and the funder and partner organisations for the impact beyond in the stakeholder-stakeholder more distal part of the project.
    - The framework can be used in the same way as it was used in the current research, providing a classification scheme for impact from which different aspects of impact can be tested.
- *Ability to define research impact*: Impact differs depending on who is interested in the answer of what it is, or as the dissertation defines impact, 'impact is any effect caused by research that has a value for someone'. Through the Classification framework for research impact, impact can be defined according to where it has impact.
- *Development and testing of CMOs*: It is essential to build and test additional CMO configurations in research impact assessments to potentially collect transferable research impact mechanisms.

- *Impact literacy at different levels*: Impact literacy as a concept has been shown to be valuable in understanding how the societal impact of research is effected, but also in understanding what different stakeholders perceive as important impacts. Impact literacy can be used to:
    - inform producers (in the case of agricultural research funders) on the need for processes, such as the development of skilled individuals that they might not traditionally have viewed as important.
    - inform researchers on understanding the way in which funders view impact and what is demanded by them from the funders' constituents.
    - impact literary is not only important on a project level, but also on a project to project level within the research strategy of an organisation. The concept of impact literacy can be used in planning the research strategy of a funder in considering how the different projects they fund will combine. This might create the chance to identify researchers or organisations who could benefit from cooperation on related problems. Sharing this vision with researchers might also allow them to better structure their research to fit in with the overall vision of a funder.

Figure 8.3 provides a visualisation of Impact literacy at different levels, which is followed by a short discussion on the topic.

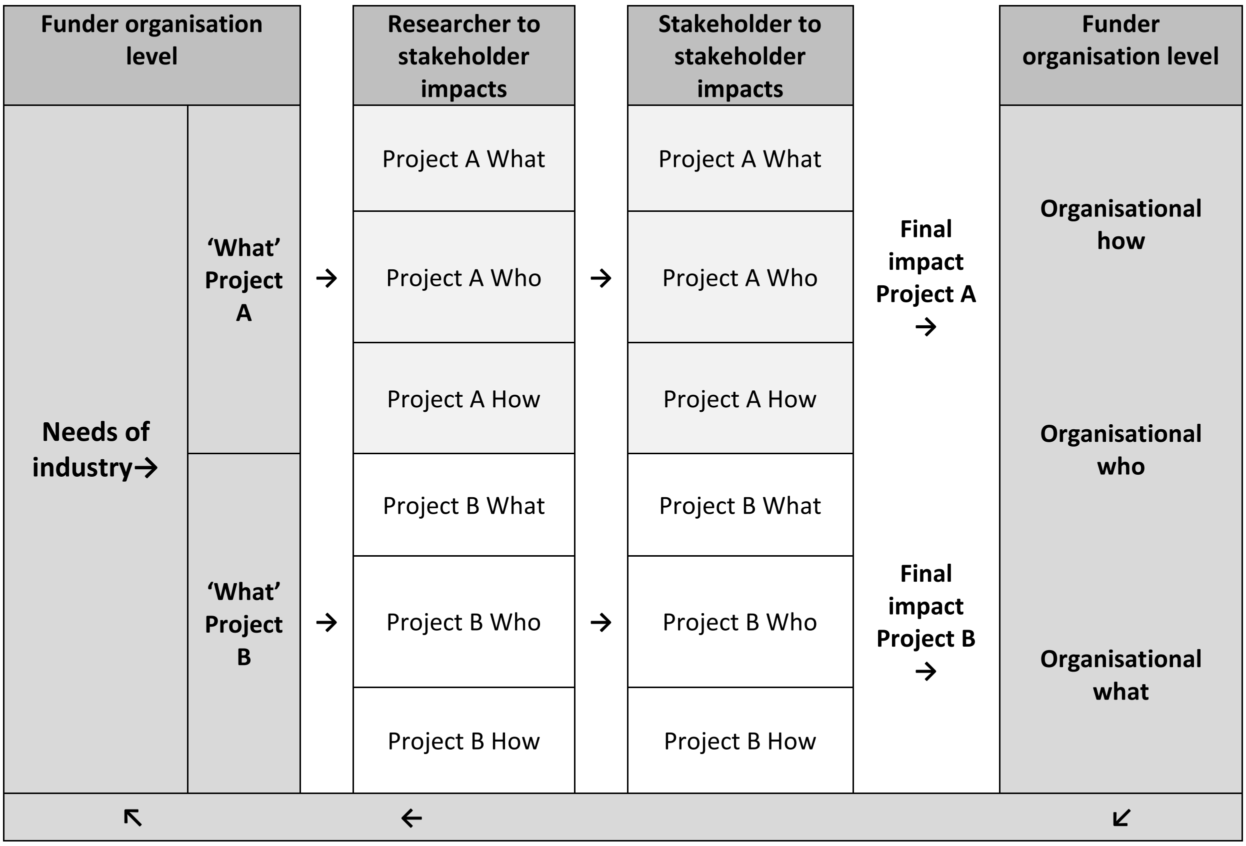

Figure 8.3 Planning the effecting of research impact with the aid of impact literacy

This dissertation has maintained that research impact can be nearly any effect of research that is seen as valuable by someone. The first question a funder needs to answer is, 'what' is it that needs to be achieved. This can allow for the selection of projects (Project A and B for example above) that meet the needs of the organisation. This is one way to overcome some of the problems identified in the survey of research funders and presented in 'Figure 7.13 Reasons for research failing to have an impact, as provided by Winetech and Hortgro'. The three main reasons listed for failure were:

- Incorrect focus
- No practical application
- Too academic

These issues could be overcome if only projects that fit into the overall research strategy of the funder were selected for funding (as long as the problem is not at the research execution level). The strategy will be based on the current needs of the industry. The second aspect shown in Figure 8.3 is the identification of 'who, what and how' of research impact in two different phases of impact effecting, a first 'researcher to stakeholder impacts' phase followed by a 'stakeholder to stakeholder impacts' phase. Researchers have control over impacts that are close in time and space to them. They should plan for impacts in the Post-research impact effecting phase (Near), while funders should plan for the effecting of impact in the Post-research impact effecting phase (Distant). For funders (including the commodity companies in the current research) it is crucial to realise that they are also responsible for the pushing of research results, especially at a higher or distal level. Thus it is essential for them to plan 'who' will be doing the pushing, 'how' and to 'what' aim.

The final column represents the overall research aims of a funder. It is important that the question of 'who, how and what' is answered at lower levels, but also at the larger organisational level. Different research projects should feed into a coherent research strategy. The individual research teams of funded projects do not engage with other research teams, rather, the funder is the one who has an overall strategic picture of what is funded and how this will have an impact.

8.5.2 Recommendations for future research

The research would like to make two main recommendations on future research. The first is the need to study the relationship between productive interactions and impact further, and the second is development of CMOs, specifically in the field of research impact assessment.

Relationship between productive interactions and impact: productive interactions can be further used to explore the different ways in which impact is effected during research projects. The current research was able to track research impact over the course of four research case study projects, visualising how these fit into theories of change and impact pathways. It was shown that research impact often extends beyond the planned scope of a research project. Some of the impacts were not valued before and some impacts were not captured due to reporting mechanisms. The impact pathways illuminate aspects of impact that would otherwise have been overlooked or provide evidence of how research impact functions.

Development of CMOs in research impact assessment: Although the concept of CMOs in research is not yet established, it provides an interesting new line of study to explore. The identification of mechanisms that stimulate research impact will allow for transferability and added learning between different research projects, potentially even between research studies from different fields. The concept and availability of examples of CMOs can also provide researchers and research funders with a better understanding of how research impact is and can be effected.

8.7 Conclusion

Productive interactions are the building blocks of research impact. They are not the impact indicators but part of the underlying mechanisms that show how research is physically undertaken, the project components. They shed light on the actions, the people, organisations (and other groupings) and how these entities are involved in effecting research impact. Productive interactions help to identify research impact mechanisms that can be used in building research impact effecting theory. Productive interactions can be used as a tool that helps to contemplate the process of research impact. Realist evaluation and CMO configurations provide understanding of how theory can be built from the processes exposed by productive interactions, theories of change and the impact pathways imbedded in the theories of change.

This dissertation has shown that productive interactions, identified in the theories of change and built form the research interactions captured in the first phase of the research can be combined into impact pathways from which CMO configurations can be developed. The similarities between SIAMPI and realist evaluation have shown that it is feasible to make use of the SIAMPI approach as a method within realist evaluation to develop 'theory' on the effecting of research impact. The impact pathways showed that productive interactions do capture building blocks of research impact that could be used in monitoring and evaluation approaches. Additionally the chapter has presented the Classification framework for research impact that can be used to study and plot research impact in its various forms (not only in relation to funded research), or provide guidance on how to build research projects that target desired impact end-points.

Reference list

Ahteensuu, M. 2012. Assumptions of the deficit model type of thinking: Ignorance, attitudes, and science communication in the debate on genetic engineering in agriculture. *Journal of Agricultural and Environmental Ethics*, 25(3):295–313.

Alvarez, S., Thiele, G., Mackay, R., Córdoba, D. & Tehelen, K. 2010. Participatory impact pathway analysis: A practical method for project planning and evaluation. *Development in Practice*, 20(8):946–958.

