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The impact of ACIAR work in agricultural research for development 1982–2022

Volume 2: A qualitative comparative analysis

100

ACIAR IMPACT ASSESSMENT SERIES

The impact of ACIAR work in agricultural research for development 1982–2022

Volume 2: A qualitative comparative analysis

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The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. ACIAR operates as part of Australia's international development cooperation program, with a mission to achieve more productive and sustainable agricultural systems, for the benefit of developing countries and Australia. It commissions collaborative research between Australian and developing-country researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

The Chief Executive Officer of ACIAR reports directly to the Australian Government Minister for Foreign Affairs. ACIAR operates solely on budget appropriation from Australia's Official Development Assistance (ODA).

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ACIAR IMPACT ASSESSMENT SERIES

ACIAR seeks to ensure that the outputs of the research it funds are adopted by farmers, researchers, extension officers, policymakers and other beneficiaries. In order to monitor the effects of its projects, ACIAR commissions independent assessments of selected projects. This series of publications reports the results of these independent studies. Publications in the series are available as hard copy, in limited numbers, and published on the ACIAR website at aciar.gov.au.

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Cover image: Pictured in the biocontrol nursery of the Plant Protection Unit, Ministry of Agriculture, Fiji, is research officer Aradhana Deesh (left) and her colleagues Pranesh Chand (middle) and Asma Begum (right). Mrs Deesh is a member of the inaugural cohort of the ACIAR Meryl Williams Fellowship. Photo: Dave Lavaki

Foreword

The Australian Centre for International Agricultural Research (ACIAR) was established in 1982 to deploy Australia's skill and expertise in agricultural science to improve food security, water security and biosecurity in the Indo-Pacific region.

Over 40 years, ACIAR has made a significant contribution to meeting the complex challenges of growing more food, reducing poverty and improving biosecurity. This 100th edition of our Impact Assessment Series is an opportunity to look back at what our research has achieved and reflect on what we have learned from 40 years of brokering and funding agricultural research partnerships in our region.

ACIAR has a longstanding commitment to assessing our impact and where possible, quantifying the achievements of our committed Australian and international research partners. Volume 1 of this report provides compelling evidence of the significant returns on our research investment across the Indo-Pacific region. This aligns with international research and evaluation work that has consistently found agricultural research for development to be an extremely effective and efficient way of investing overseas development assistance (ODA) funds.

ACIAR-supported research has made a huge contribution to regional agricultural growth. This analysis shows $14.7 billion of additional value realised in our biggest partner Indonesia, $1.4 billion of benefits in our closest neighbour Papua New Guinea, and $2.7 billion in eastern and southern Africa. Major contributions have been made to key food basins such as the Eastern Gangetic Plains, where our cropping systems and water management work has delivered invaluable knowledge to underpin more sustainable development in a global hotspot for food and water security. This analysis also shows a significant flow of co-benefits back to Australia, with approximately $3.7 billion dollars of benefits flowing to a range of sectors including crops, forestry, horticulture and agribusiness.

Volume 1 illuminates how ACIAR has contributed to this growth, not only through the well-acknowledged pathways of improved varieties and pest and disease management, but also through research into whole-of-systems management, markets and policy. The breadth of skills in the Australian and international research and innovation system is a strength that we continue to leverage as we work with partners to tackle pressing challenges including climate change, nutrition security and zoonotic diseases (such as COVID-19).

With increasing pressures on production and natural resource systems, the imperative to continually adapt and improve the management of agrifood systems remains a key priority for our partners – more than 400 organisations across 35 countries in the Indo-Pacific region. Our job is far from done.

ACIAR has a longstanding tradition as a learning organisation, committed to learning from our experience in order to continuously improve internal processes and systems, and research and extension practices in the field. Adaptive management is obviously an even more urgent imperative in a global pandemic with significant restrictions on international and in-country travel. To support this, we are increasingly investing in analyses of our collaborative, research for development model and improving our ability to synthesise, apply and share the lessons learned.

Volume 2 of this report presents the findings of a large cross-case analysis of past projects. Recognising that not all impacts can be crystallised in production numbers or financial returns, the study applied qualitative comparative analysis to identify the key research design, management and practice principles that have supported the effective translation of research knowledge into development outcomes.

This 100th report in our Impact Assessment Series showcases the scale of ACIAR achievement and the depth of what has been learned over 40 years. Our capacity to understand, celebrate and learn from past investments and past practices is fundamental to delivering further improvements in impact from this highly effective form of aid investment.

We would like to take this opportunity to thank all of the staff, researchers, government, non-government and community partners whose curiosity, drive and vision for a better future have made these achievements possible and generated the insights illustrated so clearly in these landmark volumes.

Andrew Campbell
Chief Executive Officer, ACIAR

Contents

List of tables

List of figures

Abbreviations

ACIAR Australian Centre for International Agricultural Research
AR4D Agricultural Research for Development
ARPM Associate Research Program Manager
csQCA crisp set Qualitative Comparative Analysis
fsQCA fuzzy set Qualitative Comparative Analysis
NGO non-government organisation
NRM natural resource management
PoC Practice of Change
QCA Qualitative Comparative Analysis
RPM Research Program Manager
SOGI sexual orientation and gender identity
SRA Small Research and Development Activity
ToC Theory of Change

Summary

For 40 years, the Australian Centre for International Agricultural Research (ACIAR) has been brokering research partnerships and supporting agricultural research for development (AR4D). This study seeks to draw key lessons from this 40-year period. It asks the question:

> *What elements of the ACIAR model in practice are associated with the most successful project outputs and enduring outcomes in different contexts?*

To answer this question, the existing database of ACIAR-supported research projects has been evaluated using Qualitative Comparative Analysis (QCA) logic and tools. QCA is a method that helps to analyse multiple cases (here ACIAR-supported research projects) in complex situations or complex contexts.

QCA helps to uncover patterns of causal conditions (that is, 'elements of the ACIAR model in practice') that lead to a specific outcome (that is, 'the most successful project outputs and enduring outcomes'). Therefore, the QCA method assists in understanding why an outcome was achieved in some cases but not in others.

The study builds on a dataset of 106 ACIAR-supported projects and the final analyses build on 49 of these. The projects come from all thematic areas of ACIAR research programs and from all geographical locations where ACIAR operates.

Photo: Conor Ashleigh

The ACIAR model, outcomes and causal conditions

The outcomes and causal conditions that are the central focus of this study were identified through a systematic review of the AR4D literature and extensive engagement with ACIAR staff and stakeholders. This study focused on 5 broad areas of project outputs and enduring outcomes that were observable in the dataset.

1. Innovations Systems

The extent to which the ACIAR-supported project has contributed to a bounded set of actors (including commissioned partners, national partners, stakeholders, and next and end users), activities, objects or products, institutions, and relations that are important for delivering AR4D results. Strong and moderately strong Innovations Systems outcomes were observed in most projects (76%).

2. Science and Knowledge

The extent to which the project has contributed to the development of (i) scientific knowledge, (ii) high-quality practical knowledge that can be applied in context, or (iii) a combination of these. Strong and moderately strong Science and Knowledge outcomes were observed in most projects (76%).

3. Natural Resource Management

The extent to which the project has contributed to enduring positive natural resource impacts. Strong and moderately strong Natural Resource Management outcomes were observed in approximately half of the projects (49%).

4. Policy

The extent to which the project has contributed to policy impacts. Strong and moderately strong Policy outcomes were observed in well over a third of the projects (39%).

5. Socioeconomic

The extent to which the project has contributed towards the enhanced socioeconomic resilience of farming and rural households. Strong and moderately strong Socioeconomic outcomes were observed in approximately half of the projects (49%).

Photo: Majken Soegaard

The ACIAR model was operationalised through 8 causal conditions **that may be associated with project outputs and enduring outcomes in different contexts.**

1. **Context alignment**

   The extent to which a project is aligned to the country or regional context where it will be implemented, and the national partner(s) involved in the project.

2. **Project continuity**

   The extent to which a project relates to earlier ACIAR-supported research projects in the same country and the same agricultural or policy area.

3. **Project focus**

   The extent to which a project seeks to make interventions at the micro-level (that may flow up to the macro-level) or at the macro-level (that may flow down to the micro-level).

4. **Project size**

   ACIAR has funded research projects from very small in size to very large, and everything in-between.

5. **Project design quality**

   The extent to which the original project documentation (and its updates) includes a detailed cause-and-effect narrative to explain how the proposed project interventions will result in the anticipated project outcomes.

6. **Project transition quality**

   The extent to which the project seeks to empower the national partner(s), next user(s) or end user(s) (or a combination of these) to continue using the project interventions or findings after the completion of the project, and the means by which this is accomplished.

7. **Technical competencies**

   The extent to which the project seeks to increase technical competencies, including technology, practices, and academic, policy or technical knowledge.

8. **Professional competencies**

   The extent to which the project seeks to increase professional competencies, including skills, behaviour, and practical or tacit knowledge.

Evidence-based starting points for achieving promising project outcomes

The QCA analyses have identified 24 unique pathways towards successful project outcomes that can be grouped into 5 distinct clusters. **These 5 clusters highlight the unique ACIAR point of difference in the aid program and profile the contribution ACIAR has made in certain areas**. The clusters can best be understood as evidence-based starting points for achieving promising project outcomes.

1. **Theory and practice of change**

   This cluster indicates that the combination of a strong project design quality or theory of change (ToC) and a strong project transition quality or practice of change (PoC) is a promising starting point towards achieving strong project results. In other words, a strong project design needs to be followed throughout the implementation of a project.

2. **Classic AR4D project**

   This cluster indicates that well-thought-out projects (that is, with strong design quality) that are strongly tailored to their local context and that explicitly focus on increasing technical competencies, including technology, practices, and academic, policy or technical knowledge (that is, delivering tangible results) have proven to be a promising starting point towards achieving strong project results.

3. **Scaling out**

   Scaling out is understood here as a process where, for example, interventions (and parts thereof), knowledge and practices are replicated in, or disseminated from, one context to another, or are expanded within the original context. The study has indicated that it is a promising starting point towards achieving strong project results. It is characterised by the combination of project continuity (that is, projects that continue from or build on earlier or existing ACIAR projects) and a large or very large project size.

4. **Scaling up**

   Scaling up is understood here as a process where, for example, interventions (and parts thereof), knowledge and practices are being embedded in formal administrative processes, policy or practice, or are being taken up at higher levels of practice (for example, from village to region to country). The study has indicated that it is a promising starting point towards achieving strong project results. It is characterised by projects with a macro focus, strong project transition quality and a large or very large project size.

5. **Pure or basic science**

   This cluster indicates that supporting projects that aim for pure or basic science is a promising strategy towards achieving strong Science and Knowledge outcomes. The apparent logic for the specific set of conditions that cluster here is that 'pure or basic science' programs that are context independent (to increase the generalisability of findings) and larger or longer-term projects stand a better chance of achieving desirable science and knowledge outcomes.

Lessons for the next 40 years of the ACIAR model

This study has resulted in a set of **future-focused lessons in relation to effective AR4D project support that have surfaced from past ACIAR experience**. They have relevance for future ACIAR project design and implementation, but they may also have relevance for other A4RD organisations and other areas of development.

Lesson 1: Embrace bounded variety (and equifinality and conjunctural causation)

First, there are various pathways towards desirable project outcomes ('equifinality') and none appears to have dominance over the others. This indicates that there is no 'single best way' of achieving project outcomes. In practical terms, if one pathway is not an option (for example, it is not possible to combine a strong project design with a strong project transition strategy) then other pathways can be followed towards desirable project outcomes.

Second, none of the individual causal conditions were found to be necessary for any of the outcomes. For every outcome, and in every path towards the outcomes, we observed complex configurations of causal conditions ('conjunctural causation'). This indicates that there is no 'most important condition' for achieving desired project outcomes. In practical terms, the absence of any individual condition (for example, no context alignment or no project continuation) does not impede the achievement of desirable project outcomes.

Third, we have observed a limited number of pathways towards the outcomes that cluster in 5 broad categories. The 'bounded variety' of configurations of conditions that define these categories can be embraced as evidence-based starting points for future project design and implementation. The categories themselves provide no guarantee for successful project outcomes, but they are the essential parts of project design and implementation that explain why ACIAR-supported projects have achieved successful project outcomes over the past 40 years.

Lesson 2: Always expect a Theory of Change

While the study does not point at a single causal condition that stands out as the most important one for achieving desired project outcomes, the importance of a strong ToC needs to be stressed. The condition 'project design quality' (effectively, a ToC) is a central part of 2 of the 5 broad categories, and it plays a role in 16 of the 24 paths (67%) identified. None of the other conditions recurs that often in paths towards desirable project outcomes. This indicates that ACIAR should always expect a strong ToC from the partners it works with in future projects, and it may aid its partners by developing a template or a set of clear and explicit evaluation criteria for the ToCs it expects.

Still, having a strong ToC by itself is no guarantee for desirable project outcomes. The study has shown that combining it with strong 'project transition quality' (effectively, the Practice of Change, or PoC) has been a promising starting point for ACIAR-supported projects over the past 40 years. This insight indicates that ACIAR should expect from its partners that they couple a ToC with a PoC in future projects. Again, ACIAR could develop a template or a set of clear and explicit evaluation criteria for the PoCs it expects.

Lesson 3: Pursue multiple project outcomes strategically

Two of the clusters identified ('theory and practice of change' and 'classic AR4D project') were found to contribute to all 5 outcomes across different projects. This means that, in theory, pursuing one outcome by using the configuration of conditions that characterises these 2 clusters does not rule out the achievement of any of the other outcomes. However, it has become clear that many projects pursue only a single or, at best, 2 of the project outcomes that are central to this study.

Future project teams could be more strategic in pursuing multiple project outcomes through the 24 pathways and 5 clusters uncovered here. They could identify one of the clusters that this study has found to contribute to the outcome they want to achieve, and then investigate whether and how that cluster (through its detailed pathways) creates possibilities for them to pursue additional outcomes.

Lesson 4: Set clear project quality and assessment criteria (and administer them)

A lesson that results from the raw input data, rather than from the QCA findings, is that it is exceptionally relevant for ACIAR to set clear criteria for the quality of project documentation (including evaluation documentation) and to administer and impose these when necessary. We observed a very broad variety in content and quality of this documentation. To aid future application of QCA (or other data analysis methods) to sets of ACIAR-funded projects, it is relevant for ACIAR to pursue a stricter range of the quality and quantity of the data in project documentation.

Practically speaking, the templates for the various project documents need to be updated, tightened, made fit for purpose, and made fit for contemporary AR4D project support. We acknowledge, however, that too strict templates will hamper ACIAR partners in explaining and justifying their projects. In short, a rethink of the ACIAR commissioning, management and evaluation processes is warranted to ensure that future project documentation will be more comparable across the ACIAR project portfolio (which can help to improve, among others, the accountability and transparency of project support).

Lesson 5: Evaluate, learn, adapt

We cannot emphasise enough the value of the *process* of undertaking this study, and a final lesson for ACIAR is to institutionalise a process of ongoing evaluations of sets of projects, to draw lessons from these and disseminate these lessons widely within the ACIAR network (that is, to learn), and finally, to adapt its practice of project support to the lessons learnt. This trinity ('evaluate, learn, adapt') is a well-known recipe for building a learning organisation.

The process of arriving at the outcomes and causal conditions that are central to this study has asked ACIAR staff and its stakeholders to reflect on essential questions such as: what does ACIAR want to achieve and why, how is ACIAR contributing to AR4D now and how does it want to in the future? The process of data collection has asked to reflect on essential questions such as: does ACIAR know what it is achieving and how can it improve this knowledge? Thus, in the process of the study ACIAR staff and its stakeholders were asked to critically reflect on the 'known knowns' and the 'known unknowns' of the organisation.

Answering these questions on an ongoing basis is part of being a learning organisation. This study has exposed ACIAR to a methodology and a logic that can be used as the starting point for an ongoing evaluation process, to keep reflecting on these 'known knowns' and 'known unknowns', whilst at the same time uncovering, documenting and learning from their 'unknown knowns'. For example, the 24 pathways and the 5 clusters that typify the ACIAR mode of operating identified in this study is a valuable unknown known for the organisation – it 'just' needed to be lifted out of the project database.

1 Introduction

For 40 years, the Australian Centre for International Agricultural Research (ACIAR) has been brokering research partnerships and supporting agricultural research for development (AR4D). This study seeks to draw key lessons from this 40-year period. It asks the question:

> *What elements of the ACIAR model in practice are associated with the most successful project outputs and enduring outcomes in different contexts?*

To answer this question, the existing database of ACIAR research projects has been evaluated using Qualitative Comparative Analysis (QCA) logic and tools. QCA is a method that helps with analysing multiple cases (here ACIAR-supported research projects) in complex situations or complex contexts.

QCA helps to uncover patterns of causal conditions (that is, 'elements of the ACIAR model in practice') that lead to a specific outcome (that is, 'the most successful project outputs and enduring outcomes'). QCA helps to explain why an outcome was achieved in some cases but not in others. In this assessment, QCA allows for uncovering the various (context-specific) modes of operation that have allowed ACIAR to make contributions to 'Innovations Systems' development.

It goes without saying that no single study will be capable of doing justice to the great variety of the hundreds of projects supported by ACIAR over the last 40 years, in different geographies, in partnership with diverse organisations, and within the evolving field of AR4D practice.

The broad AR4D literature has indicated – and this will likely resonate with the experience of ACIAR staff and stakeholders – that it is unlikely to find linear pathways that explain how an AR4D intervention or program has achieved its outcome (Raitzer and Norton 2009). Success depends on design, the actors involved and the context in which they are implemented (Temple et al. 2018).

Further, similar interventions or programs may have different levels of success depending on their contextual conditions, or the contextual conditions may change program performance over time (Tomich, Lidder, Dijkman, et al. 2019). QCA is ideally suited to deal with such complexities.

1.1 Qualitative Comparative Analysis: an overview

In short, a study of a large sample of ACIAR-supported projects over 40 years using regression analyses or similar techniques would most likely result in conclusions that are so abstract that they would have little meaning on the ground. Yet, a series of representative qualitative case studies would most likely not be able to capture the broader lessons that can tell us something about the ACIAR mode of operation in general (Temple et al. 2018).

QCA strikes a balance between drawing general lessons on the one hand, and locally applicable ones on the other. The method will be discussed in what follows, but for here it is sufficient to know that QCA allows for tracing performance patterns ('lessons') across cases (ACIAR-supported research projects) that are sensitive to context but at the same time, are general enough to be applied in different settings. In a nutshell, it maintains the richness of the cases that will be fed into the QCA, but prevents getting lost in the details when it comes to drawing lessons from across the cases.

Applying QCA also fits well with a current, broader shift in AR4D evaluations away from quantitative cost-benefit analyses towards more holistic evaluations that focus on a variety of outcomes – that is, beyond benefit:cost ratios (Mayne and Stern 2013; Stern et al. 2012; Temple et al. 2016). More and more, it is becoming clear that the complex causal relationships in the outcomes of AR4D programs and interventions do not allow for 'clear-cut' pathways or decisions (Norton and Raitzer 2009). AR4D efforts typically involve a set of contributory causes rather than a sole one (for example, financial support *and* end user involvement *and* knowledge generation).

In short, those AR4D programs and interventions that 'work' are typically (part of) a sufficient causal package of conditions that contribute to the desired result (Mayne and Johnson 2015; Sumberg et al. 2013). QCA may help to better understand how such conditions combine to bring about the results of AR4D programs and interventions (Mayne and Stern 2013; Stern et al. 2012).

1.2 Objectives

For this study, more than 100 ACIAR-supported research projects have been analysed, of which 49 have been used in the various QCA analyses. The projects come from all thematic areas of ACIAR research programs and from all geographical locations where ACIAR operates. In short, they are truly a cross-section of 40 years of ACIAR-supported research.

The objectives of this study were to:

- take a long-range analytical look at the ACIAR mode of operation and the contribution that ACIAR has made to AR4D
- highlight the unique ACIAR point of difference in AR4D and profile the contribution ACIAR has made in certain areas
- identify future-focused lessons in relation to effective AR4D based on past experience.

The study started in June 2020 and was completed in January 2022. The data used in this study mainly come from ACIAR project documents, end of project reviews, adoption studies and final reports. No novel data was collected for it.

1.3 Roadmap to this report

In Chapter 2, we present an outline of the method used in this study. Readers who are less interested in the technicalities of QCA are still strongly recommended to read Section 2.3, which introduces the outcomes and conditions (the 'dependent and independent variables') that are the central focus in this study.

In Chapter 3, we present the lessons learned about how the ACIAR mode of operation has supported Innovations Systems outcomes across projects.

In Chapter 4, we present the lessons learned about how the ACIAR mode of operation has supported Science and Knowledge outcomes across projects.

In Chapter 5, we present the lessons learned about how the ACIAR mode of operation has supported Natural Resource Management outcomes across projects.

In Chapter 6, we present the lessons learned about how the ACIAR mode of operation has supported Policy outcomes across projects.

In Chapter 7, we present the lessons learned about how the ACIAR mode of operation has supported Socioeconomic outcomes across projects.

In Chapter 8, we distil the implications and future-focused lessons of this study in relation to effective AR4D. We will also distil the lessons of applying QCA for AR4D impact assessments.

It should be noted that there is repetition across chapters 3 to 7 because some findings recur across the different outcomes. To ensure that the individual chapters can be read and understood as 'stand-alone' texts, we have decided to not remove this repetition. Readers of the full report will find it easy to jump over the repeating parts.

2 Methodology: Qualitative Comparative Analysis

Qualitative Comparative Analysis (QCA) has been applied widely in policy evaluations and impact assessments around the world, including in the area of AR4D (Badstue et al. 2020; Mayne and Johnson 2015; Rihoux et al. 2013; Rihoux and Marx 2013).[1]

Although QCA is gaining traction as a data-analysis method and research approach for the type of impact assessment that is presented in this report, it will be novel to some readers. This chapter introduces the basics of QCA and the motivations behind choosing this method for the impact assessment. Appendix 2 provides a more detailed and technical application of the steps taken in the various analyses presented in Chapters 3 to 7.

Readers who are less interested in the technicalities of QCA may wish to skim or even skip most of this chapter. They are, however, strongly encouraged to read Section 2.3, which introduces the outcomes and causal conditions (termed 'dependent and independent variables' in other methods) that are the central focus in this study.

Good QCA practice

QCA was introduced in the 1980s as a middle path between quantitative and qualitative social research (Ragin 1987). QCA is grounded in set theory, a branch of mathematical logic that allows researchers to study in detail how causal conditions contribute to a particular outcome. The aim of a QCA is 'to allow systematic cross-case comparisons [across an intermediate number of cases], while at the same time giving justice to within case-complexity' (Rihoux and Ragin 2009: xviii).

The fundamentals and background of the method are explained and documented in a series of textbooks (Ragin 2008; Schneider and Wagemann 2013). These handbooks are useful further references for those unfamiliar with the foundations of the method. The handbooks provide guidelines for QCA practice, which have been followed closely in conducting the analyses discussed in this report.

One of the central points for good QCA practice is to provide as much transparency in the analysis as possible. This includes giving an account of why QCA was chosen as research method, an explanation of the causal conditions and outcomes included and their operationalisation (termed 'calibration'), and an explanation of the data used (Schneider and Wagemann 2013; Van der Heijden 2017). This chapter and Appendix 2 and Appendix 3 aim to provide that transparency.

2.1 QCA methodology: what makes it stand out from other methods?

The central motivations to choose QCA as a data analysis method for this study are expectations of conjunctural causation, equifinality and data asymmetry, as discussed in the broader AR4D literature. We first explain what these concepts mean and then, in Section 2.2, why we expected to find them also within the ACIAR mode of operation.

Conjunctural causation

Conjunctural causation is a situation when an effect or outcome depends on a combination of causes or causal conditions. Practically speaking, all those causal conditions need to be present for the outcome to occur. For example, for person X to be able to get to work on time (the outcome) they need to have a means of transport (for the sake of this example, say a car), enough fuel, a road that leads to their work, and no traffic jam on that road. If any of those conditions is absent, person X will not be able to get to work on time (note: here the absence of 'no traffic jam' means that there is a traffic jam).

1 See also the discussion on QCA in the publication *ACIAR Impact Assessment Series No. 48* (Mayne and Stern 2013).

Equifinality

Equifinality is a situation when an effect or outcome can be the result of different independent causal conditions, or of different configurations of causal conditions. Practically speaking, in real-world situations different paths often lead to the same effect or outcome. For example, in addition to the above-mentioned configuration of causal conditions that gets person X to work on time (if all the causal conditions align), another one would be for that person to have a bicycle, enough stamina, a road that leads to their work, and a safe environment for cycling. Yet another one would be for person X to take a sequence of public transport options (perhaps light rail from their home to the departure train station, a train to the area where person X works, and a bus from the arrival train station to their office). All 3 configurations of conditions ('paths') are by themselves enough to get person X to work on time (assuming that no other causal conditions are needed to achieve this outcome).

Data asymmetry

Data asymmetry is a situation in which the impact of a causal condition on the outcome when that condition is present is not the inverse of the impact of that condition on the outcome when it is absent. For example, in the very first path mentioned, the presence of a traffic jam will likely result in person X being late for work. Yet the absence of a traffic jam is no guarantee that person X will be on time. This is because getting to work on time does not depend on one individual condition for person X, but on a configuration of multiple conditions.[2]

Complex causality

The sorts of projects funded by ACIAR are typically faced with situations of complex causality (and their causal complexity is often greater than the stylistic examples used here). QCA provides a highly systemised approach to unpack causal complexity. It allows for a better understanding of conjunctural causation, equifinality and asymmetry (Rihoux and Ragin 2009). However, QCA does not typically provide insight into which identified conditions, or configurations of conditions, are, quantitatively speaking, the most important or significant. To phrase this more formally:

> *The key issue [for QCA] is not which variable is the strongest (that is, has the biggest net effect) but how different conditions combine and whether there is only one combination or several different combinations of conditions (causal recipes) of generating the same outcome (Ragin 2008: 114).*

2.2 Why QCA for this study?

Ideally, QCA is chosen when conjunctural causation, equifinality and data asymmetry are expected to play a role in how conditions of interest relate to the outcomes of interest (Schneider and Wagemann 2013). As with any data analysis method, if it is chosen for the wrong reasons, questions may arise about the validity of the causal recipes it produces. In this study, QCA was chosen because the broader AR4D literature points out that conjunctural causation and equifinality play a strong role in the sort of project outputs and outcomes that result from ACIAR-supported research (this is further explored in Appendix 1 of this report).

Additionally, the possibility that such conjunctural causation and equifinality play a strong role in ACIAR-supported research projects was repeatedly mentioned in workshops with ACIAR staff and stakeholders, including associate research program managers (ARPMs), research program managers (RPMs), the Capacity Building team and representatives of the Country Network (the workshops were held before the formal QCA was started). Their tacit knowledge indicates that there are often no 'easy' explanations for why a project or program achieves certain outcomes, and that causal complexity is the rule rather than the exception in ACIAR-supported research.

Finally, interest in applying QCA for ACIAR impact assessments has been growing over the years (Mayne and Stern 2013). The possibility of applying QCA was extensively explored by ACIAR when commissioning this study of 40 years of ACIAR project support; and, before committing to the project, the commissioned party (Professor Jeroen van der Heijden) first investigated if QCA was possible from both a theoretical and practical point of view. In sum, a secondary aim of this project is to better understand whether and how QCA can be applied to future impact assessments of ACIAR-supported projects and programs.

Because of this secondary aim, the study has also helped to build QCA capacity within ACIAR. This capacity has largely been achieved through the formal training of 4 ACIAR staff in QCA logic and tools in August and September 2020 (the 'ACIAR QCA team'), the active involvement of this team throughout the project, the direct participation of 2 staff in data collection, and a series of workshops on QCA with the broader ACIAR staff and stakeholders.

2 Another manifestation of data asymmetry is when the configuration or configurations of conditions that explain to the presence of an outcome (say, 'at work on time') are not the inverse of that or those that explain its absence (thus, 'not at work on time'). This report is only concerned to understand what explains the presence of outcomes.

2.3 Outcomes and causal conditions central to this study

The outcomes and causal conditions that are central to this study have their basis in the broader AR4D literature. A systematic review of this literature was carried out to identify the most relevant outcomes and conditions for the impact assessment (see Appendix 1). The aim of the review was twofold. First, the review directly informed the selection of outcomes and causal conditions of interest for the various QCA analyses. Second, the review helped to reflect on the ACIAR mode of operation within the international AR4D context.

In parallel to the systematic review, outcomes and conditions were identified through an 'experiential selection' by the ACIAR QCA team. The team explored a sample of ACIAR-supported projects (n=14) based on available documentation (project documents, end of project reviews, adoption studies and final reports). In reading the documents, notes were made on the project 'aims' and 'actual achievements' in terms of scientific outcomes, policy outcomes, social and economic outcomes, and capacity building environment outcomes. In this process, conditions included, but were not limited to, gender conditions, team diversity, budget, project timeline, engagement with users during the project, co-investment, percentage of the budget spent in Australia (versus the partner country), extensions, level of codesign, consultation with stakeholders and partners, communication and linkages with other ACIAR projects.

The results of the 'theoretical selection' and 'experiential selection' were combined and presented for consultation with ACIAR stakeholders, including ARPMs, RPMs, the Capacity Building team and representatives of the Country Network. Based on this process, the final set of 5 outcomes and 8 conditions was selected. It should be noted here that technical restrictions have set limits to the number of causal conditions that can be included, and that the quality of some of the available data has set further limits (particularly for conditions and outcomes related to project management and gender). These limitations are discussed later in this chapter (Section 2.4 and Section 2.5).

To come to the final set of outcomes and causal conditions, the systematic literature review was carried out between June and August 2020. The experiential selection was carried out between August 2020 and February 2021. The final selection was completed in June 2021.

Outcomes

For this study, the outcomes of interest are:

1. **Innovations Systems**

   The extent to which the ACIAR-supported project has contributed to a (bounded) set of actors (including commissioned partners, national partners, stakeholders, next users and end users), activities, objects or products, institutions and relations that are important for delivering AR4D results (cf., Grandstad and Holgersson 2020). A strong innovations systems outcome is, for example, proven active engagement of, and collaboration between, project team members, national partners, stakeholders and local community members (as next or end users) *and* proven skill development and increased capacity of these people and the organisations they are part of.

2. **Science and Knowledge**

   The extent to which the project has contributed to the development of (i) scientific knowledge, (ii) high-quality practical knowledge that can be applied in context, or (iii) a combination of these. A strong science and knowledge outcome is, for example, the combination of several articles published in English language peer-reviewed academic journals *and* several training manuals, handbooks or technical guides that translate project findings for application in the local context.

3. **Natural Resource Management**

   The extent to which the project has contributed to enduring positive natural resource impacts. A strong natural resource management outcome is, for example, the proven institutionalisation of sustainable and equitable practices and management of common natural resources, such as groundwater systems, salinity management, or biodiversity *and* proven increased ecological resilience, such as restored ecosystem biodiversity (for example, increased soil carbon) or rehabilitated ecosystems (for example, coral reef systems or wetlands).

4. **Policy**

   The extent to which the project has contributed to policy impacts. A strong policy outcome is, for example, the implementation of a policy that explicitly draws on the project *and* proven involvement of policymakers in the project, for example, as participants in workshops or as sounding boards (that is, peer reviewers) through correspondence.

5. **Socioeconomic**

   The extent to which the project has contributed towards the enhanced socioeconomic resilience of farming and rural households. A strong socioeconomic outcome is, for example, proven increased socioeconomic returns, such as increased income due to new crop species or the same income achieved with less time spend due to labour saving techniques *and* proven increased socioeconomic agency, such as an increase in an individual's ability to choose the socioeconomic activities in which they participate.

Causal conditions

For this study, the following causal conditions are expected to contribute (likely in conjunction) towards the outcomes of interest:

1. **Context alignment**

   The extent to which a project is aligned to the country or regional context where it will be implemented and the national partner or partners that are involved in the project. Strong context alignment means that a project is explicitly tailored to its context *and* to its national partner or partners. This could, for example, include a mapping of key economic indicators; a mapping of relevant policy processes, actors and considerations; and a mapping of relevant operational risks (such as political stability, or socio-cultural or economic barriers to adoption). Less strong context alignment means it is loosely tailored to its context. Weak context alignment means it is not tailored to its context.[3] The latter is not an intrinsically negative situation. It could indicate that the project is treading novel ground (that is, countries or regions that are new to ACIAR).

2. **Project continuity**

   The extent to which a project relates to earlier ACIAR-supported research projects in the same country and the same agricultural or policy area. Strong project continuity means that the project directly builds on, follows up from, or is an explicit continuation of one or more existing ACIAR-supported research projects in the same country *and* the same agricultural or policy area. Less strong continuity implies it loosely relates to such projects. Weak project continuity means the project does not build on earlier ACIAR-supported research projects. Again, the latter is not an intrinsically negative situation. It could indicate that the project is broadening the ACIAR research agenda and its research interests.