American Society for Cell Biology. 2012. *San Francisco Declaration on Research Assessment*. Retrieved from http://www.ascb.org/files/SFDeclarationFINAL.pdf [Accessed 18 May 2016].

Anderson, R.A., Crabtree, B.F., Steele, D.J. & McDaniel, R.R. 2005. Case study research: The view from complexity science. *Qualitative Health Research*, 15(5):669–685.

Andoseh, S., Bahn, R. & Gu, J. 2014. The case for a real options approach to ex-ante cost-benefit analyses of agricultural research projects. *Food Policy*, 44:218–226.

ARC (Agricultural Research Council). 2016. *Legislative mandate*. Retrieved from http://www.arc.agric.za/Pages/About Us/What-We-Do.aspx [Accessed 8 August 2016].

Arksey, H. & Knight, P. 1999. *Interviewing for social scientists*. London: Sage.

Arvanitidis, P.A., & Petrakos, G. 2011. Defining Knowledge-Driven Economic Dynamism in the World Economy: A Methodological Perspective. In P. Nijkamp & I. Siedschlag (eds.). *Innovation, Growth and Competitiveness, Advances in Spatial Science.* Berlin: Springer-Verla, 15-39.

Banzi, R., Moja, L., Pistotti, V., Facchini, A. & Liberati, A. 2011. Conceptual frameworks and empirical approaches used to assess the impact of health research: An overview of reviews. *Health Research Policy and Systems*, 9(26):1-10. Retrieved from http://www.health-policy-systems.com/content/9/1/26 [Accessed 29 February 2019]

Barrell, H. 2010. Science's new social contract with society. *African Security Review*, 9(2):82-91.

Barret, D., Blundo-Canto, G., Dabat, M.H., Devaux-Spatarakis, A., Faure, G., Hainzelin, E., Mathé, S., Temple, L., Toillier, A., Triomphe, B. & Vall, E. 2018. *ImpresS methodological guide: Methodological guide to ex post evaluation of agricultural research in developing countries*. Montpellier: CIRAD.

Bayley, J.E. & Phipps, D. 2017. Building the concept of research impact literacy. *Evidence and Policy,* September 2017. Retrieved from https://www.ingentaconnect.com/content/tpp/ep/pre-prints/content-ppevidpold1600027r2 [Accessed 29 February 2019]

Bell, S., Shaw, B. & Boaz, A. 2011. Real-world approaches to assessing the impact of environmental research on policy. *Research Evaluation*, 20(3):227–237.

Bennett, J.W., Kelley, T.G. & Maredia, M.K. 2012. Integration of environmental impacts into ex-post assessments of international agricultural research: Conceptual issues, applications, and the way forward. *Research Evaluation*, 21(3):216–228.

Birckmayer, J.D. & Weiss, C.H. 2000. Theory-based evaluation in practice: What do we learn? *Evaluation Review*, 24(4):407–431.

Blamey, A. & Mackenzie, M. 2007. Theories of change and realistic evaluation: Peas in a pod or apples and oranges? *Evaluation*, 13(4):439–455.

Blankley, W. & Kahn, M. 2005. The history of research and experimental development measurement in South Africa and some current perspectives. *South African Journal of Science*, 101, March/April: 151–157.

Bloch, C., Sørensen, M.P., Graversen, E.K., Schneider, J.W., Schmidt, E.K., Aagaard, K. & Mejlgaard, N. 2014. Developing a methodology to assess the impact of research grant funding: A mixed methods approach. *Evaluation and Program Planning*, 43:105–117.

Boaz, A., Fitzpatrick, S. & Shaw, B. 2009. Assessing the impact of research on policy: A literature review. *Science and Public Policy*, 36(4):255–270.

Bornmann, L. & Bierman, F. 2012. Measuring the societal impact of research. *EMBO Reports*, 13(8):673–676.

Bornmann, L. 2013. What is societal impact of research and how can it be assessed? A literature survey. *Journal of the American Society for Information Science and Technology*, 64(2):217–233.

Boshoff, N. 2005. Lactic acid bacteria research: The fermentation of new ideas into winemaking. In T. Bailey (ed.). *The dynamic of knowledge production and utilisation: Fifteen case studies*. Stellenbosch: Centre for Research on Science and Technology, 15–88.

Boshoff, S.C. 2012. Knowledge utilisation in the South African wine industry. Unpublished PhD dissertation. Stellenbosch: Stellenbosch University. Retrieved from https://scholar.sun.ac.za/handle/10019.1/71749 [2 March 2019].

Boshoff, N. 2014a. Types of knowledge in science-based practices. *Journal of Science Communication*, 13(3):1–16.

Boshoff, N. 2014b. Use of scientific research by South African winemakers. *Journal of Science Communication*, 1:1–18.

Boshoff, N. 2017. South African corresponding authors on perceived beneficiaries and the nature of university research. *South African Journal of Higher Education*, 31(3):46–62.

Boshoff, N., Esterhuyse, H., Wachira-Mbui, D.N., Owoaje, E.T., Nyandwi, T. & Mutarindwa, S. 2018. Academics at three African universities on the perceived utilisation of their research. *South*

African Journal of Higher Education, 32(5):19–38.

Boucher, M. 1973. *Spes in Ardus: A history of the University of South Africa*. Pretoria: Wallachs.

Bowen, S.J. & Graham, I.D. 2013. From knowledge translation to engaged scholarship: Promoting research relevance and utilization. *Archives of Physical Medicine and Rehabilitation*, 94, Suppl.: S3–S8.

Bozeman, B. & Sarewitz, D. 2011. Public value mapping and science policy evaluation. *Minerva*, 49:1–23.

Bozeman, B. & Youtie, J. 2017. Socio-economic impacts and public value of government-funded research: Lessons from four US National Science Foundation initiatives. *Research Policy*, 46(8):1387–1398.

Bozeman, B. 2003. *Public Value Mapping of Science Outcomes: Theory and Method – A Monograph of the Public Value Mapping Project of the Center for Science, Policy and Outcomes*. Retrieved from https://pdfs.semanticscholar.org/7131/942a1c37b2ec2e3b42b1ea39ac284fa2c72c.pdf?_ga=2.31691323.427961857.1551517527-1499422752.1551517527 [2 March 2019].

Briggle, A.R. 2014. Opening the black box: The social outcomes of scientific research. *Social Epistemology*, 28(2):153–166.

Bryman, A. 2012. *Social research methods*. Fourth edition. Oxford: Oxford University Press.

Bush, V. 1945. *Science, the endless frontier*. Washington, DC: National Science Foundation.

Byerly, R. & Pielke, R.A. 1995. The changing ecology of United States science. *Science*, 269(5230):1531–1532.

Byng, R. 2005. Using realistic evaluation to evaluate a practice-level intervention to improve primary healthcare for patients with long-term mental illness. *Evaluation*, 11(1):69–93.

Cambon, L., Petit, A., Ridde, V., Dagenais, C., Porcherie, M., Pommier, J., Ferron, C., Minary, L. & Alla, F. 2017. Evaluation of a knowledge transfer scheme to improve policy making and practices in health promotion and disease prevention setting in French regions: A realist study protocol. *Implementation Science*, 12(83):1–10.

Campbell, D.T. & Stanley., J.C. 1963. Experimental and quasi-experimental designs for research. In N.L. Gage (ed.). *Handbook of research on teaching*. Chicago: R. McNally, 1–84.

Campbell, P. & Grayson, M. 2014. Assessing science: Lessons from Australia and New Zealand. *Nature Outlook*, 511(7510):S48–S83.

Carruthers, J. 2010. Scientists in society: The Royal Society of South Africa. *Transactions of the Royal Society of South Africa*, 63(1):1–30.

Carruthers, J. 2010. Scientists in society: The Royal Society of South Africa. *Transactions of the Royal Society of South Africa,* 63(1):1-30.

Changuion, L. & Steenkamp, B. 2012. *Disputed land: The historical development of the South African land issue, 1652–2011*. Pretoria: Protea Book House.

CIRAD (French Agricultural Research Centre for International Development). 2015a. *A five-step method*. Retrieved from https://impress-impact-recherche.cirad.fr/ex-post/a-five-step-method [Accessed 22 October 2018].

CIRAD (French Agricultural Research Centre for International Development). 2015b. *A six-step approach*. Retrieved from https://impress-impact-recherche.cirad.fr/ex-ante/a-six-step-approach [Accessed 22 October 2018].

CIRAD (French Agricultural Research Centre for International Development). 2015c. *Homepage*. Retrieved from https://impress-impact-recherche.cirad.fr/ [Accessed 22 October 2018].

CIRAD (French Agricultural Research Centre for International Development). 2015d. *What is ImpresS?* Retrieved from https://impress-impact-recherche.cirad.fr/what-is-impress [Accessed 22 October 2018].

CIRAD (French Agricultural Research Centre for International Development). 2018. *ImpresS ex ante: A methodological approach to develop the impact culture*. Retrieved from https://www.cirad.fr/en/our-research/the-impact-of-our-research/impress-ex-ante-a-methodological-approach-to-develop-the-impact-culture/principles-and-tools [Accessed 24 October 2018].

Citrus Growers' Association of Southern Africa. 2016. *Annual report 2016*. Durban.

Citrus Research International. 2017. *Research*. Retrieved from http://www.citrusres.com/research [Accessed 22 August 2016].

Constas, H. 1958. Max Weber's Two Conceptions of Bureaucracy. *American Journal of Sociology,* 63(4):400-409.

Costas, R., Prins, A., Van Leeuwen, T. & Wouters, P. 2014. Methodological Proposal for Evaluating Performance of Social Science Researchers in Mexico. In *Proceedings of the Science and Technology Indicators Conference, "Context Counts: Pathways to Master Big and Little Data".* Leiden: Universiteit Leiden - CWTS 2014, 434–443.

Coryn, C.L.S., Noakes, L.A., Westine, C.D. & Schröter, D.C. 2011. A systematic review of theory-driven evaluation practice from 1990 to 2009. *American Journal of Evaluation*, 32(2):199–226.

Creswell, J.W. & Plano-Clark, V.L. 2011. *Designing and conducting mixed methods research*. Second edition. Thousand Oaks, CA: Sage.

CSIR (Council for Scientific and Industrial Research). 2019. *About us*. Retrieved from https://www.csir.co.za/about-us [Accessed 28 February 2019].

Culdevco. 2019. *More about Culdevco*. Retrieved from https://www.culdevco.co.za/about-us/ [Accessed 28 February 2019].

DAFF (Department of Agriculture Forestry and Fisheries). 2012. *Agriculture, Forestry and Fisheries Integrated Growth and Development Plan 2012*. Pretoria.

DAFF (Department of Agriculture Forestry and Fisheries). 2013. *A profile of the South African wine market value chain*. Pretoria.

DAFF (Department of Agriculture Forestry and Fisheries). 2014a. *A profile of the South African apple market value chain 2012*. Pretoria.

DAFF (Department of Agriculture Forestry and Fisheries). 2014b. *A profile of the South African apricot market value chain 2012*. Pretoria.

DAFF (Department of Agriculture Forestry and Fisheries). 2016. *A profile of the South African apricot market value chain 2015*. Pretoria.

De Beer, G., Paterson, A. & Olivier, H. 2003. *160 years of export: The history of the Perishable Products Export Control Board*. Cape Town: The Perishable Products Export Control Board.

De Jong, S., Barker, K., Cox, D., Sveinsdottir, T. & Van den Besselaar, P. 2014. Understanding societal impact through productive interactions: ICT research as a case. *Research Evaluation*, 23(2):1–14.

De Jong, S., Van Arensbergen, P., Daemen, F., Van der Meulen, B. & Van den Besselaar, P. 2011. Evaluation of research in context: An approach and two cases. *Research Evaluation*, 20(1):61–72.

Dinsmore, A., Allen, L. & Dolby, K. 2014. Alternative perspectives on impact: The potential of ALMs and altmetrics to inform funders about research impact. *PLoS Biology*, 12(11):1–4.

Donovan, C. & Hanney, S. 2011. The “Payback Framework” explained. *Research Evaluation*, 20(3):181–183.

Donovan, C. 2008. The Australian Research Quality Framework: A live experiment in capturing the social, economic, environmental, and cultural returns of publicly funded research. *New Directions for Evaluation*, (114):47–60.

Douthwaite, B., Alvarez, S., Cook, S., Davies, R., George, P., Howell, J., Mackay, R. & Rubiano, J. 2007. Participatory impact pathways analysis: A practical application of programme theory in research for development. *The Canadian Journal of Program Evaluation*, 22(2):127–159.

Douthwaite, B., Alvarez, S., Cook, S., Davies, R., George, P., Howell, J., Mackay, R. & Rubiano, J. 2007. Participatory Impact Pathways Analysis: A pratical application of Programme Theory in Research for Development. *The Canadian Journal of Program Evaluation,* 22(2):127–159.

Economic and Social Research Council Evaluation Committee. N.d. *Branching-out: New directions in impact evaluation from the ESRC's evaluation committee*. Retrieved from https://esrc.ukri.org/files/research/research-and-impact-evaluation/branching-out-new-directions-in-impact-evaluation-from-the-esrc-s-evaluation-committee/ [Accessed 10 January 2019].

Elzinga, A. 1997. The science-society contract in historical transformation: With special reference to "epistemic drift". *Social Science Information*, 36(3):411–445.

ESRC (Economic and Social Research Council). 2009. *Taking stock: A summary of ESRC's work to evaluate the impact of research on policy & practice*. Swindon.

Estabrooks, C.A. 1999. The conceptual structure of research utilization. *Research in Nursing and Health*, 22(3):203–216.

Esterhuizen, J.M.C. & Liebenberg, G.F. 2001. The use of indicators within a comprehensive impact assessment approach in three South African research programmes. *Agriculture, Ecosystems & Environment*, 87(2):233–244.

Evans, G. & Durant, J. 1995. The relationship between knowledge and attitudes in the public understanding of science in Britain. *Public Understanding of Science*, 4(1):57–74.

Fitz-Gibbon, C.T. & Morris, L.L. 1996. Theory-based evaluation. *Evaluation Practice*, 17(2):3–9.

Gauchan, D. & Shrestha, S. 2017. Agricultural and rural mechanisation in Nepal: Status, issues and options for future. In S. Mandal, S. Bigges & S. Justice (eds.). *Rural mechanisation: A driver in agricultural change and rural development*. Dhaka: Institute for Inclusive Finance and Development, 97–118.

Gaunand, A., Hocdé, A., Lemarié, S., Matt, M. & De Turckheim, E. 2015. How does public agricultural research impact society? A characterization of various patterns. *Research Policy*, 44:849–861.

GCIS (Department of Government Communications and Information System). 2016. *South Africa year book 2014/2015*. Pretoria.

Gibbons, M. 1999. Science's new social contract with society. *Nature,* 402(81):11-18.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. & Trow, M. 1994. *The new production of knowledge: The dynamics of science and research in contemporary societies*. London: Sage.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. 1994. *The new production of knowledge: The dynamics of science and research in contemporary societies*. Sage: London.

Grant, J., Brutscher, P.-B., Kirk, S.E., Butler, L. & Wooding, S. 2009. *Capturing research impacts: A review of international practice*. Cambridge: RAND Europe.

Greef, P. & Kotze, M. 2007. *The National Agricultural Marketing Council and Commark Trust, Report no. 2007-02*. Pretoria: South African Department of Agriculture.

Green, J., Roberts, H., Petticrew, M., Steinbach, R., Goodman, A., Jones, A. & Edwards, P. 2015. Integrating quasi-experimental and inductive designs in evaluation: A case study of the impact of free bus travel on public health. *Evaluation*, 21(4):391–406.

Greenberg, S. 2016. *Corporate power in the agrofood system and South Africa's consumer food environment*. Cape Town: Institute for Poverty, Land and Agrarian Studies.

Grootfontein Agricultural Development Institute. N.d. *The history of the Grootfontein College of Agriculture*. Retrieved from http://gadi.agric.za/history.php [Accessed 12 September 2016].

Gubrium, J.F., Holstein, J.A., Marvasti, A.B., Mckinney, K.D. & Morse, J.M. 2012. The implications of interview type and structure in mixed-methods designs. In J.F. Gubrium, J.A. Holstein, A.B. Marvasti & K.D. McKinney (eds.). *The Sage handbook of interview research: The complexity of the craft*. Thousand Oaks, CA: Sage, 193–205.

Guston, D. & Keniston, K. 1994. Introduction: The social contract for science. In D. Guston & K. Keniston (eds.). *The fragile contract: University science and federal government*. Cambridge, MA: The MIT Press, 1–41.

Hanney, S., Packwood, T. & Buxton, M. 2000. Evaluating the benefits from health research and development centres: A categorization, a model and examples of application. *Evaluation*, 6(2):137–160.

Hardwick, R., Anderson, R. & Cooper, C. 2015. How do third sector organisations use research and other knowledge? A systematic scoping review. *Implementation Science*, 10(84). Retrieved from https://doi.org/10.1186/s13012-015-0265-6 [Accessed 28 February 2019].

Haynes, A., Rowbotham, S.J., Redman, S., Brennan, S., Williamson, A. & Moore, G. 2018. What can we learn from interventions that aim to increase policy-makers' capacity to use research? A realist scoping review. *Health Research Policy and Systems*, 16(31):1–27.

Hirsch, J. E. 2005. An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences of the United States of America*, 102(46): 16569–16572.

Hortgro Science. 2015. *Annual report 2014–2015*. Stellenbosch.

Hortgro Science. 2017. *Annual report 15–16*. Stellenbosch.

Hortgro Science. 2018. *Annual report 2016/17*. Stellenbosch.

Hortgro Science. N.d. *Our structure*. Retrieved from http://www.hortgro-science.co.za/our-structure/ [Accessed 26 August 2016].

Hortgro. N.d. *Welcome to Hortgro*. Retrieved from https://www.hortgro.co.za/ [Accessed 24 August

2016].

IGWS (Institute for Grape and Wine Sciences). 2019. *About IGWS*. Retrieved from http://igws.co.za/about [Accessed 28 February 2019].