3. **Project focus**

   The extent to which a project seeks to make interventions at the micro-level (that may flow up to the macro-level), or the extent to which a project seeks to make interventions at the macro level (that may flow down to the micro-level). Projects with a micro-level focus are interventions that seek to increase the skills or knowledge at the 'ground level', or the technologies or strategies used at that level. They aim to change patterns of behaviour, action and interaction between users at the 'ground level'. Projects with a macro-level target the institutional or system level and seek to address system-level constraints, such as agroecological dependencies, insufficient knowledge on crop disease, or misalignments across the whole value chain. These projects pursue systemic and 'system level' change.

4. **Project size**

   ACIAR has funded research projects of various sizes, from the small to the very large, and everything in-between. A small project is, for example, a Small Research and Development Activity (SRA) that aims to understand the production and value chain of sheep and goat production in Pacific island countries and to identify the research needed for developing more profitable smallholder production systems. Small projects are typically carried out by a small research team from the commissioned partner (for example, an Australian university). A large project is, for example, a long-term study of how the Chinese wool industry can increase its economic effectiveness and environmental sustainability through local experiments and implementation of Australian technology and knowledge. Large projects are typically carried out by research teams from various Australian universities, local universities and local research centres, local industry associations (or similar) and other local (and sometimes Australian) stakeholders.

3 For the description of the causal conditions, here we use the 3 qualitative categories 'strong', 'less strong' and 'weak' because that makes the discussion easier to follow for those who are not (very) familiar with QCA. Practically speaking, the 'less strong' category is the full sliding scale between 'strong' and 'weak'. In the QCA proper, we split the 'less strong' category into 'moderate' (meaning, qualitatively closer to 'strong') and 'modest' (meaning, qualitatively closer to 'weak'). See further under Section 2.4.

5. **Project design quality**

   The extent to which the original project document (and its updates) includes a detailed cause-and-effect narrative to explain how the proposed project interventions will result in the anticipated project outcomes. In the broader AR4D literature, this is often referred to as a 'Theory of Change' or ToC (Douthwaite et al. 2020; Maru, Sparrow, Butler, et al. 2018; Maru, Sparrow, Stirzaker, et al. 2018). Strong project design quality means that initial project documents include a set of well-articulated end of project outcomes, and a detailed explanation of how project outcomes will contribute to ongoing or durable impacts. The initial project documents include, for example, a set of hypotheses (or similar) about how the project will bring about change, stabilise it and amplify it, *and* a set of relationships between the program or intervention and its intended outcome(s). Less strong project design implies that the original project documents only present a partial or not very detailed cause-and-effect narrative. Weak project design quality implies that such a narrative is not included in the project documents.

6. **Project transition quality**

   The extent to which the project seeks to empower the national partner(s), next user(s), or end user(s) (or a combination of these) to continue using the project interventions or findings after the completion of the project, and the means by which this is achieved. In relation to the ToC concept, this condition could be conceptualised as the 'Practice of Change' or PoC (Arensman et al. 2017; Geddes et al. 2007). Strong project transition quality means that the initial project documents include a set of well-articulated empowerment or transition strategies for a variety of people or organisations that were followed throughout the project. For example, during the final phase of a project, the training of national partner staff is increased, *and* workshops are organised for local policymakers to share project results, *and* findings are documented in the local language and made accessible in an easy-to-understand manner (for example, animations) for next users. Less strong project transition quality implies that empowerment or transition strategies are in place for some, but not all, people and organisations involved (for example, for the national partner but not for local policymakers and next users). Weak project transition quality means that the initial project documents do not include such strategies or that these were explicitly not followed throughout the project.

7. **Technical competencies**

   The extent to which the project seeks to increase technical competencies, which includes technology, technical practices, and academic, policy or technical knowledge. A strong focus on technical competencies means that the initial project documents provide explicit qualitative or quantitative statements of the technical competencies the project seeks to achieve *and* provide a detailed explanation of how these will be achieved. A less strong focus on technical competencies means that the initial project documents do not explicate the technical competencies it seeks to achieve in qualitative or quantitative terms (that is, it gives a broad or vague description of the sorts of technical competencies it aims for), or do not provide a detailed explanation of how the technical competencies it pursues will be achieved. A weak focus on technical competencies means that the initial project documents do not mention any technical competencies that could result from the project.

8. **Professional competencies**

   The extent to which the project seeks to increase professional competencies, including skills, behaviour and practical or tacit knowledge. A strong focus on professional competencies means that the initial project documents provide explicit qualitative or quantitative statements of the professional competencies the project seeks to achieve *and* provide a detailed explanation of how these will be achieved. A less strong focus on professional competencies means that the initial project documents do not explicate the professional competencies it seeks to achieve in qualitative or quantitative terms (that is, it gives a broad or vague description of the sorts of professional competencies it aims for), or do not provide a detailed explanation of how the professional competencies it pursues will be achieved. A weak focus on technical competencies means that the initial project documents do not mention any professional competencies that could result from the project.

Photo: Conor Ashleigh

2.4 Calibration and coding

In the preceding description of conditions and outcomes, it has already become clear that project outcomes can be achieved to a greater or lesser extent, and that project conditions can be present to a greater or lesser extent. For example, a project can have 'strong project design quality', 'weak project design quality', or something in-between these qualitative categories ('sets'). The strength of QCA is that it allows us to include these empirically observed qualitative differences of the conditions to understand whether they affect the empirically observed qualitative differences of the outcomes.

Practically speaking, QCA allows us not only to explore in a binary manner whether, for example, project design quality (in combination with other conditions) plays a role in achieving a particular project outcome, but also to explore whether qualitative differences in project design quality play a role as well. This means that we can include in our analysis the broad, qualitative area between the categories 'strong project design quality' and 'weak project design quality'. Therefore, in this project evaluation we apply fuzzy set QCA (fsQCA) because it allows us to best capture the qualitative differences in the project outcomes and the causal conditions of the ACIAR-supported projects that we have included in the impact assessment.

Data calibration

Because we work with qualitative differences in our data, an essential part of the study is data calibration. In practice, the raw (qualitative and quantitative) data from the source documents need to be transformed into sets that indicate qualitative differences in that data. This process is undertaken for each outcome and each condition. For fsQCA, data is typically calibrated into fine-grained sets that indicate whether the qualitative (and sometimes, quantitative) status of an outcome or condition is, for example, high/moderate/modest/low, present/more-present-than-absent/more-absent-than-present/absent, or strong/moderate/modest/weak.[4] To recap, the strength of fsQCA is that it enables relatively accurate delineation of qualitative differences in the raw data.

Established QCA practice requires researchers to be clear about this calibration. This means that researchers must develop rules to assign their cases to a qualitative set. In particular, they must explain the 2 extremes of the observed data (that is, maximum and minimum parameters in a set), and the crossover point of the data (that is, the stage at which the data are considered to have full ambiguity) (Basurto and Speer 2012; Schneider and Wagemann 2013). The operationalisation of outcomes and conditions (set descriptions, their extremes, and crossover points) that are used in the technical part of any QCA are often the result of an iterative process. This process can be informed by theoretical knowledge, critical knowledge of cases and their contexts, as well as prior knowledge of the researchers and stakeholders involved.

Within this project, we have combined a theoretically informed calibration with an experiential approach to calibration, similar to how the outcomes and conditions of interest were selected (see above, 2.3). In short, the ACIAR QCA team has been strongly involved in developing the descriptors for data calibration, and ACIAR representatives (including ARPMs, RPMs, Capacity Building team, and representatives of the Country Network) have been consulted for feedback. Coming to the final descriptors for data calibration has taken 6 rounds of iteration, which started in May 2021 and were completed by September 2021.

Appendix 3 provides the full set of descriptors for calibration of outcomes and conditions in this study.

Data collection

The data used in this study mainly come from ACIAR Project Documents, End of Project Reviews, Adoption Studies and Final Reports.[5] At the start of the project, we had digital access to 106 projects. None of the projects we had digital access to had commenced before 1990. Because of logistic challenges, we have decided to not include projects in the impact assessment from the 'paper archive' of ACIAR (thus, prior to 1990).[6] Also, whilst QCA can be applied to datasets that involve more than 100 cases (here, ACIAR-supported projects), it has conventionally been applied to datasets of 10–50 cases (Greckhamer et al. 2013; Schneider and Wagemann 2013; Vis 2012).

4 Please note, more finely scaled fuzzy sets are possible, but often a 4-point scale serves the purpose of a QCA.

5 Early in the process Impact Assessment documents were also explored. However, due to the lack of consistency and relevant information in helping to unravel 'causal conditions' and 'outcomes' in these documents, it was decided to not use them in the formal part of the study.

6 Throughout the study, researchers were located in Australia, New Zealand, Germany and the Netherlands.

When collecting data in a QCA study, researchers effectively explore the available data and capture these according to the calibration descriptors. For this study, the original data from the Project Documents, End of Project Reviews, Adoption Studies and Final Reports have been coded to fit the agreed upon descriptors. Outcomes and causal conditions that were observed to be in their maximum qualitative state (as per the calibration descriptors) were coded '1.00', for instance to indicate a 'strong innovations systems outcome', 'strong project transition quality', a 'very large project size' or a 'micro-level project focus'.[7] Outcomes and conditions that were observed to be in their minimum qualitative state (as per the calibration descriptors) were coded '0.00', for instance to indicate a 'weak innovations systems outcome', 'weak project transition quality', a 'small project size' or a 'macro-level project focus'.

Outcomes and conditions that were observed to have a qualitative state between these 2 extremes were coded also. Outcomes and conditions that were observed to be closer to the maximum qualitative state (coded as '1.00') than to the minimum qualitative state (coded '0.00') but not in that maximum qualitative state were coded '0.67', for instance to indicate a 'moderate innovations systems outcome', 'moderate project transition quality', a 'large project size' or a 'micro-to-macro level project focus'. Outcomes and conditions that were observed to be closer to the minimum qualitative state than to the maximum qualitative state but not in that minimum qualitative state were coded '0.33', for instance to indicate a 'modest innovations systems outcome', 'modest project transition quality', a 'medium project size' or a 'macro-to-micro level project focus'.

To ensure consistency in coding, each project was coded by 2 researchers. The project leader, Professor Jeroen van der Heijden, has coded all projects, and ACIAR QCA Team members have each coded half of all the projects. Discrepancies in coding have been resolved through weekly meetings between these 3 researchers during the coding stage. Typically, during the early phases of coding it becomes clear that the calibration descriptors require fine-tuning or modest changes (Rihoux and Ragin 2009; Schneider and Wagemann 2013). Anticipating this, we have reflected on the calibration after coding roughly a third of the projects, and have made modest changes to our calibration descriptors to make these more attuned to the available data. All earlier coded projects have been recoded following the final calibration descriptors.

Data collecting and coding commenced in July 2021 and was completed in November 2021.

2.5 Data quality

Whilst collecting data from the various source documents (ACIAR project documents, end of project reviews, adoption studies and final reports), we faced several data quality challenges. Some of these are worth mentioning here, although it is beyond the scope of this study to scrutinise the way projects are proposed to ACIAR, project progress is accounted for and project results are evaluated and reviewed. The challenges we experienced help to understand the quality of the data that was used for the QCA analyses, and how the quality of data has affected the number of ACIAR-supported projects that could be included in the QCA analyses that are central to Chapters 3 through 7.

A first challenge was that of the 106 projects initially identified for this study, only 77 projects have the full set of source documents available. The projects with (some) missing documents are distributed throughout the initial set of 106, and the missing documents are no indication that a project has not yet been completed. The most common problem is missing Adoption Studies, while the second most common problem is missing, incomplete, or impartial End of Project Reviews. Because of logistical constraints, reviewers must sometimes rely heavily on information provided by the commissioned partner, and thus cannot produce a complete or impartial review.[8] As a result, we had to reduce the set of projects to the 77 for which we had full project documentation.

A second challenge was that there was considerable variety in the quality of the source documents. This was true for all types of source documents, but particularly for Project Documents. Some Project Documents present a clear problem statement, explain what the project seeks to achieve (an outcome or set of outcomes), how it expects to achieve its outcomes (a detailed cause-and-effect narrative), and why the project is relevant (from a science, development or other point of view). Other Project Documents provide lengthy academic literature reviews with ambiguous or missing problem statements, are unclear about their goals and objectives (what they seek to achieve and how this will be done), lack an explanation of their relevance, or some combination of these issues.

7 The central logic behind the calibration is a sliding scale that indicates the qualitative states of 'strong', 'moderate', 'modest', and 'weak'. The exceptions to this logic this are the conditions 'project focus' (which is coded as 'micro focus', 'micro-to-macro focus', 'macro-to-micro focus', and 'macro focus') and 'project size' (which is coded as 'very large', 'large', 'medium', and 'small').

8 We also observed several instances of an external reviewer being exceptionally critical of a project and the achieved outcomes, but then strikingly concluded by applauding the project team for their good work, suggesting ACIAR extend or expand its funding support for the project, or both.

A third challenge was that some project parts appear to get more attention than was warranted, and other parts received less attention than was needed. For example, if we consider the 5 project outcomes that are the central focus of this study, ACIAR Project Documents, Adoption Studies and Final Reports appear to overemphasise the expected and achieved 'Innovations Systems' and 'Science and Knowledge' outcomes and underemphasise (and perhaps under-report) 'Natural Resource Management', 'Policy', and 'Socioeconomic' outcomes. Arguably, the latter 3 outcomes are harder to observe and justify as having resulted from the project than the former 2, but in documentation of 17 of the 77 projects we could not find *any* reporting on *any* of these 3 outcomes, whilst 'Innovations Systems' and 'Science and Knowledge' had been given ample attention. Furthermore, none of these 17 projects was a 'pure' scientific undertaking, such as a literature review, where it might logically be assumed that 'Natural Resource Management', 'Policy', and 'Socioeconomic' would not be outcomes. Because of this possible under-reporting, and, therefore, because of the possible low-quality of project documentation in these projects, we have removed these 17 projects from the database. This left us with 60 projects total.

A fourth challenge, and one that relates to the previous 2, was that some project parts received scant attention in the project documentation, such as: project management by the commissioned partner, which is an issue that is often not touched on, even in project reviews; project management by the national partner; sexual orientation and gender identity (SOGI); and gender issues (both as a condition for project outcomes, as well as an outcome itself). To take the latter as an example, across the 77 projects that have full project documentation, only 20 make meaningful statements about gender issues and how they may relate to achieving project outcomes (this includes project documentation that explains meaningfully why gender issues will likely not affect project outcomes), and the project documentation of only 8 projects provide information on any relevant gender outcomes that have been achieved. Because of this lack of information on some critical conditions and outcomes, we have not been able to include project management, and SOGI and gender issues as outcomes and causal conditions in this study.[9]

These challenges complicated data collection and may explain why the initial QCA analyses carried out on the 60 projects that we were left with after cleaning up the dataset, resulted in logical inconsistencies in the first iterations of the QCA analyses (see Appendix 2). To overcome these inconsistencies, another 11 projects had to be removed from the dataset. Hence, the QCA analyses that are central to Chapters 3 to 7 are drawn from a total of 49 projects. Despite the culling of a large number of projects from the original dataset of 106 projects, the final set of 49 projects comes from all thematic areas of research supported by ACIAR, from all geographical locations supported by ACIAR, and has a representative distribution across the time period covered by the original dataset. In short, we feel confident that the final set of 49 projects is representative of the full dataset of 106 projects that we started with initially.[10]

Ex-post facto use of available data

The data quality challenges experienced were partly a result of our ex-post facto using of available data. The various source documents were not developed and written to be used in *this study*. The set of outcomes and conditions identified and applied here does not necessarily reflect the outcomes and conditions that have historically been the central focus in all research areas and geographical locations of ACIAR-funded research projects over the past 40 years. The data that we required was sometimes readily available in the source documents, while at other times it required some interpretation to make the available data fit the outcomes, causal conditions and qualitative categories that we are using here.

9 With too little overall data on an outcome or condition, a QCA is technically not possible.

10 The critical reader may disagree and argue that in the process of 'cleaning up' we have most likely culled the poorer performing projects from the original dataset of 106 projects. The set of 49 may then be biased towards successful projects. We agree this may be the case, but the central aim of the impact assessment is to understand what elements of the ACIAR model in practice are associated with the most *successful* project outputs and enduring outcomes in different contexts. To achieve this aim, we logically need to look at those projects that have achieved successful project outcomes.

2.6 QCA specific terminology and other technicalities

QCA uses specific language that may be unfamiliar to some readers of this report. In Appendix 2, we provide a detailed explanation of each of the steps taken in the QCA analyses presented in Chapters 3 to 7. Readers interested in all the details and technicalities are recommended to consult that appendix. Here we restrict ourselves to introducing some of the main terminology and technicalities in which QCA differs from other analysis techniques that have not already been touched on in the previous sections.

QCA specific terminology

Within QCA, types of interacting conditions that lead to, or are associated with, an outcome are referred to as 'paths', and a full set of paths that leads to, or is associated with, an outcome is referred to as a 'solution'. In QCA, associations between conditions and outcomes are expressed in terms of necessity and sufficiency. The goal of QCA is to find (configurations of) conditions that are necessary or sufficient for the outcome (Ragin 2008):

- **Necessity** refers to a situation in which the outcome cannot be produced without the condition: if the outcome is present, the condition is present.
- **Sufficiency** refers to a situation in which a condition itself can produce the outcome without the help of other conditions.

To give an example, oxygen is a necessary condition for human life (humans need oxygen to sustain life), but oxygen by itself is not sufficient to sustain life (food and water, for instance, are other necessary conditions).

Parameters of fit

It is rare to find solutions in which all cases conform to an identified relation of necessity or sufficiency. Recall the transport example introduced in Section 2.1. The first hypothetical path that explained the outcome 'get to work on time' consisted of the configuration 'a car *and* enough fuel *and* a road that leads to person X's work *and* no traffic jam on that road'. In practice, it would be unusual that everyone who got to work on time (besides person X, there would be person Y, person Z, etc.) in this example conformed to exactly that path (some may have used public transport, others a bicycle, and so on). Even if they all conformed to this path, there would have been qualitative differences among them (for example, they used different cars, had different amounts of fuel in their cars, used different roads, or faced different levels of congestion).

Thus, we may wonder how strongly a path (or the solution in full) relates to an outcome and how relevant it is to that outcome. Within QCA, there are 2 parameters of fit that allow us to ascertain this:

- **Consistency:** a measure that indicates the degree to which the cases (here, ACIAR-supported projects) that share the same configuration of conditions (a 'path') also share the same outcome. This measure is akin to 'significance' in statistical methods (Thiem 2010).
- **Coverage:** a measure that indicates the prevalence or relevance of a path (its 'empirical importance'). This measure is akin to R-square in statistical methods (Thiem 2010).

Limits to the number of conditions

In this study, we seek to understand both whether and how a set of 8 causal conditions (our 'analytical model' or 'theoretical model') combined in ACIAR-supported projects and achieved the outcomes of interest. Some readers may wonder why we did not include more conditions. As discussed in Section 2.5, the data quality did not allow a focus on some conditions, such as project management and gender, but another reason is that there are limits to the number of conditions that can reasonably be used in a QCA analysis (Schneider and Wagemann 2013). The broader QCA literature recommends keeping the number of included conditions moderate (approximately 5-8). Just as in statistical methods, where too many independent variables will not yield significant results, too many conditions in a QCA analysis result in meaningless findings; the resultant paths would be so complex, they would prove too difficult to interpret (Schneider and Wagemann 2010). For a set of 49 cases, as we have here, 8 conditions are acceptable (Marx 2006).

Counterfactuals

An attractive feature of QCA is that it allows for using counterfactual assumptions in tracing associations between causal conditions and outcomes, and configurations of causal conditions and outcomes. Such counterfactual assumptions may come from the existing literature, from the empirical evidence at hand, or from a combination of these. In this study we only rely on what are known as 'easy counterfactuals'. That is, we only use simplifying assumptions that are in line with the data and existing theoretical knowledge (Schneider and Wagemann 2013).[11]

11 In Chapters 3 to 7 we present what are known as 'intermediate solutions' and use these as the basis for further interpretation of the findings. In the various technical appendixes, we also present the 'complex solutions'. The latter only rely on empirical observations and do not use simplifying assumptions based on counterfactuals.

3 Innovations Systems outcomes

This chapter presents the QCA findings for Innovations Systems outcomes and our interpretation of them. This chapter asks: **How do the conditions of interest combine and is there only one configuration or several configurations of conditions (that is, pathways) towards Innovations Systems outcomes?**

Section 3.1 presents a summary of the full analysis. Sections 3.2 to 3.4 each present a distinct cluster of causal pathways resulting from the analysis and illustrate it with an example from the ACIAR project database.

Section 3.5 draws conclusions. The detailed analytical steps taken are presented in Appendix 2 (for the application of QCA in this report in general) and Appendix 4 (for the Innovations Systems outcome in particular).

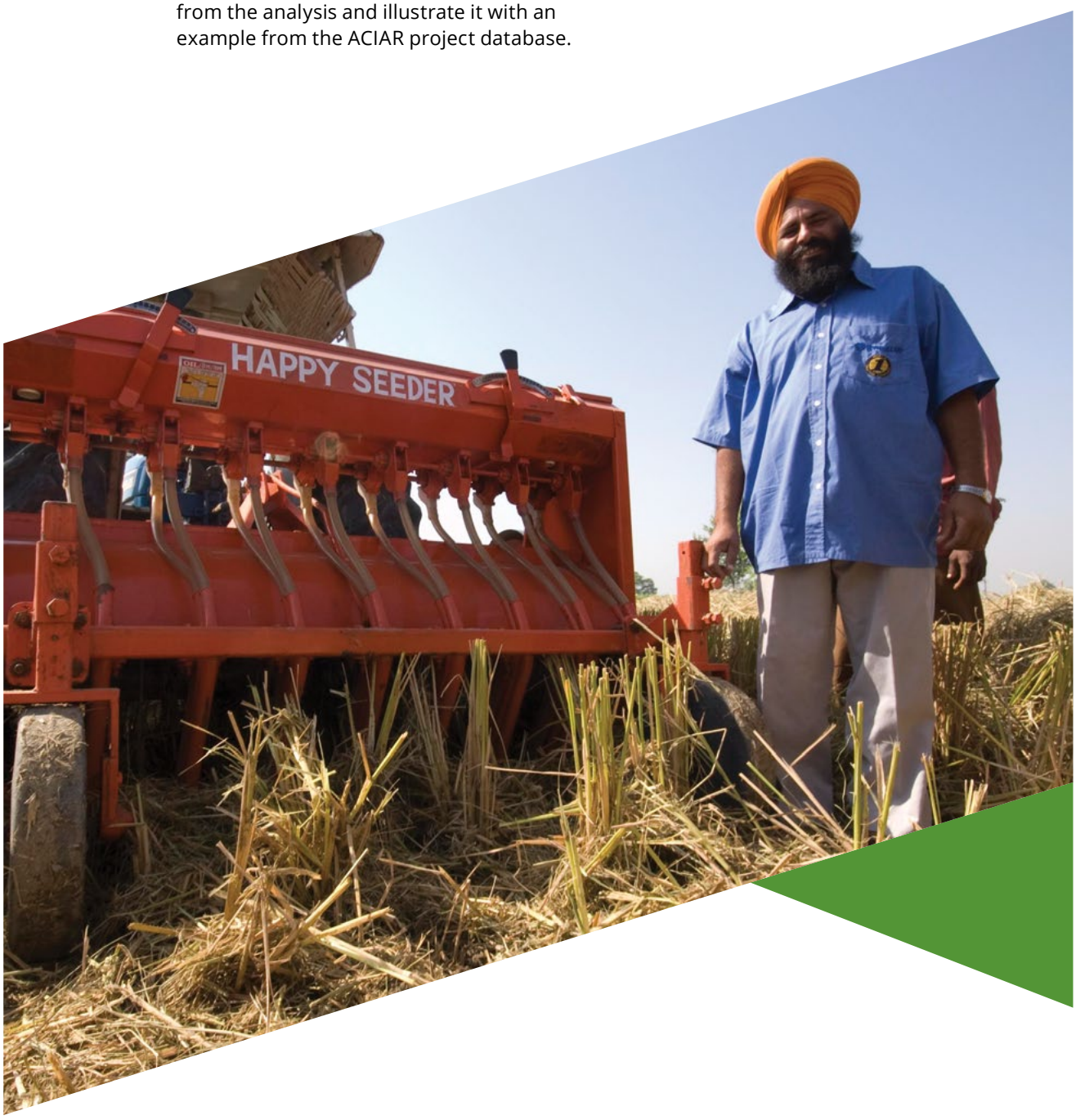


Photo: Melissa Marino

3.1 Full analysis

Innovations Systems were conceptualised as a bounded set of actors (including commissioned partners, national partners, stakeholders, next users and end users), activities, objects or products, institutions and relations that are important for delivering AR4D results. Following the calibration descriptors, we observed strong and moderately strong innovations systems in 37 projects (9 strong and 28 moderately strong), representing 76% of the 49 projects included in the QCA.

The analysis of necessary conditions does not indicate that any of the 8 conditions is necessary for the outcome. In other words, none of the conditions causes the outcome by itself. This indicates that conditions likely interact in their contribution towards the outcome.

The analysis of sufficient conditions confirms this expectation. A total of 7 detailed pathways are identified as being related to the outcome (the 'solution' of the analysis). The solution coverage of this analysis is 0.77. This indicates that a large share of the empirics is explained by the 8 conditions that are the central focus of this study. The solution consistency of this analysis is 0.97. This indicates that the solution is of high empirical importance in reaching the outcome.

Figure 1 illustrates the 7 pathways identified. For example, the first path in this figure (Path #2) indicates that of the projects analysed those that have a strong design quality *and* a strong project transition quality *and* context alignment *and* project continuity *and* a (very) large project size have resulted in strong Innovations Systems outcomes.

Figure 1 groups the 7 pathways identified in 3 broad clusters based on the most common combinations of conditions observed (for this outcome and the other outcomes analysed in this study). Sections 3.2 to 3.4 each discuss one of these clusters.

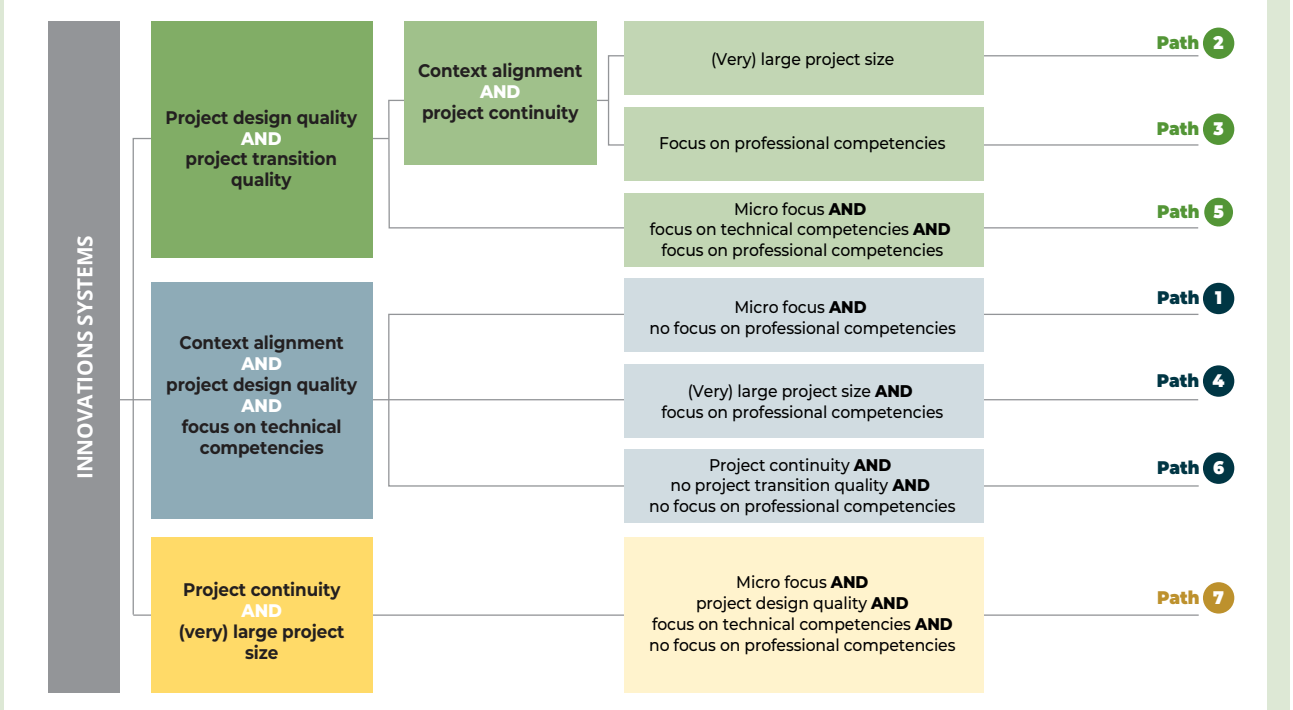


Figure 1 Paths to Innovations Systems outcomes

Notes: The solution presented is the intermediate pathway for the outcome Innovations Systems; the solution coverage is 0.77 and the solution consistency is 0.97.

The word 'no' indicates that the condition is absent in the path.

3.2 Cluster 1: Theory *and* Practice of Change

Three pathways (Path #2, Path #3, and Path #5) group around the combination of 'project design quality' and 'project transition quality'. This cluster covers 15 projects.

There appears to be an inherent logic behind this cluster that confirms the insights from the literature review (see Appendix 1). **It indicates that the combination of a strong project design quality (or a Theory of Change, ToC) and a strong project transition quality (or Practice of Change, PoC) is a promising starting point towards achieving strong Innovations Systems.** In other words, strong project design and good follow-through in practice are required during the implementation of a project. That is not to say that the combination of a strong project design and strong project transition is a guarantee for achieving strong Innovations Systems. The green pathways in Figure 1 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful Innovations Systems outcomes.

Within this cluster, a sub-cluster of 12 projects stands out. These all have the combination of 'context alignment' and 'project continuity'. In other words, these projects are tailored to their geographical location and national partner(s) and relate to earlier ACIAR-supported research projects in the same country and the same agricultural or policy area.

Feeding village poultry in the Solomon Islands (LPS/2003/054)

An ACIAR-supported project from the database that illustrates this cluster well is 'Feeding village poultry in the Solomon Islands' (LPS/2003/054). This project provides a clear exemplar of ToC and PoC in practice. In this case, a combination of a strong project design, a strong transition plan, alignment with the context of work, and the continuation of ACIAR projects led to strong innovations systems outcomes. It is worth noting that the project has achieved good results across the board, with the exception of Natural Resource Management.

The project was twofold in its intervention; first, the team worked on a micro-level with smallholder village farmers, primarily through a partner non-government organisation (NGO), and second, they worked at a macro-level in developing a research facility that shared research from across the Pacific to test diet formulation of poultry feed. The design was facilitated in cooperation with a local NGO, where specific contexts of working were considered alongside a focus on project transition, with the NGO taking on responsibility for activities once the ACIAR project concluded.

The capacity built by this project is significant, with 1,500 farmers trained in preparing poultry diets and the continuation of training once the project had concluded. At the time of the adoption study, the skills acquired through training and the methodology used in the project were still being utilised and uptake across the Solomon Islands was increasing. The project also saw the development of a research facility, but this has been made redundant due to a lack of continued funds for research activities. This project is a strong example of building capacity at a micro-level with ongoing adoption of certain project aspects.

3.3 Cluster 2: Classic AR4D project

Another 3 pathways (Path #1, Path #4, and Path #6) group around the combination of 'context alignment' and 'project design quality' and 'technical competencies'. This cluster covers 15 projects.

Where the logic of the previous cluster can be traced back to the broader AR4D literature, this cluster has its logic explicitly in the available data. **It indicates that a form of 'Classic AR4D project' has proven to be successful towards achieving strong Innovations Systems.** In other words: well-thought-out projects (that is, with strong design quality) that are strongly tailored to their local context and that explicitly focus on increasing technical competencies, including technology, practices, and academic, policy or technical knowledge (that is, delivering tangible results) have proven to be a promising starting point for project support towards strong Innovations Systems. That is not to say that this combination of conditions is a guarantee for achieving strong Innovations Systems. The blue pathways in Figure 1 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful Innovations Systems outcomes.

An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta
(ASEM/1995/119)

Photo: Massimo Munnichi

An ACIAR-supported project from the database that illustrates this cluster well is 'An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta' (ASEM/1995/119). The project used a participatory framework, where partners (including Can Tho University, Vietnam) and end users (including farmers, provincial administrators and researchers) identified priority research issues for the rice-shrimp farming system in the Mekong Delta. The alignment to the context of work was embedded throughout the design, perhaps most evident in a detailed analysis and discussion of specific districts and provinces.

The project leveraged local knowledge systems to understand and then develop the nutritional value of locally available feeds. A clear capacity-building strategy was developed through a 'whole farm model' (a farming-systems approach). The strategy incorporated and investigated interactions between physical, environmental and economic factors. It sought to understand the strengths of the project partners and to highlight areas that would be developed during the project, from the research level to the policy level.

At the time of the adoption study, the community capacity had significantly increased, and farmers trained through the project were continuing to train other farmers in shrimp husbandry. The research scientists continue to use technical skills they learned whilst participating in the project to identify the presence of the 'white spot virus' and reduce its impact (the white spot syndrome is a highly contagious and highly lethal viral infection in shrimp). The innovations systems were advanced at the individual level (for example, researchers), the project level and the community level. The project led to the awarding of 2 ACIAR John Allwright Fellowships and to the development of individual researchers, with 2 PhDs and 3 Masters being awarded.