INRA (Institut national de la recherche agronomique). 2017. *Translating research into impacts: 30 case studies*. Retrieved from http://www.inra.fr/en/Scientists-Students/Economics-and-social-sciences/All-the-news/Translating-research-into-impacts-30-case-studies [Accessed 23 May 2017].

Jagosh, J., Bush, P.L., Salsberg, J., Macaulay, A.C., Greenhalgh, T., Wong, G., Cargo, M., Green, L.W., Herbert, C.P. & Pluye, P. 2015. A realist evaluation of community-based participatory research: Partnership synergy, trust building and related ripple effects. *BMC Public Health*, 15(725):1–11.

Jagosh, J., Tilley, N. & Stern, E. 2016. Realist evaluation at 25: Cumulating knowledge, advancing debates and innovating methods. *Evaluation*, 22(3):267–269.

Jansen, M.W. & Ruwaard, D. 2012. Making an impact instead of "publish or perish". *European Journal of Public Health*, 22(5):613–614.

Joly, P.-B., Gaunand, A., Colinet, L., Larédo, P., Lemarié, S. & Matt, M. 2015. ASIRPA: A comprehensive theory-based approach to assessing the societal impacts of a research organization. *Research Evaluation*, 24:440–453.

Jupp, V. 2006. *The Sage dictionary of social research methods*. London: Sage.

Kamenetzky, A., Hinrichs-Krapels, S., Wooding, S. & Grant, J. 2015. Impacts of agricultural research: An approach of societal values. Impacts of agricultural research - an approach of societal values*. An International Conference organized by the French National Institute for Agricultural Research (INRA)*. Paris, 3-4 November.

Kelley, T., Ryan, J. & Gregersen, H. 2008. Enhancing ex post impact assessment of agricultural research: The CGIAR experience. *Research Evaluation*, 17(3):201–212.

Kilpatrick, H. 1998. *Impact assessment discussion paper no. 2: Measuring the benefits of social science research*. Washington, D.C. International Food Policy Research Institute.

Kings College London & Digital Science. 2015. *The nature, scale and beneficiaries of research impact: An initial analysis of Research Excellence Framework (REF) 2014 impact case studies*. London: King's College London.

Kreindler, S.A. 2018. Advancing the evaluation of integrated knowledge translation. *Health Research Policy and System,* 16(104):1–10.

Krlev, G., Münscher, R. & Mülbert, K. 2013. *Social return on investment (SROI): State-of-the-art and perspectives – a meta-analysis of practice in social return on investment (SROI) studies* *published 2002–2012*. Heidelberg: Centre for Social Investment.

Krull, W. 2005. Exporting the Humboldtian university. *Minerva*, 43(1):99–102.

Kuschke, I. & Geyer, J. 2016. *Agriculture: Market intelligence report*. Cape Town: GreenCape.

Kwan, P., Johnston, J., Fung, A.Y.K., Chong, D.S.Y., Collins, R.A. & Lo, S.V. 2007. A systematic evaluation of payback of publicly funded health and health services research in Hong Kong. *BMC Health Services Research*, 7(121):1–10.

KwaZulu-Natal Department of Agriculture and Rural Development. N.d. *History of Cedara College*. Retrieved from http://www.kzndard.gov.za/history-of-cedara-college [Accessed 9 September 2016].

KWV (Koöperatiewe Wijnbouwers Vereniging van Zuid-Afrika). N.d. *Our company – our history*. Retrieved from http://www.kwv.co.za/our-company/timeline?skip-screening=true [Accessed 23 August 2016].

KWV. N.d. *Our history*. Retrieved from http://www.kwv.co.za/our-company/timeline?skip-screening=true [Accessed 26 February 2019].

Lane, J.E. 2000. *New public management*. London: Routledge.

Leffler, M.P. 2010. Ideology and the origins of the Cold War. In M.P. Leffler & O.A. Westad (eds.). *The Cambridge history of the Cold War*. Cambridge: Cambridge University Press, 20–43.

Lepori, B. & Reale, E. 2012. S&T indicators as a tool for formative evaluation of research programs. *Evaluation*, 18(4):451–465.

Leydesdorff, L. 1996. Emergence of a triple helix of university–industry–government relations. *Science and Public Policy*, 23(5):279–286.

Liebenberg, F. & Kirsten, J. 2006. Agricultural R&D in the developing world. In P.G. Pardey, J.M. Alston & R.R. Piggott (eds.). *Agricultural R&D in the developing world: Too little, too late?* Washington, DC: International Food Policy Research Institute, 195–226.

Liebenberg, F. 2013. South African agricultural production, productivity and research performance in the 20th century. Unpublished PhD dissertation. Pretoria: University of Pretoria. Retrieved from https://repository.up.ac.za/handle/2263/24416 [Accessed 2 March 2019]

Liebenberg, F. 2015. *Agricultural advisory services in South Africa*. Pretoria: Department of Agricultural Economics, Extension and Rural Development, University of Pretoria.

Liebenberg, F., Pardey, P. G. & Kahn, M. 2011. South African agricultural R & D investments: Sources, structure, and trends, 1910-2007. *Agrekon*, 5(3):1-26

Liebenberg, F., Pardey, P.G. & Kahn, M. 2010. *South African agricultural research and development: A century of change*. Minneapolis, MN: University of Minnesota.

Loots, J. 2017. *State of the SA wine industry – 2017*. Retrieved from http://vinpro.co.za/state-sa-wine-industry/ [Accessed 14 March 2017].

Lounsbury, C.P. 1940. The pioneer period of economic entomology in South Africa. *Journal of the Entomological Society of Southern Africa*, 3:9–29.

Maag, S., Alexander, T.J., Kase, R. & Hoffmann, S. 2018. Indicators for measuring the contributions of individual knowledge brokers. *Environmental Science and Policy,* 89(2018):1–9.

Madaus, G. 2004. Ralph W. Tyler's Contribution to Program Evaluation. In C.A. Alkin (ed.). *Evaluation roots: Tracing theorists' views and influences*. London: Sage, 70–79.

Makkonen, T. 2013. Government science and technology budgets in times of crisis. *Research Policy*, 42(3):817-822.

Marchal, B., Van Belle, S., Van Olmen, J., Hoerée, T. & Kegels, G. 2012. Is realist evaluation keeping its promise? A review of published empirical studies in the field of health systems research. *Evaluation*, 18(2):192–212.

Maredia, M.K., Shankar, B., Kelley, T.G. & Stevenson, J.R. 2014. Impact assessment of agricultural research, institutional innovation, and technology adoption: Introduction to the special section. *Food Policy*, 44:214–217.

Mark, M.M., Henry, G.T. & Julnes, G. 1998. A realist theory of evaluation practice. *New Directions for Evaluation*, (78):3–32.

Martin, B.R. 2003. The changing social contract for science and the evolution of the university. In A. Guena, A. Salter & W.E. Steinmueller (eds.). *Science and innovation: Rethinking the rationales for funding and governance*. Cheltenham: Edward Elgar, 7–29.

Matt, M., Colinet, L., Gaunand, A. & Joly, P. 2017. Opening the black box of impact – Ideal-type impact pathways in a public agricultural research organization. *Research Policy*, 46:207–218.

Meagher, L.R. 2013. *Research impact on practice: Case study analysis final report*. Swindon: ESRC.

Meijer, I. 2012. *Societal returns of scientific research: How can we measure it?* Leiden: Centre for Science and Technology Studies.

Midmore, P. 2017. The science of impact and the impact of agricultural science. *Journal of Agricultural Economics*, 68(3):611–631.

Miettinen, R., Tuunainen, J. & Esko, T. 2015. Epistemological, artefactual and interactional–institutional foundations of social impact of academic research. *Minerva*, 53(3):257–277.

Milat, A.J., Bauman, A.E. & Redman, S. 2015. A narrative review of research impact assessment models and methods. *Health Research Policy and Systems*, 13(1):1–7.

Miller, J.D. 1983. Scientific literacy: A conceptual and empirical review. *Daedalus*, 112(2): 29–48.

Millstone, E., Van Zwanenberg, P. & Marshall, F. 2010. Monitoring and evaluating agricultural science and technology projects: Theories, practices and problems. *IDS Bulletin*, 41(6):75–87.

Moed, H.F. 2013. The societal impact of research. *Research Trends*, (33):1–28.

Molas-Gallart, J. & Tang, P. 2011. Tracing 'productive interactions' to identify social impacts: An example from the social sciences. *Research Evaluation*, 20(3):219–226.

Molas-Gallart, J., Salter, A.J., Patel, P., Scott, A. & Duran, X. 2002. *Measuring third stream activities: Final report to the Russell Group of Universities*. Brighton: Science and Technology Policy Research Unit.

Morton, S. 2015. Progressing research impact assessment: A "contributions" approach. *Research Evaluation*, 24:405–419.

Mountain, A. N.d. *Theory of change*. Retrieved from https://www.betterevaluation.org/en/resources/guide/theory_of_change [Accessed 29 October 2018].

Nightingale, P. & Scott, A. 2007. Peer review and the relevance gap: Ten suggestions for policy-makers. *Science and Public Policy*, 34(8):543–553.

NOW (Nederlandse Organisatie voor Wetenschappelijk Onderzoek). 2018. *Theory of change and impact pathway*. Retrieved from https://www.nwo.nl/en/about-nwo/organisation/nwo-domains/wotro/Impact+toolkit/Impact+toolkit+-+tools+and+methods [Accessed 9 November 2018].