3.4 Cluster 3: Scaling out

The remaining pathway (Path #7) is part of a cluster that recurs across the solutions for the various outcomes analysed in this study. It groups around the combination of 'project continuity' and 'project size'. Here, it covers 3 projects.

The logic of this cluster comes from both the broader AR4D literature (see Appendix 1) and the available data. **It indicates that 'scaling out' is a promising strategy towards achieving strong Innovations Systems.** Scaling out is understood here as a process where, for example, interventions (or parts thereof), knowledge, and practices from one context are replicated in, or disseminated to, another context, or are expanded within the original context (Schut et al. 2020). However, Path #7 indicates that this combination of project continuity with project size is by no means a guarantee for achieving strong Innovations Systems. The yellow pathway in Figure 1 indicates that this combination of conditions always combines with other conditions in complex pathways towards successful Innovations Systems outcomes.

Value-adding to PNG agroforestry systems
(FST/2004/050)

An ACIAR-supported project from the database that illustrates this cluster well is 'Value-adding to PNG agroforestry systems' (FST/2004/050). The project partnered with the Papua New Guinea Forest Authority Institute and worked closely with smallholder foresters (i.e. it had a focus on the micro-level). The project was designed to capitalise on and develop partnerships with key non-government actors with established tree-growing activities in particular target regions of Papua New Guinea. Whilst the project was not a direct continuation of an ACIAR project, it was closely related to, and built upon, the research of several past ACIAR projects with the same research partners. The project was in the higher size threshold, with a high design quality and a focus on technical and professional competencies.

The project documentation indicated a strong project design quality, evidenced by, among others, a strong methodology and implementation plan, which included a scoping study that aided in identifying potential challenges up-front. The project documentation indicated that the innovation system was developed and expanded by this project, although at the time of the adoption study this primarily impacted communities and organisations who had participated in the project, rather than new communities and organisations. The project worked with other ACIAR-supported projects to produce the 'Three Growers Tool Kit', a platform for information sharing and learning. As a result of the project, the livelihoods of farmers and other community members have been improved by a greater and more diverse stream of income.

At the institutional level, the project strengthened the capacity of the Department of Forestry at the Papua New Guinea University of Technology, allowing them to offer a postgraduate program and to engage in partnership research projects. At the smallholder level, capacity development has raised awareness and developed skills relevant to tree growing, including seedling and clonal production, in 200 Upper Markham communities of Marawasa, Ragigumpuan and Wangkung.

3.5 Conclusion

This chapter has presented the main insights from the QCA findings for Innovations Systems outcomes and our interpretation of them. We observed strong and moderately strong Innovations Systems outcomes in most of the projects included in the QCA (37 projects, 76%).

None of the conditions were found to be necessary for the outcome, and the analysis of sufficiency indicated 7 detailed pathways towards it. These pathways can be grouped in 3 broad clusters that have their logic in both the broader AR4D literature and the available data. The clusters indicate that the following combinations of conditions are promising starting points towards achieving strong Innovations Systems:

- a theory of change (ToC) joined with a practice of change (PoC)
- classic AR4D project – supporting projects that are strongly tailored to their context, have a strong design quality, and explicitly focus on increasing technical competencies
- the scaling out of projects, either by expanding existing projects at a larger scale in the original context, or by transposing them (fully or partially) to novel contexts.

4 Science and Knowledge outcomes

This chapter presents the QCA findings for Science and Knowledge outcomes and our interpretation of them. This chapter asks: **How do the conditions of interest combine and is there only one configuration or several configurations of conditions (that is, pathways) towards Science and Knowledge outcomes?**

Section 4.1 presents a summary of the full analysis. Sections 4.2 to 4.6 each present a distinct cluster of causal pathways resulting from the analysis and illustrate it with an example from the ACIAR project database.

Section 4.7 draws conclusions. The detailed analytical steps taken are presented in Appendix 2 (for the application of QCA in this report in general) and Appendix 5 (for the Science and Knowledge outcome in particular).

Readers may notice some overlap with the previous chapter. This is a result of similarities in the pathways observed for the different outcomes that are the central focus of this study.

Photo: Conor Ashleigh

4.1 Full analysis

Science and Knowledge were conceptualised as the extent to which the ACIAR-supported project has contributed to the development of (i) scientific knowledge, (ii) high-quality practical knowledge that can be applied in context or (iii) a combination of these. A strong science and knowledge outcome is, for example, the combination of several articles published in English language peer-reviewed academic journals *and* several training manuals, handbooks, or technical guides that translate project findings for application in the local context. Following the calibration descriptors, we observed strong and moderately strong Science and Knowledge outcomes in 37 projects (19 strong and 18 moderately strong), representing 76% of the 49 projects included in the QCA.

The analysis of necessary conditions does not indicate that any of the 8 conditions is necessary for the outcome. In other words, none of the conditions causes the outcome by itself. This indicates that conditions likely interact in their contribution towards the outcome.

The analysis of sufficient conditions confirms this expectation. A total of 8 detailed pathways are identified as being related to the outcome (the 'solution' of the analysis). The solution coverage of this analysis is 0.73. This indicates that a large share of the empirics is explained by the 8 conditions that are the central focus of this study. The solution consistency of this analysis is 0.91. This indicates that the solution is of high empirical importance in reaching the outcome.

Figure 2 illustrates the 8 pathways identified. For example, the first path in this figure (Path #13) indicates that of the projects analysed those that have a strong design quality and a strong project transition quality *and* context alignment *and* project continuity *and* a macro focus and a (very) large project size have resulted in strong Science and Knowledge outcomes.

Figure 2 groups the 8 pathways in 5 broad clusters based on the most common combinations of conditions observed (for this outcome and the outcomes analysed in this study). Sections 4.2 to 4.6 each discuss one of these clusters.

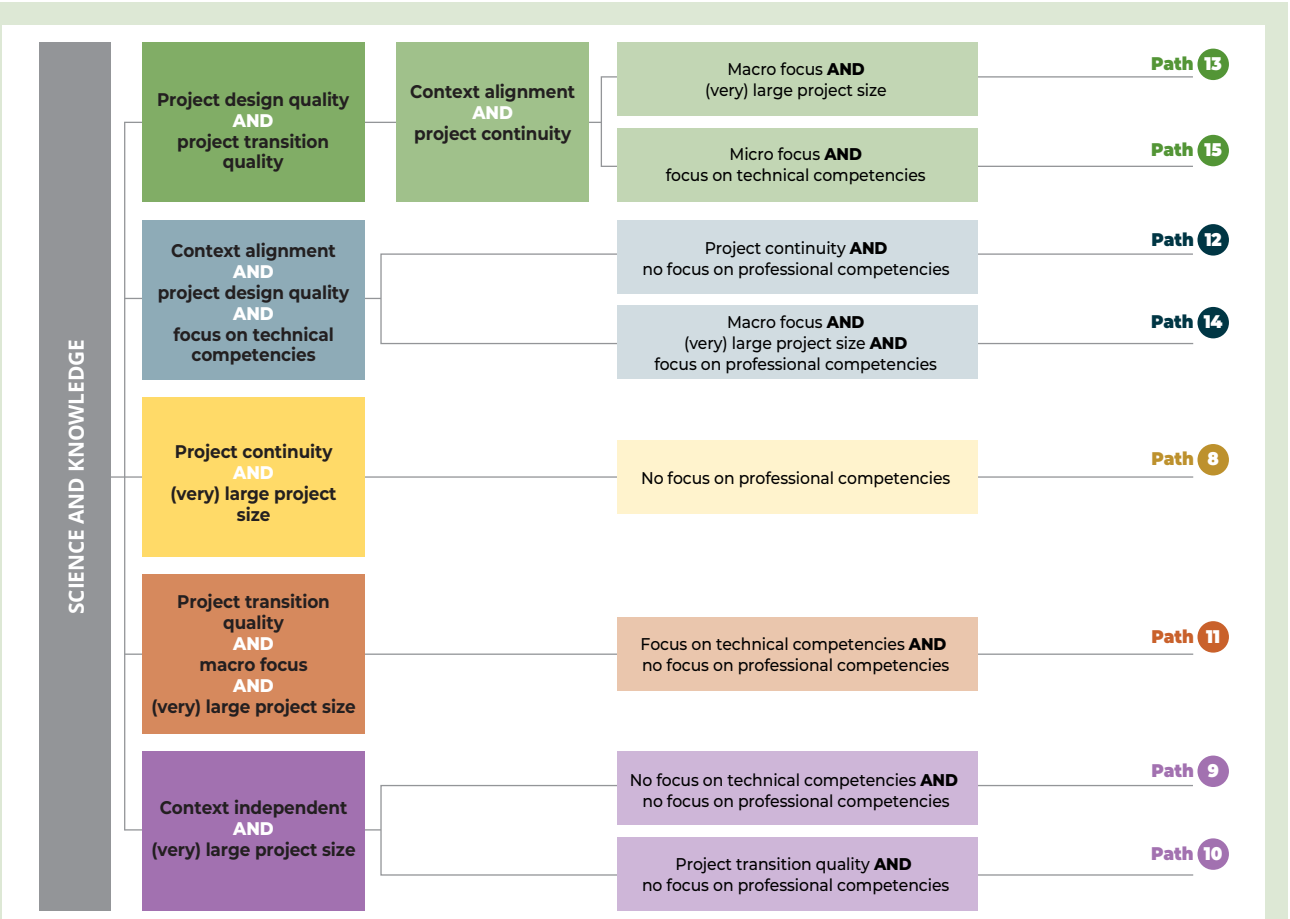


Figure 2 Paths to Science and Knowledge outcomes

Notes: The solution presented is the intermediate pathway for the outcome Science and Knowledge; the solution coverage is 0.73 and the solution consistency is 0.91.

The word 'no' indicates that the condition is absent in the path.

4.2 Cluster 1: Theory *and* Practice of Change

Two pathways (Path #13 and Path #15) group around the combination of 'project design quality' and 'project transition quality'. This cluster covers 8 projects.

There appears to be an inherent logic behind this cluster that confirms the insights from the literature review (see Appendix 1). **It indicates that the combination of a strong project design quality (or a theory of change, ToC) and a strong project transition quality (or practice of change, PoC) is a promising starting point towards achieving strong Science and Knowledge results.** In other words, strong project design and good follow-through in practice are required during the implementation of a project. That is not to say that the combination of a strong project design and strong project transition is a guarantee for achieving strong Science and Knowledge outcomes. The green pathways in Figure 2 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful Science and Knowledge outcomes.

Within this cluster, we observed the same sub-cluster as discussed in the previous chapter: the combination of 'context alignment' and 'project continuity'. In other words, these projects are tailored to their context, area, and national partner(s), and relate to earlier ACIAR-supported research projects in the same country and the same agricultural or policy area.

Increased productivity and reduced risk in pig production and market chains. Component 2: animal production
(AH/2010/019)

An ACIAR-supported project from the database that illustrates this cluster well is 'Increased productivity and reduced risk in pig production and market chains. Component 2: animal production' (AH/2010/019). The project has achieved strong science and knowledge outcomes, combines a high-quality project design with a high-quality project transition, and has strong context alignment and strong project continuity. This project was the last in a series that used One-Health principles to address persistent animal health and biosecurity problems in pig production in Laos, with the aim of increasing smallholder-based pig value in order to provide stable and reliable income to smallholder families.

The project had a targeted design, established clear aims around disease and market risk management, and had a logical set of activities that responded to these aims. Within the project design and throughout the project implementation, there was a strong focus on the transition of produced knowledge. A strong link was forged with decision-makers, an alliance that included stakeholders and next users was formed, and there was an emphasis placed on activities of dissemination. The project included and engaged NGOs, large development agencies, extension officers and communities.

The combination of quality design and quality transition in tandem with strong context alignment and project continuity resulted in this project producing rigorous science in international journals and local-language manuals. The project produced relevant options of high value for Lao communities on the basis of good science. However, due to shifts in consumer markets, it was not found to have strong outcomes in other areas.

4.3 Cluster 2: Classic AR4D project

Another 2 pathways (Path #12 and Path #14) group around the combination of 'context alignment' and 'project design quality' and 'technical competencies'. This cluster covers 10 projects.

Whilst the logic of the previous cluster can be traced back to the broader AR4D literature, this cluster has its logic explicitly in the available data. **It indicates that a form of 'classic AR4D project' has proven to be successful towards achieving strong Science and Knowledge results.** In other words: well-thought-out projects (that is, with strong design quality) that are strongly tailored to their local context and that explicitly focus on increasing technical competencies, including technology, practices, and academic, policy or technical knowledge (that is, delivering tangible results), have proven to be a promising starting point for project support towards strong Science and Knowledge results. That is not to say that this combination of conditions is a guarantee for achieving strong Science and Knowledge outcomes. The blue pathways in Figure 2 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful Science and Knowledge outcomes.

More efficient breeding of drought resistant peanuts in India and Australia
(CS1/1997/114)

An ACIAR-supported project from the database that illustrates this cluster well is 'More efficient breeding of drought resistant peanuts in India and Australia' (CS1/1997/114) . This project implemented an upstream science research approach to the major constraints associated with drought to peanut productivity in dryland areas of India and Australia. The project responded to the research priorities of both the Indian government and the project partner, which were to stabilise peanut yields in dryland areas and tailor the approach to the project context.

Built on 10 years of previous ACIAR research, the project focused on breeding drought-resistant peanut varieties through the identification of genetic traits, the development of rapid and low-cost tools and the application of the genetic traits in a targeted breeding program. It had a clear aim and targeted activities, and worked with immediate next users in the production and translation of knowledge.

The project had a strong focus on building technical capacities in the project team, establishing drought research facilities at collaborating centres and enhancing the research skills and expertise of collaborating scientists through training programs and applied research. This project achieved strong science and knowledge outcomes, publishing over 50 peer-reviewed journal articles in international journals.

4.4 Cluster 3: Scaling out

A single pathway (Path #8) is part of a cluster that recurs across the solutions for the various outcomes analysed in this study. It groups around the combination of 'project continuity' and 'project size'. Here, it covers 11 projects.

The logic of this cluster comes from both the broader AR4D literature (see Appendix 1) and the available data. **It indicates that 'scaling out' is a promising strategy towards achieving strong Science and Knowledge results.** Scaling out (sometimes referred to as 'horizontal scaling') is understood here as a process where, for example, interventions (and parts thereof), knowledge, and practices, are replicated in, or disseminated from, one context to another, or are expanded within the original context (Schut et al. 2020). However, Path #8 indicates that this combination of project continuity with project size is by no means a guarantee for achieving strong Science and Knowledge outcomes. The yellow pathway in Figure 2 indicates that this combination of conditions always combines with other conditions in complex pathways towards successful Science and Knowledge outcomes.

Biological control of *Chromolaena odorata* in PNG (CP/1996/091)

Photo: Conor Ashleigh

An ACIAR-supported project from the database that illustrates this cluster well is 'Biological control of *Chromolaena odorata* in PNG' (CP/1996/091). This project researched and implemented biological control agents to control an invasive weed species that was significantly impacting smallholder subsistence farm and plantation productivity in Papua New Guinea.

This large project was the continuation of ACIAR-supported work started in Indonesia and the Philippines in the early 1990s before it was eventually scaled out to include Papua New Guinea. It involved the close engagement of national governmental scientists, local provincial officers and smallholder communities. The main technical output of the project was the successful control of the invasive weed, leading to the production of a local-language manual, numerous peer-reviewed papers in international journals, and presentations at international workshops and conferences to the wider scientific community.

The project also achieved strong Innovations Systems outcomes, Socioeconomic outcomes and Natural Resource Management outcomes as a result of its scientific achievements. The successful control of the weed resulted in a reduction in burning, reduced labour and costs associated with weed control, and increased biodiversity.

4.5 Cluster 4: Scaling up

A single pathway (Path #11) is part of a cluster that recurs across the solutions for the various outcomes analysed in this study. It groups around the combination of 'project transition quality' and 'project size' and 'macro focus'. Here, it covers 7 projects.

The logic of this cluster comes from both the broader AR4D literature (see Appendix 1) and the available data. **It indicates that 'scaling up' is a promising strategy towards achieving strong Science and Knowledge results.** Scaling up (sometimes referred to as 'vertical scaling') is understood here as a process where, for example, interventions (and parts thereof), knowledge and practices are being embedded in formal administrative processes, policy or practice, or are being taken up at higher levels of practice (for example, from village to region to country). In other words, the project affects or impacts laws, policies or formal practices at the level of project development or intervention, or possibly at an even higher level (Schut et al. 2020). However, Path #11 indicates that this combination of project transition quality, macro focus and project size is by no means a guarantee for achieving strong Science and Knowledge outcomes. The orange pathway in Figure 2 indicates that this combination of conditions always combines with other conditions in complex pathways towards successful Science and Knowledge outcomes.

Increasing crop production through biological control of soil-borne root diseases
(LWR2/1996/080)

An ACIAR-supported project from the database that illustrates this cluster well is 'Increasing crop production through biological control of soil-borne root diseases' (LWR2/1996/080). This project achieved strong Science and Knowledge outcomes and strong Natural Resource Management outcomes through the evaluation of biological control agents for soil-borne diseases and for 'scaling up' the initial project through commercialisation.

The project addressed serious issues in crop productivity in China and Australia due to root-disease-induced yield losses, and targeted wheat, vegetable (tomato, cucumber, pepper) and cotton crops. The project took a macro-focus approach, evaluating a selection of Australian and Chinese bacteria for effective and reliable control of soil-borne root diseases. It worked closely with a range of stakeholders, including scientists, students, NGO partners and the Chinese and Australian private sectors, to formalise the knowledge produced throughout the project on biocontrol inoculants by enabling the development of a commercial product for farmers to use.

The project also involved a substantial amount of international exchanges and training in molecular genetic techniques and the practical application of microbial work, resulting in the building of technical competencies across collaborating scientists and students.

4.6 Cluster 5: Pure or basic science

The remaining 2 pathways (Path #9 and Path#10) group around the combination of 'context independence' and 'project size'. This cluster covers 7 projects.

This cluster has its logic explicitly in the available data. The source material indicates that most projects in this cluster have an explicit 'pure or basic science' orientation. Thus, the clustering that we observe may be more a result of the types of projects that it clusters (more 'science oriented' than 'development oriented') than the set of conditions. Nevertheless, **the cluster indicates that supporting projects that aim for pure or basic science is a promising strategy towards achieving strong Science and Knowledge results.** The apparent logic for the specific set of conditions that cluster here is that 'pure or basic science' programs may pursue context independency (to increase the generalizability of findings), and that larger or longer-term projects stand a better chance of achieving desirable Science and Knowledge outcomes. However, this combination of context independence with project size is by no means a guarantee for achieving strong Science and Knowledge outcomes. The purple pathways in Figure 2 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful Science and Knowledge outcomes.

Managing the rumen ecosystem to improve utilisation of thornless acacias
(AS1/1998/010)

An ACIAR-supported project from the database that illustrates this cluster well is 'Managing the rumen ecosystem to improve utilisation of thornless acacias' (AS1/1998/010). This project used a global comparative approach across Ethiopia, South Africa and Indonesia to develop new scientific knowledge on the use and management systems of thornless acacias as a fodder tree. The ultimate aim of this project was to provide management systems for the widespread use of thornless acacias to increase ruminant productivity for smallholder farmers in sub-Saharan Africa and south-east Asia.

The project produced significant scientific knowledge, evidenced by the significant number of published peer-reviewed international journal papers, resulting in strong Science and Knowledge outcomes. However, a project-specific Impact Evaluation found the project had not resulted in practical outcomes for smallholders or Innovations Systems, Natural Resource Management, Policy or Socioeconomic outcomes. The project relied on existing networks to communicate findings and concluded there was further need for investigation into the toxicity of the thornless acacia.

4.7 Conclusion

This chapter has presented the main insights from the QCA findings for Science and Knowledge outcomes and our interpretation of them. We observed strong and moderately strong science and knowledge outcomes in most of the projects included in the QCA (37 projects, 76%).

None of the conditions were found to be necessary for the outcome, and the analysis of sufficiency indicated 8 detailed pathways towards it. These pathways can be grouped in 5 broad clusters that have their logic in both the broader AR4D literature and the available data. The clusters indicate that the following combinations of conditions are promising starting points towards achieving strong Science and Knowledge outcomes:

- a theory of change (ToC) joined with a practice of change (PoC)
- classic AR4D project – supporting projects that are strongly tailored to their context, have a strong design quality, and explicitly focus on increasing technical competencies
- the scaling out of projects, either by expanding existing projects at a larger scale in the original context, or by transposing them (fully or partially) to novel contexts
- the scaling up of projects, mainly by embedding project results in law, policy, or formalised practice at the level of the project or a higher level
- large, context-independent projects ('pure or basic science' projects).

5 Natural Resource Management outcomes

This chapter presents the QCA findings for Natural Resource Management (NRM) outcomes and our interpretation of them. This chapter asks: **How do the conditions of interest combine and is there only one configuration or several configurations of conditions (that is, pathways) towards NRM outcomes?**

Section 5.1 presents a summary of the full analysis. Sections 5.2 to 5.4 each present a distinct cluster of causal pathways resulting from the analysis and illustrate this with an example from the ACIAR project database. Section 5.5 draws conclusions.

The detailed analytical steps taken are presented in Appendix 2 (for the application of QCA in this report in general) and Appendix 6 (for the NRM outcome in particular).

Readers may notice some overlap with the previous chapters. This is a result of similarities in the pathways observed for the different outcomes that are the central focus of this study.

Photo: Peter Lowe

5.1 Full analysis

NRM outcomes were conceptualised as the extent to which an ACIAR-supported project has contributed to enduring positive natural resource impacts. A strong NRM outcome is, for example, the proven institutionalisation of sustainable and equitable practices and management of common natural resources, such as groundwater systems, salinity management, or biodiversity *and* proven increased ecological resilience, such as restored ecosystem biodiversity (for example, increased soil carbon), or rehabilitated ecosystems (for example, coral reef systems or wetlands). Following the calibration descriptors, we observed strong and moderately strong NRM outcomes in 24 projects (7 strong and 17 moderately strong), representing 49% of the 49 projects included in the QCA.

The analysis of necessary conditions does not indicate that any of the 8 conditions is necessary for the outcome. In other words, none of the conditions causes the outcome by itself. This indicates that conditions likely interact in their contribution towards the outcome.

The analysis of sufficient conditions confirms this expectation. A total of 6 detailed pathways are identified as being related to the outcome (the 'solution' of the analysis). The solution coverage of this analysis is 0.67. This indicates that a substantial share of the empirics is explained by the 8 conditions that are the central focus of this study. Still, the solution leaves 12 projects unexplained, which indicates that our set of 8 conditions may be too limited to understand the full picture of how ACIAR projects contribute to NRM outcomes (see also Appendix 6). The solution consistency of this analysis is 0.97. This indicates that the solution is of high empirical importance in reaching the outcome.

Figure 3 illustrates the 6 pathways identified. For example, the first path in this figure (Path #20) indicates that of the projects analysed those that have a strong design quality *and* a strong project transition quality *and* a micro focus *and* a (very) large project size *and* a focus on both technical *and* professional competencies have resulted in strong NRM outcomes.

Figure 3 groups the pathways identified into 3 broad clusters based on the most common combinations of conditions observed (for this outcome and the outcomes analysed in this study). Sections 5.2 to 5.4 each discuss one of these clusters.

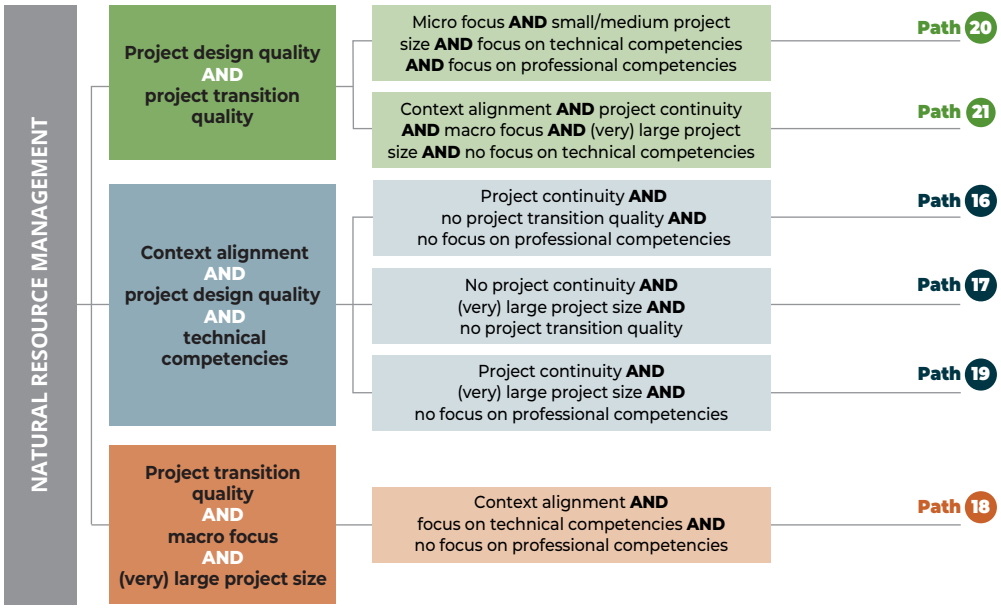


Figure 3 Paths to Natural Resource Management outcomes

Notes: The solution presented is the intermediate pathway for the outcome NRM or Policy (see Appendix 6); the solution coverage is 0.67 and the solution consistency is 0.97.

The word 'no' indicates that the condition is absent in the path.

5.2 Cluster 1: Theory *and* Practice of Change

Two pathways (Path #20 and Path #21) group around the combination of 'project design quality' and 'project transition quality'. This cluster covers 4 projects.

There appears to be an inherent logic behind this cluster that confirms the insights from the literature review (see Appendix 1). **It indicates that the combination of a strong project design quality (or a theory of change, ToC), and a strong project transition quality (or practice of change, PoC) is a promising starting point towards achieving strong NRM results.** In other words, strong project design and good follow-through in practice are required during the implementation of a project. That is not to say that the combination of a strong project design and strong project transition is a guarantee for achieving NRM outcomes. The green pathways in Figure 3 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful NRM outcomes.

Utilising basic soil data for the sustainable management of upland soils in Vietnam and Australia (SMCN/2002/085)

Photo: Conor Ashleigh

An ACIAR-supported project from the database that illustrates this cluster well is 'Utilising basic soil data for the sustainable management of upland soils in Vietnam and Australia' (SMCN/2002/085). Addressing soil degradation in tropical upland areas of Vietnam, this project aimed to translate soil data into management strategies and decision support frameworks appropriate for long-term productivity and sustainability of soils.

The project approached the research with clear objectives and worked at both community and government levels. The frameworks and management strategies developed were disseminated with deliberate and effective strategies to a wide range of next users. They worked extensively with communities through champion farmers and local NGOs and extension officers, and scaled out further by linking to World Vision development projects.

Due to clear design and strategic transition activities, the project resulted in the adoption of management practices, contributing to the resilience and productivity of tropical upland soils.

5.3 Cluster 2: Classic AR4D project

Another 3 pathways (Path #16, Path #17, and Path #19) group around the combination of 'context alignment' and 'project design quality' and 'technical competencies'. This cluster covers 6 projects.

Where the logic of the previous cluster can be traced back to the broader AR4D literature, this cluster has its logic explicitly in the available data. **It indicates that a form of 'classic AR4D project' has proven to be successful towards achieving strong NRM results.** In other words: well-thought-out projects (that is, with strong design quality) that are strongly tailored to their local context and that explicitly focus on increasing technical competencies, including technology, practices, and academic, policy or technical knowledge (that is, delivering tangible results), have proven to be a promising starting point for project support towards strong NRM results. That is not to say that this combination of conditions is a guarantee for achieving strong NRM outcomes. The blue pathways in Figure 3 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful NRM outcomes.

Impacts of fire and its use for sustainable land and forest management in Indonesia and northern Australia
(FST/2000/001)

An ACIAR-supported project from the database that illustrates this cluster well is 'Impacts of fire and its use for sustainable land and forest management in Indonesia and northern Australia' (FST/2000/001). This project aimed to explore ways in which effective fire management activities could be implemented to economically benefit impoverished rural communities living in the tropical forest and peatland areas of western Indonesia.

The project had a strong design, focusing on identifying fire patterns, reviewing policy frameworks, assessing the impact of fire management strategies and enhancing the technical management capacity of stakeholders within the system. The development of effective partnerships was a key outcome of the project. The project built collaborative and supportive partnerships, which ensured strong context alignment across various levels of government (provincial, regional, local), local communities, NGOs and research institutions. Utilising the strong partnerships formed, extensive training of management authorities and communities in technical fire management was a core activity throughout the project at regional and local levels.

The combination of quality design, context alignment, the building up of technical competencies, a large project size and project continuity resulted in this project achieving strong outcomes across Natural Resource Management, Science and Knowledge, and Policy Outcomes, all of which contributed to the reduction of destructive fires in western Indonesia.

5.4 Cluster 3: Scaling up

A single pathway (Path #18) is part of a cluster that recurs across the solutions for the various outcomes analysed in this study. It groups around the combination of 'project transition quality' and 'project size' and 'macro focus'. Here, it covers 3 projects.

The logic of this cluster comes from both the broader AR4D literature (see Appendix 1) and the available data. **It indicates that 'scaling up' is a promising strategy towards achieving NRM results.** Scaling up (sometimes referred to as 'vertical scaling') is understood here as a process where, for example, interventions (and parts thereof), knowledge and practices are being embedded in formal administrative processes, policy or practice, or are being taken up at higher levels of practice (for example, from village to region to country). In other words, the project affects or impacts laws, policies or formal practices at the level of project development or intervention, or possibly at an even higher level (Schut et al. 2020). However, Path #18 indicates that this combination of project transition quality, macro focus and project size is by no means a guarantee for achieving strong NRM outcomes. The orange pathway in Figure 3 indicates that this combination of conditions always combines with other conditions in complex pathways towards successful NRM outcomes.

Improving feed sustainability for marine aquaculture in Vietnam and Australia
(FIS/2006/141)

Photo: Khanh Long

An ACIAR-supported project from the database that illustrates this cluster well is 'Improving feed sustainability for marine aquaculture in Vietnam and Australia' (FIS/2006/141). This large project was the final in a series focusing on improving the environmental sustainability of marine aquaculture feed through reducing the use of 'trash fish'.

The project built on earlier initiatives and worked with Vietnamese research institutions, relevant government agencies and the commercial aquafeed industry to consolidate lessons learned and focused on knowledge transfer to 'scale-up' more sustainable, quality aquaculture feed. The project established an ongoing network of next users, with the aim of increased collaboration between industry, government and research in this area at an institutional level.

The project resulted in the transfer of research outputs to commercial partners and the production of manufactured feed for 5 key marine aquaculture species, without the use of low-value fish. This resulted in strong Science and Knowledge outcomes, as well as strong outcomes in the categories Innovations Systems and Natural Resource Management. The project helped to ease pressure on wild fish stocks and reduced localised pollution and degradation of water quality.

5.5 Conclusion

This chapter has presented the main insights from the QCA findings for NRM outcomes and our interpretation of them. We observed strong and moderately strong NRM outcomes in approximately half of the projects included in the QCA (24 projects, 49%).

None of the conditions were found to be necessary for the outcome, and the analysis of sufficiency indicated 6 detailed pathways towards it. These pathways can be grouped in 3 broad clusters that have their logic in both the broader AR4D literature and the available data. The clusters indicate that the following combinations of conditions are promising starting points towards achieving strong NRM outcomes:

- a theory of change (ToC) joined with a practice of change (PoC)
- classic AR4D project – supporting projects that are strongly tailored to their context, have a strong design quality, and explicitly focus on increasing technical competencies
- the scaling up of projects, mainly by embedding project results in law, policy, or formalised practice at the level of the project or a higher level.

6 Policy outcomes

This chapter presents the QCA findings for Policy outcomes and our interpretation of them. This chapter asks: **How do the conditions of interest combine and is there only one configuration or several configurations of conditions (that is, pathways) towards Policy outcomes?**

Section 6.1 presents a summary of the full analysis. Sections 6.2 to 6.4 each present a distinct causal cluster resulting from the analysis and illustrate this with an example from the ACIAR project database. Section 6.5 draws conclusions.

The detailed analytical steps taken are presented in Appendix 2 (for the application of QCA in this report in general) and Appendix 6 (for the Policy outcome in particular).

Readers may notice some overlap with the previous chapters. This is a result of similarities in the pathways observed for the different outcomes that are the central focus of this study.[12]

Photo: Massimo Munnichi

12 The close reader may observe that there is extensive overlap between Chapters 4 and 5. We explain this in Appendix 6.

6.1 Full analysis

Policy outcomes were conceptualised as the extent to which an ACIAR-supported project has contributed to policy impacts. A strong Policy outcome is, for example, the implementation of a policy that explicitly draws on the project *and* proven involvement of policymakers in the project, for example, as participants in workshops or as sounding boards (that is, peer reviewers) through correspondence. Following the calibration descriptors, we observed strong and moderately strong Policy outcomes in 19 projects (5 strong and 14 moderately strong), representing 39% of the 49 projects included in the QCA.