Nowotny, H., Scott, P. & Gibbons, M. 2003. 'Mode 2' revisited: The new production of knowledge. *Minerva*, 41:179–194.

Onwude, D.I., Abdulstter, R., Gomes, C. & Hashim, N. 2016. Mechanisation of large-scale agricultural fields in developing countries: A review. *Journal of the Science of Food and Agriculture*, 96(12):3969–3976.

Ozor, F. 2014. Research governance and scientific knowledge production in The Gambia. *South African Journal of Science*, 110(9):1–9.

Pardey, P., Roseboom, J. & Anderson, J.R. 1991. Regional perspectives on national agricultural research. In P. Pardey, J. Roseboom & J.R. Anderson (eds.). *Agricultural research policy: International quantitative perspectives*. Cambridge: Cambridge University Press, 195–264.

Pawson, R. & Manzano-Santaella, A. 2012. A realist diagnostic workshop. *Evaluation*, 18(2):176–191.

Pawson, R. & Tilley, N. 1997. *Realistic evaluation*. London: Sage.

Pawson, R. & Tilley, N. 2004. *Realist evaluation*. Retrieved from http://www.communitymatters.com.au/RE_chapter.pdf [Accessed 29 May 2017].

Pawson, R., Greenhalgh, T., Harvey, G. & Walshe, K. 2005. Realist review: A new method of systematic review designed for complex policy interventions. *Journal of Health Services*

Research & Policy, 10(1):21–34.

Penfield, T., Baker, M.J., Scoble, R. & Wykes, M.C. 2014. Assessment, evaluations, and definitions of research impact: A review. *Research Evaluation*, 23(1):21–32.

Pohl, C., Rist, S., Zimmermann, A., Fry, P., Gurung, G.S., Schneider, F., Speranza, C.I., Kiteme, B., Boillat, S., Serrano, E., Hadorn, G.H. & Urs, W. 2010. Researchers' roles in knowledge co-production: Experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal. *Science and Public Policy*, 37(4):267–281.

Pommier, J., Guével, M.-R. & Jourdan, D. 2010. Evaluation of health promotion in schools: A realistic evaluation approach using mixed methods. *BMC Public Health*, 10(43):1-12.

Powell, W.W., and Snellman, K. 2004. The knowledge economy. *Annual Review of Sociology*, 30:199-220.

PwC (PricewaterhouseCoopers). 2014. *Are you competing? The South African wine industry insights survey 2014*. Stellenbosch.

Research Councils UK. 2007. *Study on the economic impact of the Research Councils*. Swindon.

Research Councils UK. 2011. *Efficiency 2011-15 : Ensuring Excellence with Impact*. Swindon.

Research Excellence Framework. 2011. *Assessment framework and guidance on submissions*. Retrieved from http://www.ref.ac.uk/media/ref/content/pub/ assessmentframeworkandguidanceonsubmissions/GOS including addendum.pdf [Accessed 10 January 2019].

Reynolds, A. 2005. Reserved Seats in National Legislatures: A Research Note. *Legislative Studies Quarterly*, 30(2): 301-310.

Robinson-Garcia, N., Van Leeuwen, T.N. & Rafols, I. 2017. Using almetrics for contextualised mapping of societal impact: From hits to networks. *Science and Public Policy*. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2932944 [Accessed 2 March 2019]

Rogers, P.J. 2007. Theory-based evaluation: Reflections ten years on. *New Directions for Evaluation*, (114):107–114.

Rogers, P.J. N.d. *Introduction to impact evaluation*. Better Evaluation. Retrieved from https://www.betterevaluation.org/en/resources/guide/introduction_impact_evaluation [Accessed 10 January 2019].

Roseboom, J., Pardey, P.G., Von Bach, H.S. & Van Zyl, J. 1994. *Statistical brief on the national agricultural research system of South Africa*. The Hague: International Service for National Agricultural Research.

Royal Society of South Africa. N.d. *Brief history*. Retrieved from http://www.royalsocietysa.org.za/?page_id=122 [Accessed 8 September 2016].

Rymer, L. 2011. *Measuring the impact of research: The context for metric development*. Canberra: Group of Eight.

Salter, K.L. & Kothari, A. 2014. Using realist evaluation to open the black box of knowledge translation: A state-of-the-art review. *Implementation Science*, 9(115). Retrieved from https://implementationscience.biomedcentral.com/articles/10.1186/s13012-014-0115-y [Accessed 2 March 2019].

Samuel, G.N. & Derrick, G.E. 2015. Societal impact evaluation: Exploring evaluator perceptions of the characterization of impact under the REF2014. *Research Evaluation*, 24(3):229–241.

SAPO (South African Plant Improvement Organisation). 2019. *About*. Retrieved from http://www.saplant.co.za/ [Accessed 28 February 2019].

Sapolsky, H.M. 1994. Financing science after the Cold War. In D. Guston & K. Keniston (eds.). *The fragile contract: University science and federal government*. Cambridge, MA: The MIT Press, 160–176.

SAWIS (South African Wine Industry Information and Systems). 2019. *About SAWIS Index*. Retrieved from http://www.sawis.co.za/info/about2.php [Accessed 28 February 2019].

Simis, M.J., Madden, H., Cacciatore, M.A. & Yeo, S.K. 2016. The lure of rationality: Why does the deficit model persist in science communication? *Public Understanding of Science*, 25(4):400–414.

Sinclair, A.I. 2003. Deregulation in the South African citrus industry. Unpublished Masters thesis. Stellenbosch: Stellenbosch University.

Singleton, R.A. & Straits, B.C. 2010. Survey research. In R.A Singleton & B.C Straits (eds.). *Approaches to social research*. Fifth edition. New York, NY: Oxford University Press, 263–308.

Smith, B.W. & Van Schalkwyk, J.A. 2002. The white camel of the Makgabeng. *Journal of African History*, 43:235–254.

Spaapen, J. & Van Drooge, L. 2011. Introducing “productive interactions” in social impact assessment. *Research Evaluation*, 20(3):211–218.

Spaapen, J., Dijstelbloem, H. & Wamelink, F. 2007. *Evaluating research in context: A method for comprehensive research assessment*. The Hague: Consultative Committee of Sector Councils for Research and Development.

Spaapen, J., Van Drooge, L., Propp, T., Van der Meulen, B., Shinn, T., Marcovich, A., Van den Besselaar, P., De Jong, S., Barker, K., Cox, D., Morrison, K., Sveinsdottir, T., Pearson, D., D’Ippolito, B., Prins, A., Molas-gallart, J., Tang, P. & Castro-Martínez, E. 2011. *SIAMPI final report*. Retrieved from http://www.siampi.eu/Content/SIAMPI_Final report.pdf [Accessed 10

January 2019].

Springer-Heinze, A., Hartwich, F., Simon Henderson, J., Horton, D. & Minde, I. 2003. Impact pathway analysis: An approach to strengthening the impact orientation of agricultural research. *Agricultural Systems*, 78(2):267–285.

Stein, D. & Valters, C. 2012*. Understanding 'theory of change' in international development: A review of existing knowledge.* London: Justice and Security Research Programme.

Stelzer, F., Wanner, M. & Schäpke, N. 2015. *Understanding and creating societal impact of sustainability transitions research through "real-world laboratories"*. Retrieved from https://core.ac.uk/download/pdf/35143022.pdf [Accessed 10 January 2019].

SU (Stellenbosch University). N.d.(a). *Experimental farms*. Retrieved from http://www.sun.ac.za/english/faculty/agri/departments1/experimental-farms [Accessed 9 September 2016].

SU (Stellenbosch University). N.d.(b). *Genetics: History*. Retrieved from http://www.sun.ac.za/english/faculty/agri/genetics/about-us/history [Accessed 9 September 2016].

SU (Stellenbosch University). N.d.(c). *Historical background*. Retrieved from http://www.sun.ac.za/english/about-us/historical-background [Accessed 9 September 2016].

The Bill of Rights of the Constitution of the Republic of South African. 1996. *Government Gazette*. (No. 17678).

The Presidency Republic of South Africa. 2018. *President Ramaphosa tells Parliament and the nation, SA is on a path to economic renewal*. Retrieved from http://www.thepresidency.gov.za/press-statements/president-ramaphosa-tells-parliament-and-nation%2C-sa-path-economic-renewal [Accessed 10 June 2018].

The South African Fresh Produce Online Magazine*.* 2010. *SA history: Deciduous Board*. Retrieved from http://safreshproduceonline.co.za/fullarticle.asp?id=112 [Accessed 3 March 2019]

The South African Journal of Science. N.d. *About*. Retrieved from http://sajs.co.za/about/history [Accessed 8 September 2016].

The World Bank. 1994. *South African agriculture: Structure, performance and options for the future*. Washington, DC.

Thornton, P.K., Schuetz, T., Förch, W., Cramer, L., Abreu, D., Vermeulen, S. & Campbell, B.M. 2017. Responding to global change: A theory of change approach to making agricultural research for development outcome-based. *Agricultural Systems*, 152:145–153.

Tilley, N. 2000a. Experimentation and criminal justice policies in the United Kingdom. *Crime and Delinquency*, 46(2):194–213.

Tilley, N. 2000b. *Realistic evaluation: An overview*. Retrieved from https://pdfs.semanticscholar.org/22e3/e2921a12a72c1cb0e22ef170bf2a45643e83.pdf [Accessed 10 January 2019].

Van den Akker, W. & Spaapen, J. 2017. *Productive interactions: Societal impact of academic research in the knowledge society*. Leuven: LERU.

Van der Linden, S.L., Leiserowitz, A.A., Feinberg, G.D. & Maibach, E.W. 2015. The scientific consensus on climate change as a gateway belief: Experimental evidence. *PLoS ONE*, 10(2):1–9.

Van Dorp, A.L.C., Lowik, S.J.A. & De Weerd-Nederhof, P.C. 2017. Actors in productive interactions for societal impact: A Dutch case. In *The XXVIII ISPIM Innovation Conference, Composing the Innovation Symphony*. Vienna: International Society for Professional Innovation Management, 1-8.

Van Drooge, L. & Spaapen, J. 2017. Evaluation and monitoring of transdisciplinary collaborations. *The Journal of Technology Transfer*, 1–15. Retrieved from https://doi.org/10.1007/s10961-017-9607-7 [Accessed 2 March 2019].

Van Drooge, L., Vandeberg, R., Zuijdam, F., Mostert, B., Van der Meulen, B. & Bruins, E. 2011. *Valuable indicators for valorisation*. The Hague: Rathenau Institute.

Van Wyk, A. 2014. *Do 40 000 whites own 80% of South Africa?* Retrieved from http://mg.co.za/article/2014-09-15-do-40-000-whites-own-80-of-south-africa [Accessed 12 September 2016].

Vink, N., Williams, G. & Kirsten, J. 2004. South Africa. In K. Anderson (ed.). *The world's wine markets: Globalization at work*. Cheltenham: Edward Elgar, 227–251.

Walker, C. & Dubb, A. 2013. *Fact check 1: Land reform*. Cape Town: PLAAS.

Weingart, P. 1997. From "Finalization" to "Mode 2": old wine in new bottles? *Social science information*, 36(4):591–613.

Weiss, C.H. 1978. Broadening the concept of research utilization. *Sociological Symposium*, 21:20–33.

Weiss, C.H. 1979. The many meaning of research utilization. *Public Administration Review*, 39(5):426–431.

Weiss, C.H. 1980. Knowledge creep and decision accretion. *Knowledge: Creation, Diffusion, Utilization*, 1(3):381–404.

Weiss, C.H. 1980. Knowledge Creep and Decision Accretion. *Science Communication*. 1(3):381-404.

Weiss, C.H. 1995. Nothing as practical as good theory: Exploring theory-based evaluation for comprehensive community initiatives for children and families. In J.P. Connell, A.C. Kubisch, L.B. Schorr & C.H. Weiss (eds.). *New approaches to evaluating community initiatives: Concepts, methods, and contexts*. Washington, DC: The Aspen Institute, 65–92.

Weiss, C.H. 1997. Theory-based evaluation: Past, present, and future. *New Directions for Evaluation*, 1997(76):41–55.

Weiss, C.H. 2004. Rooting for evaluation: A cliff notes version of my work. In C.A. Alkin (ed.). *Evaluation roots: Tracing theorists' views and influences*. London: Sage, 153–168.

Weißhuhn, P., Helming, K. & Ferretti, J. 2017. Research impact assessment in agriculture: A review of approaches and impact areas. *Research Evaluation*, 27, October: 36–42.

White, H. 2009. *Theory-based impact evaluation: Principles and practice*. New Delhi: 3ie.

Wildschut, L.P. 2014. Theory-based evaluation, logic modelling and the experience of SA non-governmental organisations. Stellenbosch: Stellenbosch University. Unpublished PhD dissertation. Retrieved from http://scholar.sun.ac.za/handle/10019.1/86604 [Accessed 2 March 2019]

Winetech. 2015. *Annual report 2015*. Stellenbosch.

Winetech. 2017. *Winetech annual report 2016*. Stellenbosch.

Winetech. N.d. *About*. Retrieved from http://www.winetech.co.za/about [Accessed 5 September 2016].

Wohlforth, W.C. 1995. Realism and the End of the Cold War. *International Security*, 19(3):91-129.

Wolf, B., Lindenthal, T., Szerencsits, J.M., Holbrook, J.B., Heß, J., Szerencsits, M., Holbrook, J.B. & Hess, J. 2013. Evaluating research beyond scientific impact: How to include criteria for productive interactions and impact on practice and society. *Gaia*, 22(2):103-114.

Wolf, B.M., Häring, A.-M. & Heß, J. 2015. Strategies towards evaluation beyond scientific impact: Pathways not only for agricultural research. *Organic Farming*, 1(1):3–18.

Worth, S. 2012. *Agricultural extension in South Africa: Status quo report*. Pretoria: Department of Agriculture, Forestry and Fisheries.

Wynne, B. 1991. Knowledges in context. *Science, Technology, & Human Values*, 16(1):111–121.

Yin, R.K. 2009. *Case study research: Design and methods*. Fourth edition. Thousand Oaks, CA: Sage.

Appendices

Appendix 1 Researcher interview schedule for productive interactions

1. Background/ Interviewee profile	[Introduction: The study forms part of a larger project in which we are investigating the impact of research on society. The current interview is part of a case study based on the societal impact of the project [RESEARCH TITLE]. We want to see how impact forms and builds over time within research projects.] 1.1 [*"Warm-up question"*] Could you, in a few sentences, tell me a little about your current research interests? 1.2 How would you describe your position at your current place of employment, and has it changed since you worked on the [NAME OF RELEVANT PROJECT] research project?
2. Context	I would now like to ask some questions relating to the time when you worked on the [NAME OF RELEVANT PROJECT] research project. 2.1 What was your position and role in the [NAME OF RELEVANT PROJECT] research project? 2.2 How did you become interested in the [NAME OF RELEVANT PROJECT] research project? 2.3 Can you remember how you became aware of the available funding from [WINETECH/HORTGRO/CRI]? 2.4 Thinking back on the [NAME OF RELEVANT PROJECT] research, could you briefly talk me through the main steps, or phases, of the research?
3. Focus on mechanisms of interaction	In the next few questions, I want to explore the activities (what you did) during the research process (before, during and after the research process).
3.1 Direct interactions	3.1.1 Did you regularly interact with any winemakers, cellar masters or other practitioners related to the field of the research during the [NAME OF RELEVANT PROJECT] research? 3.1.2.1 During the run of the research project, were there any other individuals, researchers or organisations you regularly interacted with (face-to-face, phone, email)? 3.1.2.2 Who if any were some of the other researchers involved and what were their roles? 3.1.3 Did any of the practitioners [3.1.1] or other people [3.1.2] <u>contribute to the design</u> of the research? 3.1.4 Do you think these practitioners and other people you mentioned, <u>influenced the research</u> in any other way? 3.1.5 Do you currently have any relationship with any of the practitioners or

	people discussed above – and if so, what does this entail? -[follow up] Is this relationship different from before the research was undertaken?
3.2 Indirect interactions	3.2.1 Did the project produce any outputs? (Probe: articles, webpages, models, guidelines, videos, etc.) 3.2.2 Did any of the practitioners or people discussed above, <u>help with the creation of the project's outputs</u>? 3.2.3 Were there any other individuals or organisations that assisted in producing the research outputs? 3.2.4 Did you get any feedback on any of these outputs?
3.3 Material/ financial interactions	3.3.1 Which stakeholders or funders contributed in any way to the research project? (probe: funding, joined projects, use of facilities, etc.) 3.3.1 What was provided to you under the formal agreements that formed part of the project?
4. Outcome/ impact and consequences	I would now like to look at the outcomes and impact of the [NAME OF RELEVANT PROJECT] project. I just want you to answer as you see fit. There are no correct answers – it is your opinion that I am interested in. 4.1 Did you in anyway track the effect that the results of your research has had on any part of the non-research community? [Probe: Have you had any feedback from any stakeholders or interested individuals regarding your research or research outputs? Which outputs have caused the biggest interest?] 4.2 Have you yourself, or your organisation made use of the research findings from the [NAME OF RELEVANT PROJECT] project in any way beyond the academic context? 4.3 Since completing the [NAME OF RELEVANT PROJECT] project, have you done any follow-up studies or undertaken other activities related to oxidisation in wine (Follow-up question: have you engaged with any researchers/funders in this regard?) 4.4.1 Do you think anyone benefited from the research project, and if so, how? (probe: solved problems, basis for new ideas, arguments or justifications, confirmed perception, used to develop services or articles for public consumption?) 4.4.2 If not, what would you say the reasons are? 4.5 [*If positive answer in 4.2 or 4.4.1*] After completing the research project, which people/actors/organisations have been the most important in determining the uptake/impact of the research? 4.5.1 How?

	4.5.2 Did they have any influence on setting the research agenda? 4.5.3 What type of influence did these people have on your research? 4.5.4 Did they offer you any useful expertise? If so in what way?
5. Conclude	5. Thank you very much for your time. I have asked all of the question that I wanted to ask. Is there anything else related to the topics we discussed that you would like to tell me something about, or do you have any questions related to these topics that you would like to ask me?