The analysis of necessary conditions does not indicate that any of the 8 conditions is necessary for the outcome. In other words, none of the conditions causes the outcome by itself. This indicates that conditions likely interact in their contribution towards the outcome.

The analysis of sufficient conditions confirms this expectation. A total of 6 detailed pathways are identified as being related to the outcome (the 'solution' of the analysis). The solution coverage of this analysis is 0.67. This indicates that a substantial share of the empirics is explained by the 8 conditions that are the central focus of this study.

Still, the solution leaves 7 projects unexplained, which indicates that our set of 8 conditions may be too limited to understand the full picture of how ACIAR projects contribute to Policy outcomes (see also Appendix 6). The solution consistency of this analysis is 0.97. This indicates that the solution is of high empirical importance in reaching the outcome.

Figure 4 illustrates the 6 pathways identified. For example, the first path in this figure (Path #20) indicates that of the projects analysed those that have a strong design quality *and* a strong project transition quality *and* a micro focus *and* a (very) large project size *and* a focus on both technical *and* professional competencies have resulted in strong Policy outcomes.

Figure 4 groups the pathways identified into 3 broad clusters based on the most common combinations of conditions observed (for this outcome and the outcomes analysed in this study). Sections 6.2 to 6.4 each discuss one of these clusters.

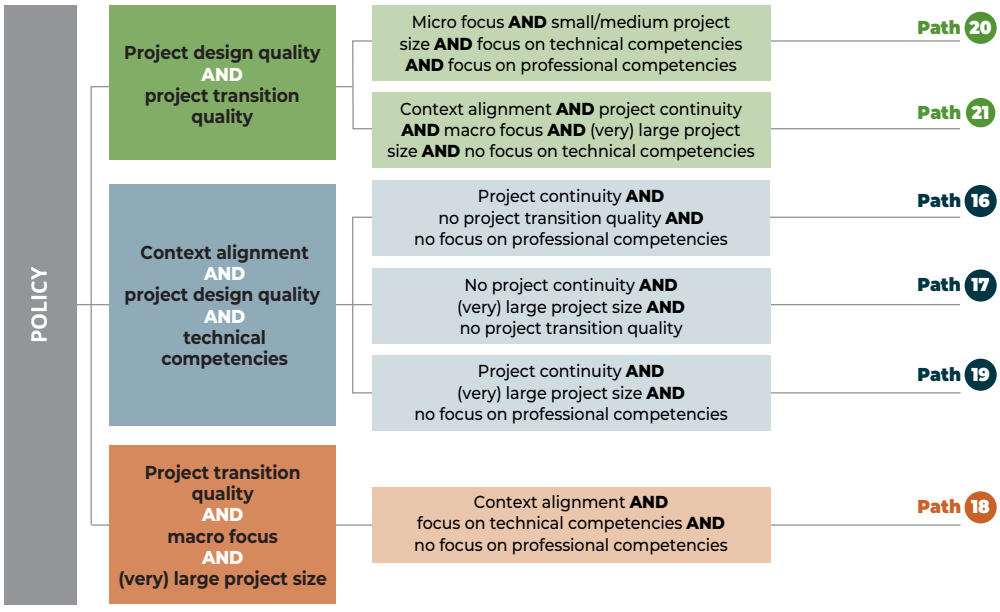


Figure 4 Paths to Policy outcomes

Notes: The solution presented is the intermediate pathway for the outcome NRM or Policy (see Appendix 6); the solution coverage is 0.67 and the solution consistency is 0.97.

The word 'no' indicates that the condition is absent in the path.

6.2 Cluster 1: Theory *and* Practice of Change

Two pathways (Path #20 and Path #21) group around the combination of 'project design quality' and 'project transition quality'. This cluster covers 3 projects.

There appears to be an inherent logic behind this cluster that confirms the insights from the literature review (see Appendix 1). **It indicates that the combination of a strong project design quality (or a theory of change, ToC) and a strong project transition quality (or practice of change, PoC) is a promising starting point towards achieving strong Policy results.** In other words, strong project design and good follow-through in practice are required during the implementation of a project. That is not to say that the combination of a strong project design and strong project transition is a guarantee for achieving strong Policy outcomes. The green pathways in Figure 4 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful Policy outcomes.

Sustaining and growing Landcare systems in the Philippines and Australia
(ASEM/2002/051)

Photo: Jeoffrey Maitem

An ACIAR-supported project from the database that illustrates this cluster well is 'Sustaining and growing Landcare systems in the Philippines and Australia' (ASEM/2002/051). It is a prime example of a project with positive policy outcomes, and it has also performed exceptionally well in the other outcome categories that are the central focus of this study. The project was funded jointly by ACIAR and AusAID and was designed in direct collaboration with Filipino counterparts. The project helped to expand and improve the work of the Landcare Foundation of the Philippines Inc.

The project used a Sustainable Livelihoods framework with a Participatory Action Research methodology, whereby project personnel were directly involved in planning and implementing aspects of the program in partnership with farmer groups and institutions. The project prioritised ongoing sustainability of the Landcare agency and project with a strong alignment to the context of the work. A detailed understanding of the working environments and policies, from a grassroots level through to local and federal government levels, was evident. This project was a direct transition from a previous ACIAR project that piloted the Landcare approach to agricultural development.

Overall, the project was focused on setting up institutional systems to manage the Landcare system in the Philippines and set up a new government agency to do this. A multitude of policy outcomes resulted, including the integration of Landcare into multiple institutional landscapes. The municipalities of Calveria, Lantapan, Ned and Pilar Abohol all continued the implementation of the project through the integration of the project into local and regional government agencies. Support for the project ranged from dedicated staff and funding allocation to prioritising capacity building in farmers, from investment in extension officers to the creation of a special MENRO (Municipal Environment and Natural Resources) office that included staff to oversee the implementation of the Landcare policy, as well as the promotion of environmental programs.

6.3 Cluster 2: Classic AR4D project

Another 3 pathways (Path #16, Path #17, and Path #19) group around the combination of 'context alignment' and 'project design quality' and 'technical competencies'. This cluster covers 8 projects.

Where the logic of the previous cluster can be traced back to the broader AR4D literature, this cluster has its logic explicitly in the available data. **It indicates that a form of 'classic AR4D project' has proven to be successful towards achieving strong Policy results.** In other words: well-thought-out projects (that is, with strong design quality) that are strongly tailored to their local context and that explicitly focus on increasing technical competencies including technology, practices, and academic, policy or technical knowledge (that is, delivering tangible results) have proven to be a promising starting point for project support towards strong Policy results. That is not to say that this combination of conditions is a guarantee for achieving strong Policy outcomes. The blue pathway in Figure 4 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful Policy outcomes.

Agrochemical pollution of water resources under tropical intensive agricultural systems
(LWR1/1994/054)

An ACIAR-supported project from the database that illustrates this cluster well is 'Agrochemical pollution of water resources under tropical intensive agricultural systems' (LWR1/1994/054). This project was based in Thailand and Malaysia and aimed to create high-level systemic change of 'agrosystems' at local and regional levels. The project created new methods and techniques to assess pollution risks at a systemic level and partnered with World Vision, who carried out extension activities.

The project arose following a recommendation from an external review of an earlier ACIAR project. It achieved strong outcomes across the board and resulted in decreased overuse of pesticides and fertilisers, and decreased contamination of ground and surface water. Community adoption of the project was significantly stronger in Thailand than Malaysia. The policy outcomes include governmental regulation to ban certain chemicals that were found to pollute water resources and impact the environment detrimentally. As a result, community impacts were also high, particularly in areas where the pollution level and impacts from chemicals severely impacted the health of the population.

In Thailand the project results were incorporated into the National Agricultural Policy for the promotion of organic farming and food safety. The project recommendations were also implemented by the local extension officers. The local authority in the project area has prohibited leasing areas with a high risk of chemical pollution for commercial vegetable production, and vegetable growing near schools was restricted. The Thai Department of Health provided funding for training farmers on chemical use and for transferring to the Integrated Pest Management systems. In Malaysia the project provided additional baseline information for the Pesticides Board of Malaysia to initiate regulatory action for the restricted use of the insecticide and acaricide Endosulfan, which is now banned for use in the vicinity of water bodies. Authorities have also promoted the use of rain shelters to conserve the soil resource base.

6.4 Cluster 3: Scaling up

A single pathway (Path #18) is part of a cluster that recurs across the solutions for the various outcomes analysed in this study. It groups around the combination of 'project transition quality' and 'project size' and 'macro focus'. Here, it covers 2 projects.

The logic of this cluster comes from both the broader AR4D literature (see Appendix 1) and the available data. **It indicates that 'scaling up' is a promising strategy towards achieving strong Policy results.** Scaling up (sometimes referred to as 'vertical scaling') is here understood as a process where, for example, interventions (and parts thereof), knowledge and practices are being embedded in formal administrative processes, policy or practice, or are being taken up at higher levels of practice (for example, from village to region to country). In other words, the project affects or impacts laws, policies or formal practices at the level of project development or intervention, or possibly at an even higher level (Schut et al. 2020). However, Path #18 indicates that this combination of project transition quality, macro focus and project size is by no means a guarantee for achieving strong Policy outcomes. The orange pathway in Figure 4 indicates that this combination of conditions always combines with other conditions in complex pathways towards successful Policy outcomes.

Enhancing institutional performance in watershed management in Andhra Pradesh, India
(LWR/2006/158)

An ACIAR-supported project from the database that illustrates this cluster well is 'Enhancing institutional performance in watershed management in Andhra Pradesh, India' (LWR/2006/158). The project was implemented in tandem with another ACIAR-supported project that was working on policy and which had many programs and a significant amount of funding due to prioritisation by the Indian Government. The project focused on system-level change in Andhra Pradesh, India, and had a strong capacity-building focus at both the institutional and grassroots level, with 45,000 farmers trained by the end of the project. This project performed moderately strong or strong in all outcome categories that are the central focus of this study.

It is important to note that the project took place in 2 regions and indicated that where state government support was high, project adoption was more likely to be successful. For example, in Ahdhra Pradesh there was high prioritisation and buy-in from the government, which resulted in a higher level of confidence from communities within the project team. This may explain why better Socioeconomic outcomes were achieved there. The adoption study indicates that the project reduced out-migration from the region due to the socioeconomic impacts achieved.

Throughout the project, policymakers and administrators at the district, state, and national levels were engaged in a participatory process to help drive institutional change to support watershed development. The overarching understanding that came from the development of policy was the need to address broader social issues, especially those regarding landless and marginalised groups.

6.5 Conclusion

This chapter has presented the main insights from the QCA findings for Policy outcomes and our interpretation of them. We observed strong and moderately strong Policy outcomes in well over a third of the projects included in the QCA (19 projects, 39%).

None of the conditions were found to be necessary for the outcome, and the analysis of sufficiency indicated 6 detailed pathways towards it. These pathways can be grouped into 3 broad clusters that have their logic in both the broader AR4D literature and the available data. The clusters indicate that the following combinations of conditions are promising starting points towards achieving strong Policy outcomes:

- a theory of change (ToC) joined with a practice of change (PoC)
- classic AR4D project – supporting projects that are strongly tailored to their context, have a strong design quality, and explicitly focus on increasing technical competencies
- the scaling up of projects, mainly by embedding project results in law, policy, or formalised practice at the level of the project or a higher level.

7 Socioeconomic outcomes

This chapter presents the QCA findings for Socioeconomic outcomes and our interpretation of them. This chapter asks: **How do the conditions of interest combine and is there only one configuration or several configurations of conditions (that is, pathways) towards Socioeconomic outcomes?**

Section 7.1 presents a summary of the full analysis. Sections 7.2 and 7.3 each present a distinct causal cluster resulting from the analysis and illustrate it with an example from the ACIAR project database. Section 7.4 draws conclusions.

The detailed analytical steps taken are presented in Appendix 2 (for the application of QCA in this report in general) and Appendix 7 (for the Socioeconomic outcome in particular).

Readers may notice some overlap with the previous chapters. This is a result of similarities in the pathways observed for the different outcomes that are the central focus of this study.

Photo: Conor Ashleigh

7.1 Full analysis

Socioeconomic outcomes were conceptualised as the extent to which an ACIAR-supported project has contributed towards the enhanced socioeconomic resilience of farming and rural households. A strong Socioeconomic outcome is, for example, proven increased socioeconomic returns, such as increased income due to new crop species or the same income achieved with less time spend due to labour saving techniques, *and* proven increased socioeconomic agency, such as an increase in an individual's ability to choose the socioeconomic activities in which they participate. Following the calibration descriptors, we observed strong and moderately strong Socioeconomic outcomes in 24 projects (7 strong and 17 moderately strong), representing 49% of the 49 projects included in the QCA.

The analysis of necessary conditions does not indicate that any of the 8 conditions is necessary for the outcome. In other words, none of the conditions causes the outcome by itself. This indicates that conditions likely interact in their contribution towards the outcome.

The analysis of sufficient conditions confirms this expectation. A total of 5 detailed pathways are identified as being related to the outcome (the 'solution' of the analysis). The solution coverage of this analysis is 0.66. This indicates that a substantial share of the empirics is explained by the 8 conditions that are the central focus of this study. Still, the solution leaves 12 projects unexplained, which indicates that our set of 8 conditions may be too limited to understand the full picture of how ACIAR projects contribute to Socioeconomic outcomes. The solution consistency of this analysis is 0.86. This indicates that the solution is of high empirical importance in reaching the outcome.

Figure 5 illustrates the 5 pathways identified. For example, the first path in this figure (Path #24) indicates that of the projects analysed those that have a strong design quality *and* a strong project transition quality *and* context alignment *and* project continuity *and* a micro focus *and* a focus on professional competencies have resulted in strong Socioeconomic outcomes.

Figure 5 groups the 5 pathways identified into 2 broad clusters based on the most common combinations of conditions observed (for this outcome and the outcomes analysed in this study). Sections 7.2 and 7.3 each discuss one of these clusters.

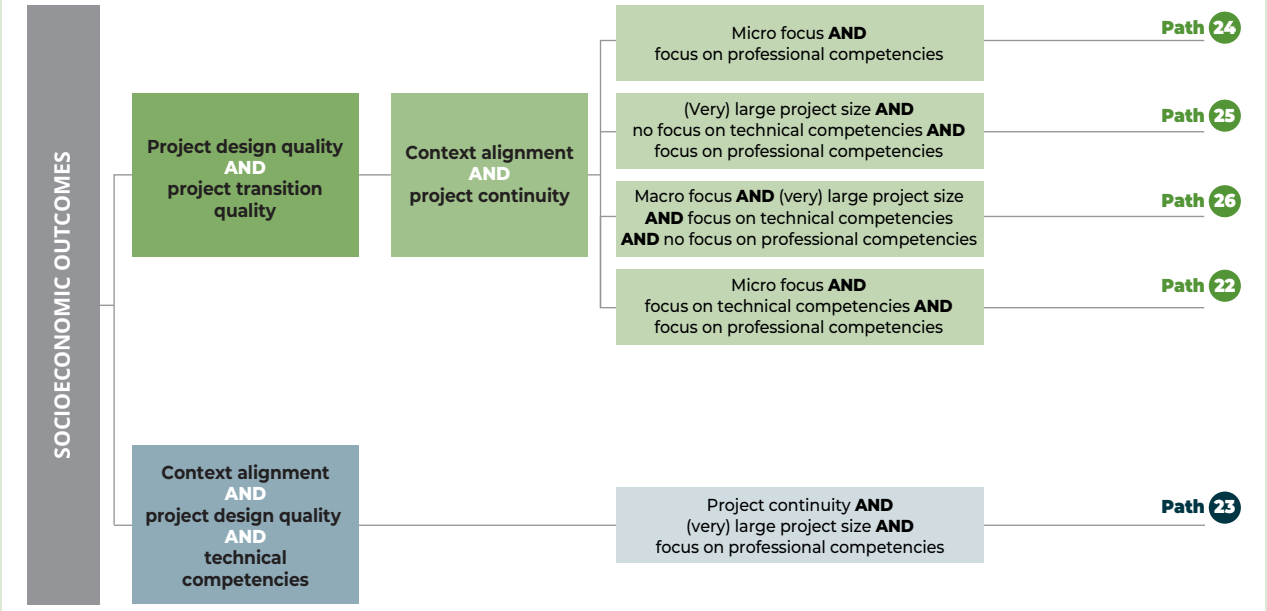


Figure 5 Paths to Socioeconomic outcomes

Notes: The solution presented is the intermediate pathway for the outcome Socioeconomic; the solution coverage is 0.66 and the solution consistency is 0.86.