Appendix 2 Stakeholder interview schedule for productive interactions

1. Background/ Interviewee profile	[Introduction: The study forms part of a larger project in which we are investigating the impact of research on society. The current interview is part of a case study based on the societal impact of the project (NAME OF RELEVANT PROJECT), undertaken by (NAME OF PRINCIPLE INVESTIGATOR AND RESEARCH ORGANISATION). We want to see how impact forms and builds over time within research projects.] 1.1 How would you describe your position at your current place of employment? 1.2 Are you aware of research on [NAME OF RELEVANT PROJECT], that has been undertaken by [NAME OF PRINCIPLE INVESTIGATOR AND RESEARCH ORGANISATION]? 1.3 Do you feel that the topic of [TOPIC] is relevant to you?
2. Context	2.1 How do you generally keep up-to-date on research results that you are interested in? 2.1.1 Are there any people you rely on for information? 2.1.2 Are there any publications or other sources that you consult for information? 2.2 What is it about these publications or other sources that make them appealing to you, why do you rely on them? 2.3.1 What kind of contact do you have with the people you use as sources of information, that you mentioned above? 2.3.2 Would you say you trust their opinions, and why?
3. Focus on mechanisms of interaction	In the next few questions, I will explore your interactions with researchers, specifically those that worked on the [NAME OF RELEVANT PROJECT] research by [NAME OF PRINCIPLE INVESTIGATOR AND RESEARCH ORGANISATION].
3.1 Direct interactions	3.1 Did you interact with any of the researchers who were part of the [NAME OF RELEVANT PROJECT]? 3.1.1 Did you participate in the design of the project in any way, or did you help them to conceptualise their research? 3.1.2 Did you interact with the researchers during the research process? 3.1.3 Have you had any contact with the researchers after the completion of the research? 3.1.4 [IF ANY CONTACT] Would you say there has been any change in your relationship with the researchers from before or during the research and after? If so, how?
3.2 Indirect interactions	3.2.1 Have you seen any type of publications or information on the [TOPIC] that was produced by the [NAME OF RELEVANT PROJECT] project? (academic papers

	and articles, popular texts, web pages, videos, etc.) 3.2.2[IF HAVE SEEN] How did you come across these publications or where did you find the information? 3.2.3 [IF HAVE SEEN] Which publication or source of information best presented the information, and why?
3.3 Material/ financial interactions	3.3.1 [IF HAVE SEEN] Did you participate in creating any of the publications you mentioned? 3.3.2 Do you feel that you contributed in any (other) way to the research on [TOPIC]? (Financial, material, etc.)
4. Outcome/ impact and consequences	In the next few questions, I will explore whether you made use of the results of the study on [TOPIC] by [NAME OF PRINCIPLE INVESTIGATOR AND RESEARCH ORGANISATION]. 4.1 What would you say the [NAME OF RELEVANT PROJECT] research has meant for you, your [FARM/CELLAR/ORGANISATION]? 4.1.1 Did you in any way use the findings and results on [TOPIC] that you read about/saw or heard of in the publications and from the people we discussed earlier? 4.1.2 Do you think the research results on [TOPIC] has had any impact on the way you think about [THEIR INDUSTRY] or any other related field of interest? 4.1.3 Have you contacted the researchers of the [TOPIC] study after seeing the results of their work? If so, for what purpose? 4.2 Do you think there are any other ways in which something has changed at your [FARM/CELLAR/ORGANISATION] from before you saw the oxidisation results to after? Or, from before being in contact with the [TOPIC] researchers to after?

Appendix 3 Survey on impact literacy: Hortgro

1. Potential scenarios of research impact

The phrases below sketch scenarios that might be considered research impact. All scenarios relate to Hortgro-funded research projects. Please read each phrase and indicate the extent to which you consider it to illustrate the impact a Hortgro-funded research project should have. (Mark with an X.)

Scenarios	Very important impact of Hortgro research	Moderately important impact of Hortgro research	Slightly important impact of Hortgro research	Unimportant impact of Hortgro research
A farming group introduces a successful pest-control strategy in a district, based on the research results of a Hortgro funded study that was presented to them at their study group.	1	2	3	4
Public health improves because of reduced use of chemical pest control in the agricultural sector since bio-control strategies have been adopted that are based on Hortgro research.	1	2	3	4
The university centre/department that housed a Hortgro-funded project can undertake more complex research for the deciduous fruit industry (e.g. because its analytical capacity has improved), because of the funding received under a Hortgro project	1	2	3	4
A sales agent experiences a rise in sales because of the published findings of a Hortgro-funded project confirming the properties of the product sold by the agent.	1	2	3	4
An international research team that assisted the researchers involved in a Hortgro-funded project has joined the Hortgro-funded researchers in an international	1	2	3	4

Scenarios	Very important impact of Hortgro research	Moderately important impact of Hortgro research	Slightly important impact of Hortgro research	Unimportant impact of Hortgro research
research network that regularly co-publishes.				
Producers across different regions implement the recommendations of a practice guideline informed by a Hortgro-funded project.	1	2	3	4
A farmer who took part in a Hortgro-funded project as a research participant has improved the yield of an orchard based on knowledge he gained during the study.	1	2	3	4
Researchers abroad use the published results of a Hortgro-funded research project to inform their research methodology for a replication study in their own context.	1	2	3	4
The living standard of the general population rises because of lower food prices associated with the introduction of mechanisation in agriculture, which mechanisation process is partially informed by Hortgro research.	1	2	3	4
A group of farmers sharing an irrigation system benefit from increased river water supply that has resulted from reduced water use on a farm upstream, where the owner introduced water-saving strategies based on the published findings of a Hortgro-funded project.	1	2	3	4
The researchers involved in a Hortgro-funded project have forged strong professional ties with each other, resulting in their continued research cooperation in other projects.	1	2	3	4
A researcher in the Hortgro-funded project receives external (non-Hortgro) funding to undertake similar research in a different industry based on the success of the Hortgro project.	1	2	3	4

Scenarios	Very important impact of Hortgro research	Moderately important impact of Hortgro research	Slightly important impact of Hortgro research	Unimportant impact of Hortgro research
A researcher in the Hortgro-funded project becomes more skilled (e.g. acquires a higher qualification).	1	2	3	4
A previously untapped market opens up for a cultivar in the deciduous fruit industry because of a Hortgro-funded project.	1	2	3	4
The researchers involved in a Hortgro-funded project create their own consultancy based on the expertise they gained from the project.	1	2	3	4
A public sector laboratory working in the deciduous fruit industry recruits an employee who obtained a qualification by means of a Hortgro-funded project.	1	2	3	4
A research institute that housed a Hortgro-funded project subsequently attracts more research grants than before because of the success of the Hortgro project.	1	2	3	4
Based on the results of a Hortgro-funded project, Hortgro has become aware that a disease previously thought to be uncommon is prevalent in South African orchards.	1	2	3	4
A farmer who took part in a Hortgro-funded project as a research participant has cut input costs by reducing water usage based on insights gained from the project.	1	2	3	4
An industry body has implemented a new export protocol for the cultivar it oversees based on the results of a Hortgro-funded research project in which the industry body had cooperated.	1	2	3	4
A group of farmers from a single district who assisted in a Hortgro-funded project as research participants have implemented a pest-control strategy in their area based	1	2	3	4

Scenarios	Very important impact of Hortgro research	Moderately important impact of Hortgro research	Slightly important impact of Hortgro research	Unimportant impact of Hortgro research
on lessons learnt from the project.				
A farmer who has no knowledge of the Hortgro-funded research project experiences a reduced prevalence of pests, because a neighbour who participated in the project has applied the project findings on pest control successfully.	1	2	3	4

2. Own examples of research impact

2.1 List what you would regard to be the *ideal research impacts* of Hortgro-funded projects (three impacts at most).

Ideal research impact 1: ……………………………………………………………………………………………….

………

………

Ideal research impact 2: ……………………………………………………………………………………………….

………

………

Ideal research impact 3: ……………………………………………………………………………………………….

………

………

2.2. Think of research projects that you consider to have been a waste of money in terms of no or little impact. **Without mentioning a specific project**, please state why you hold this opinion (three reasons at most).

Reason 1: …….

………

………

Reason 2: …….

………

………

Reason 3: …….

………

………

3. Role-players in knowledge and technology transfer

3.1. The organisations below potentially play a role in *knowledge- and technology-transfer* related activities in Hortgro-funded research projects. Please rate their importance for *knowledge and technology transfer*. (Mark with an X.)

Group/organisation	Very important	Moderately important	Slightly important	Not important at all	Do not know
Agricultural Research Council and its relevant institutes	1	2	3	4	5
Private or independent laboratories/research centres (Example: ExperiCo)	1	2	3	4	5
Agricultural training institutes (Example: Elsenburg)	1	2	3	4	5
Universities	1	2	3	4	5
Council for Scientific and Industrial Research (CSIR)	1	2	3	4	5
Culdevco	1	2	3	4	5
Hortgro	1	2	3	4	5
Hortgro Science	1	2	3	4	5
Industry focussed 'popular' magazines (Example: South African fruit journal)	1	2	3	4	5
Industry representative bodies (Example: Forelle Producers Association)	1	2	3	4	5
International academic journals	1	2	3	4	5
National Department of Agriculture, Forestry and Fisheries	1	2	3	4	5
Private corporations in South Africa (Example: importers/exporters)	1	2	3	4	5
SAPO Trust	1	2	3	4	5
South African academic journals	1	2	3	4	5

3.2. Are there any organisations missing from the list above that you feel should be included? If so, please name them:

1. ....

2. ……

3. ……

3.3. Below, please identify the *three* organisations (from the list in 3.1 or from your additions at 3.2) that you view as most important as regards facilitating *research and technology transfer* in the deciduous fruit industry. For each organisation, please **(1)** supply its name, **(2)** state one or more reasons for your choice, and **(3)** list the individuals at these organisations whom you think are most important for research and technology transfer. *[NB: **Please do not mention specific people**, only role or job descriptions. The focus is on the job or position, not on the individual who is the current incumbent. In other words, whose job is it to make research and technology transfer happen?]*

Organisation 1	
Reason	
Important jobs/positions	

Organisation 2	
Reason	
Important jobs/positions	

Organisation 3	
Reason	
Important jobs/positions	

4. General information

Which of the following apply to your current employment/job/position? Please tick all applicable options.

University-based researcher/academic	1
Researcher in the public sector	2
Researcher in the private sector	3
Technical advisor	4
Executive/manager of a firm/company	5
Farmer/producer	6
Technology or knowledge transfer professional	7
Technical/quality assurance manager	8
Other (Specify: ……………………………..…………………………………………..)	9

- THE END -

Appendix 4 Survey on impact literacy: Winetech

1. Potential scenarios of research impact

The phrases below sketch scenarios that might be considered research impact. All scenarios relate to Winetech-funded research projects. Please read each phrase carefully and indicate the extent (if any) to which you consider it to illustrate the impact of Winetech-funded research. (Mark with an X.)

Scenarios	Very important impact of Winetech research	Moderately important impact of Winetech research	Slightly important impact of Winetech research	Unimportant impact of Winetech research
The researchers involved in a Winetech-funded project have forged strong professional ties with each other, resulting in their continued research cooperation in other projects.	1	2	3	4
An industry body has implemented a new protocol for the cultivar it oversees, which was based on the results of a Winetech-funded research project in which the industry body had cooperated.	1	2	3	4
A research institute that housed a Winetech-funded project subsequently attracts more research grants than before because of the success of the Winetech project.	1	2	3	4
The living standard of the general population rises because of lower food prices associated with the introduction of mechanisation in agriculture, which mechanisation process is partially informed by Winetech research.	1	2	3	4
A sales agent experiences a rise in sales because of the published findings of a Winetech-funded project confirming the properties of the product sold by the agent.	1	2	3	4

Scenarios	Very important impact of Winetech research	Moderately important impact of Winetech research	Slightly important impact of Winetech research	Unimportant impact of Winetech research
A researcher in the Winetech-funded project becomes more skilled (e.g. acquires a higher qualification).	1	2	3	4
The university centre/department that housed the Winetech-funded project can undertake more complex research for the wine industry (e.g. because its analytical capacity has improved), because of the funding received under a Winetech project	1	2	3	4
A group of farmers from a single district who assisted in a Winetech-funded project as research participants have implemented a pest-control strategy in their area based on lessons learnt from the project.	1	2	3	4
A group of farmers sharing an irrigation system benefit from increased river water supply that has resulted from reduced water use on a farm upstream, where the owner introduced water-saving strategies based on the published findings of a Winetech-funded project.	1	2	3	4
A public sector laboratory working in the wine industry recruits an employee who received training or obtained a qualification by means of a Winetech-funded project.	1	2	3	4
Producers across different wine regions implement the recommendations of a practice guideline informed by a Winetech-funded project.	1	2	3	4
A farmer who has no knowledge of the Winetech-funded research project experiences a reduced prevalence of pests, because a neighbour who participated in the project has applied the project findings on pest control successfully.	1	2	3	4

Scenarios	Very important impact of Winetech research	Moderately important impact of Winetech research	Slightly important impact of Winetech research	Unimportant impact of Winetech research
An international research team that assisted the researchers involved in a Winetech-funded project has joined the Winetech-funded researchers in an international research network that regularly co-publishes.	1	2	3	4
A previously untapped market opens for the wine industry because of a Winetech-funded project.	1	2	3	4
Based on the results of a Winetech-funded project, Winetech has become aware that a vine disease thought to be uncommon is prevalent in South African vineyards.	1	2	3	4
A farmer who took part in a Winetech-funded project as a research participant has cut input costs by reducing water usage based on insights gained from the project.	1	2	3	4
The researchers involved in a Winetech-funded project create their own consultancy based on the expertise they gained from the project.	1	2	3	4
A wine cellar produces wines of higher quality by using new analytical capacity at a university, which had been developed during a Winetech-funded project and of which the winemaker at the cellar learned at an industry information day.	1	2	3	4
A winemaker who took part in a Winetech-funded project as a research participant has improved the quality of the cellar’s wine based on knowledge gained during the study.	1	2	3	4
Public health improves because of reduced use of chemical pest control in the agricultural sector since bio-control strategies have been adopted that are based on	1	2	3	4

Scenarios	**Very important impact of Winetech research**	**Moderately important impact of Winetech research**	**Slightly important impact of Winetech research**	**Unimportant impact of Winetech research**
Winetech research.				
A researcher in the Winetech-funded project receives external (non-Winetech) funding to undertake similar research in a different industry based on the success of the Winetech project.	1	2	3	4
Researchers abroad use the published results of a Winetech-funded project to inform their research methodology for a replication study in their own context.	1	2	3	4
The researchers involved in a Winetech-funded project improve the course material for pre-graduate Viticulture and Oenology students.	1	2	3	4
A company in the international wine industry recruits a student who was part of a Winetech-funded research team.	1	2	3	4
A company that operates outside the wine industry recruits a student who was part of a Winetech-funded research team.	1	2	3	4

2. Own examples of research impact

2.1 List what you would regard to be the *ideal research impacts* of Winetech-funded projects (three impacts at most).

Ideal research impact 1: ……………………………………………………………………………………………….

………

………

Ideal research impact 2: ……………………………………………………………………………………………….

………

………

Ideal research impact 3: ……………………………………………………………………………………………….

………

………

2.2. Think of research projects that you consider to have been a waste of money in terms of no or little impact. **Without mentioning a specific project**, please state why you hold this opinion (three reasons at most).

Reason 1: ……….

………

………

Reason 2: ……….

………

………

Reason 3: ……….

………

………

3. Role-players in knowledge and technology transfer

3.1. The organisations below potentially play a role in *knowledge- and technology-transfer* related activities in Winetech-funded research projects. Please rate their importance for *knowledge and technology transfer* below. (Mark with an X.)

Group/organisation	Very important	Moderately important	Slightly important	Not important at all	Do not know
Agricultural Research Council (ARC) and its relevant institutes	1	2	3	4	5
Agricultural training institutes (example: Elsenburg)	1	2	3	4	5
Council for Scientific and Industrial Research (CSIR)	1	2	3	4	5
Department of Agriculture, Forestry and Fisheries	1	2	3	4	5
Industry representative bodies (example: Shiraz SA)	1	2	3	4	5
Industry-focussed 'popular' magazines (example: *Wineland*)	1	2	3	4	5
Institute for Grape and Wine Sciences (IGWS)	1	2	3	4	5
International academic journals (example: *American Journal of Enology and Viticulture*)	1	2	3	4	5
Private corporations in South Africa (examples: Distell, importers and exporters)	1	2	3	4	5
Private/independent laboratories/research centres	1	2	3	4	5
South African academic journals (example: *South African Journal of Enology and Viticulture*)	1	2	3	4	5
South African Wine Industry Information and Systems (SAWIS)	1	2	3	4	5
Universities	1	2	3	4	5
VinPro	1	2	3	4	5
Winetech	1	2	3	4	5

3.2. Are there any organisations missing from the list above that you feel should be included? If so, please name them:

1. ……

2. ……

3. ……

3.3. Below, please identify the *three* organisations (from the list in 3.1 or from your additions at 3.2) that you view as most important as regards facilitating *research and technology transfer* in the wine industry. For each organisation, please **(1)** supply its name, **(2)** state one or more reasons for your choice, and **(3)** list the individuals at these organisations whom you think are most important for research and technology transfer. *[NB: **Please do not mention specific people**, only role or job descriptions. The focus is on the job or position, not on the individual who is the current incumbent. In other words, whose job is it to make research and technology transfer happen?]*

Organisation 1	
Reason	
Important jobs/positions	

Organisation 2	
Reason	
Important jobs/positions	

Organisation 3	
Reason	
Important jobs/positions	

4. General information

Which of the following apply to your current employment/job/position? Please tick all applicable options.

Technology or knowledge transfer professional	1
University-based researcher/academic	2
Researcher in the public sector	3
Researcher in the private sector	4
Industry consultant	5
Executive officer/manager of a firm/company/cellar	6
Farmer/winemaker/producer	7
Other (Specify: ……………………………..…………………………………………..)	8

- THE END -