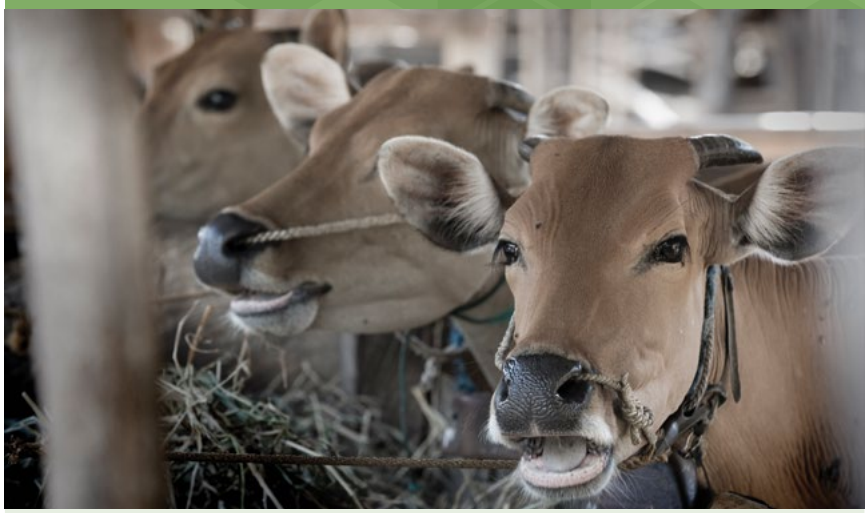
The word 'no' indicates that the condition is absent in the path.

7.2 Cluster 1: Theory *and* Practice of Change

Four pathways (Path #22, Path #24, Path #25, and Path #26) group around the combination of 'project design quality' and 'project transition quality'. This cluster covers 10 projects.

There appears to be an inherent logic behind this cluster that confirms the insights from the literature review (see Appendix 1). **It indicates that the combination of a strong project design quality (or a theory of change, ToC) and a strong project transition quality (or practice of change, PoC) is a promising starting point towards achieving strong Socioeconomic results.** In other words, strong project design and good follow-through in practice are required during the implementation of a project. That is not to say that the combination of a strong project design and strong project transition is a guarantee for achieving strong Socioeconomic outcomes. The green pathways in Figure 5 indicate that this combination of conditions always combines with other conditions in complex pathways towards successful Socioeconomic outcomes.

Scaling up herd management strategies in crop-livestock systems in Lombok
(SMAR/2006/096)



An ACIAR-supported project from the database that illustrates this cluster well is 'Scaling up herd management strategies in crop-livestock systems in Lombok' (SMAR/2006/096). The livestock project was developed to support the Government of Indonesia's goals for increasing self-sufficiency in beef production and for boosting economic development of some of the lowest socioeconomic regions.

The project was strongly aligned to its context through the involvement of national partners that specifically understood the locality of work. The project was strongly focused on ensuring sustainability after the project team left the region. The practices promoted by the project were built on existing knowledge and infrastructure, and their further development was informed by how these resources were perceived and used. This made the adoption of practices more accessible for many project households. A social network analysis was conducted to ascertain and assess the key institutions most responsible for the dissemination of project information. This approach gave community members easy access to the project.

At the end of the project, participating farmer groups stated that engagement with the project had increased their skills in, and knowledge of, improved livestock management practices. Moreover, the social capital of this group had also improved, through increased cohesion, communication and cooperation. The project also increased farmers' incomes and new techniques meant less labour was required, meaning community members had more time for household duties.

7.3 Cluster 2: Classic AR4D project

The remaining pathway (Path #23) groups around the combination of 'context alignment' and 'project design quality' and 'technical competencies'. This cluster covers 4 projects.

Where the logic of the previous cluster can be traced back to the broader AR4D literature, this cluster has its logic explicitly in the available data. **It indicates that a form of 'classic AR4D project' has proven to be successful towards achieving strong Socioeconomic results.** In other words: well-thought-out projects (that is, with strong design quality) that are strongly tailored to their local context and that explicitly focus on increasing technical competencies, including technology, practices, and academic, policy or technical knowledge (that is, delivering tangible results), have proven to be a promising starting point for project support towards strong Socioeconomic results. That is not to say that this combination of conditions is a guarantee for achieving strong Socioeconomic outcomes. The blue pathway in Figure 5 indicates that this combination of conditions always combines with other conditions in complex pathways towards successful Socioeconomic outcomes.

Improving economic outcomes for smallholders growing teak in agroforestry systems in Indonesia (FST/2005/177)

An ACIAR-supported project from the database that illustrates this cluster well is 'Improving economic outcomes for smallholders growing teak in agroforestry systems in Indonesia' (FST/2005/177). The project aimed to improve economic prospects of commercial businesses and smallholder teak plantations in Indonesia. The project was characterised by a strong alignment with its context, a strong consideration of the local working environment, and a high-quality project design.

The project helped smallholders to address various problems that they encountered while running their teak plantation businesses. Through using timber-marketing strategies and practical silvicultural tools, the economic benefits from their teak plantations were vastly improved. In addition, the project provided farmers access to microcredit through a microfinance scheme and an institutional model. In addition to increased economic benefits for smallholders, the project also achieved technical and policy outputs. For example, the project resulted in a proposed revision of government regulation to simplify procedures in obtaining timber transport documents and reduce the transaction costs of smallholders in marketing their timber.

The project documentation indicates that the project outputs were adopted by researchers and farmers at both village and national levels. Overall, the risks associated with running a business or teak plantation was decreased and income was slightly increased due to a change in management strategies. At the village level, the knowledge and skills taught have continued to be used by farmers to improve their teak plantation management and timber-marketing strategies. Based on responses from the surveyed farmers, a majority has taken up project outputs (64%). Silviculture practices were also adopted by a majority of farmers (75%), as were microfinance and marketing aspects (57% and 59% respectively).

7.4 Conclusion

This chapter has presented the main insights from the QCA findings for Socioeconomic outcomes and our interpretation of them. We observed strong and moderately strong Socioeconomic outcomes in approximately half of the projects included in the QCA (24 projects, 49%).

None of the conditions was found to be necessary for the outcome, and the analysis of sufficiency indicated 5 detailed pathways towards it. These pathways can be grouped in 2 broad clusters that have their logic in both the broader AR4D literature and the available data. The clusters indicate that the following combinations of conditions are promising starting points towards achieving strong Socioeconomic outcomes:

- a theory of change (ToC) joined with a practice of change (PoC)
- classic AR4D project – supporting projects that are strongly tailored to their context, have a strong design quality, and explicitly focus on increasing technical competencies.

8 Study conclusion and reflections

Chapters 3 through 7 have each explored if and how the conditions of interest combine *and* whether there is only one configuration or several configurations of conditions (that is, pathways) towards the outcomes that are the central focus of this study.

In this concluding chapter, we take a step back and look at the full set of pathways uncovered and what they tell us about how the ACIAR model in practice is associated with the most successful project outputs and enduring outcomes in different contexts.

Section 8.1 presents the main findings about the set of causal conditions that we have used in this study (the elements of the ACIAR model) and the extent to which they have allowed us to explain the outcomes of ACIAR-supported projects.

Section 8.2 reflects on the 5 central clusters of pathways uncovered and presents the findings about how the ACIAR mode of operation has contributed to AR4D and successful project outcomes.

Section 8.3 reflects on what this study has taught us about the unique ACIAR point of difference.

Section 8.4 takes a step back and presents future-focused lessons that may help to improve AR4D project support based on past ACIAR experience.

Section 8.5 reflects on the value of QCA for this and future ACIAR impact assessments.

8.1 Main findings

This study has sought to understand **what elements of the ACIAR model in practice are associated with the most successful project outputs and enduring outcomes in different contexts.**

Causal conditions

The ACIAR model has been operationalised through 8 causal conditions:

1. **Context alignment:** the extent to which a project is aligned to the country or regional context where it will be implemented and the national partner(s) involved in the project.
2. **Project continuity:** the extent to which a project relates to earlier ACIAR-supported research projects in the same country and the same agricultural or policy area.
3. **Project focus:** the extent to which a project seeks to make interventions at the micro-level (that may flow up to the macro-level) or at the macro-level (that may flow down to the micro-level).
4. **Project size:** ACIAR has funded research projects from the very small to the very large, and everything in-between.
5. **Project design quality:** the extent to which the original project documentation (and its updates) includes a detailed cause-and-effect narrative to explain how the proposed project interventions will result in the anticipated project outcomes.
6. **Project transition quality:** the extent to which the project seeks to empower the national partner(s), next user(s) or end user(s) (or a combination of these) to continue using the project interventions or findings after the completion of the project, and the means by which this is accomplished.
7. **Technical competencies:** the extent to which the project seeks to increase technical competencies, including technology, practices, and academic, policy or technical knowledge.
8. **Professional competencies:** the extent to which the project seeks to increase professional competencies, including skills, behaviour, and practical or tacit knowledge.

This operationalisation of the ACIAR model was the result of theoretical and experiential selection. For the theoretical selection a systematic review of the literature was carried out; for the experiential selection a variety of ACIAR stakeholders were consulted, including ARPMs, RPMs, the Capacity Building team, and representatives of the Country Network.

Initially, a broader set of causal conditions was conceptualised that also included project management (by ACIAR, the commissioned partner and the national partners) and gender-related topics (such as the male-female ratio of project teams and whether project documentation indicated explicit gender awareness). Unfortunately, there was not enough information available in the project documentation (Project Documents, End of Project Reviews, Adoption Studies and Final Reports) to allow us to use these additional causal conditions in the various QCA analyses.

Outcomes

The notion of 'project outputs and enduring outcomes in different context' has been operationalised through 5 broad outcomes:

1. **Innovations Systems:** the extent to which the ACIAR-supported project has contributed towards a bounded set of actors (including commissioned partners, national partners, stakeholders, and next and end users), activities, objects or products, institutions, and relations that are important for delivering AR4D results.
2. **Science and Knowledge:** the extent to which the ACIAR-supported project has contributed to the development of (i) scientific knowledge, (ii) high-quality practical knowledge that can be applied in context, or (iii) a combination of these.
3. **Natural Resource Management:** the extent to which the ACIAR-supported project has contributed to enduring positive natural resource impacts.
4. **Policy:** the extent to which the ACIAR-supported project has contributed to policy impacts.
5. **Socioeconomic:** the extent to which the ACIAR-supported project has contributed towards the enhanced socioeconomic resilience of farming and rural households.

The same approach of theoretical and experiential selection was used to operationalise these outcomes.

Initially, we had also included 'gender impacts' as an outcome, but as with some of the originally planned conditions, there was not enough information available in the project documentation to assess whether and how the ACIAR model has contributed to achieving gender outcomes.

In addition, there are considerable differences in project documents in how project outcomes are reported. As a general rule, Innovations Systems outcomes and Science and Knowledge outcomes get more attention than the other 3 outcomes that are the central focus of this report. Arguably, the former outcomes are easier to observe for the project team and external reviewers, and they are easier to relate directly to the project interventions. The latter outcomes will likely take a longer time to emerge and will be affected by a broader set of factors than the project interventions, thus making them less easy to observe and relate directly to the project.

Because of data quality limitations, we had to exclude 57 projects from the original dataset of 106 ACIAR-supported projects. The various QCA analyses are based on a set of 49 projects. As we explain in Chapter 2, this set of 49 projects comes from all thematic areas of research supported by ACIAR, from all geographical locations supported by ACIAR, and has a good distribution across the time period covered by the original dataset. In short, we feel confident that the set of 49 projects is representative of the 106 projects that we started with initially.

Explanatory power of the model

Overall, the theoretical model of 8 causal conditions that we have used to operationalise the ACIAR model has substantial explanatory power. In other words, **these 8 causal conditions are central to why the ACIAR model in practice has contributed to successful project outputs and enduring outcomes in different contexts.**

There are, however, differences in how well the theoretical model can explain the variance in outcome data that we have collected from the project documentation. This becomes most obvious if we compare the coverage, consistency, and unexplained projects of the solutions that relate to the individual outcomes. Table 1 presents an overview.

The solution coverage indicates how well the empirical observations are explained by the theoretical model. A solution coverage of 0.75 is typically considered as indicating good fit, but lower numbers are acceptable (Schneider and Wagemann 2013). The solution coverage scores for the outcomes Innovations Systems and Science and Knowledge indicate that the theoretical model of 8 conditions is suitable for understanding how configurations of the conditions contribute to these outcomes.

The solution coverage scores for the outcomes NRM, Policy and Socioeconomic are not problematic (that is, the theoretical model of 8 conditions is suitable for understanding how configurations of these conditions contribute to these 3 outcomes), but they do indicate that it is likely that other causal conditions are also at play. This is confirmed by the share of projects that we found to have an outcome present, but that are not explained by the paths in the solution (particularly for the outcomes NRM and Socioeconomic).

The solution consistency indicates how important the full solution is to reach the outcome. A solution consistency of 1.00 indicates that there is a perfect subset relation between the cases that have the outcome *and* are part of the paths in the solution. A minimum solution consistency of 0.75 is advised when considering if the solution is indeed of high empirical importance in reaching the outcome (Rihoux and Ragin 2009). This requirement is met for all outcomes.

Table 1 Parameters of fit and unexplained projects per outcome

Outcome	Solution coverage	Solution consistency	Unexplained projects
Innovations Systems	0.77	0.97	10 (27%)
Science and Knowledge	0.73	0.91	9 (24%)
Natural Resource Management (NRM)	0.67	0.97	12 (50%)
Policy	0.67	0.97	7 (37%)
Socioeconomic	0.66	0.86	12 (50%)

Note: the percentage 'unexplained projects' indicates the share of projects that we observed to have an outcome present but that is not explained by the solution. For example, we observed that 37 projects had the outcome Innovations Systems. The solution of the analysis for sufficiency does not explain 10 out of these 37 projects, representing 27%.

8.2 Five clusters of pathways uncovered

None of the 8 causal conditions were observed to be necessary for any of the outcomes studied. In other words, none of the causal conditions either cause or explain any of the ACIAR project outcomes by itself.

Building on QCA logic and techniques, we have uncovered a total of 24 unique pathways (that is, configurations of causal conditions) that contribute to the various outcomes that are central to this study.[13] In each pathway several causal conditions combine. In short, we have observed, as expected, conjunctural causation (the clustering of conditions) and equifinality (different pathways contribute to the same outcome).

It is a positive discovery to have systematically uncovered only 24 pathways in this assessment. With the set of 8 causal conditions, a set of 256[14] different pathways is theoretically possible. In other words, we have empirically observed only 9% (= 24/256) of the theoretically possible paths towards ACIAR project outcomes. We read this insight as indicating that the ACIAR mode of operation (as observed in the set of 49 projects included in the QCAs) is targeted and coherent within the broad boundaries that the individual conditions offer.[15]

Yet, the most relevant insight that comes from this study is that, **when taking a long-range analytical look at the ACIAR mode of operation and the contribution that ACIAR has made to AR4D, 5 distinct clusters of pathways stand out**. The clusters are:

1. **Theory and practice of change**: this cluster indicates that the combination of a strong project design quality (or a theory of change, ToC) and a strong project transition quality (or practice of change, PoC) is a promising starting point towards achieving strong project results. In other words, a strong project design needs to be followed throughout the implementation of a project. This cluster is illustrated in green in Figure 6.
2. **Classic AR4D project**: this cluster indicates that well-thought-out projects (that is, with strong design quality) that are strongly tailored to their local context and that explicitly focus on increasing technical competencies, including technology, practices, and academic, policy or technical knowledge (that is, delivering tangible results) have proven to be a promising starting point towards achieving strong project results. This cluster is illustrated in blue in Figure 6.
3. **Scaling out**: scaling out (sometimes referred to as 'horizontal scaling') is understood here as a process where, for example, interventions (and parts thereof), knowledge, and practices, are replicated in, or disseminated from, one context to another, or are expanded within the original context. The impact assessment has indicated that it is a promising starting point towards achieving strong project results. It is characterised by the combination of project continuity (that is, projects that continue from or build on earlier or existing ACIAR projects) and a large or very large project size. This cluster is illustrated in yellow in Figure 6.
4. **Scaling up**: scaling up (sometimes referred to as 'vertical scaling') is understood here as a process where, for example, interventions (and parts thereof), knowledge, and practices, are being embedded in formal administrative processes, policy or practice, or are being taken up at higher levels of practice (for example, from village to region to country). The impact assessment has indicated that it is a promising starting point towards achieving strong project results. It is characterised by projects with a macro focus, strong project transition quality, and a large or very large project size. This cluster is illustrated in orange in Figure 6.
5. **Pure or basic science**: this cluster indicates that supporting projects that aim for pure or basic science is a promising strategy towards achieving strong Science and Knowledge outcomes. The apparent logic for the specific set of conditions that cluster here is that 'pure or basic science' programs that are context independent (to increase the generalisability of findings) and that larger or longer-term projects stand a better chance of achieving desirable project outcomes. This cluster is illustrated in purple in Figure 6.

13 The close reader may observe that we have presented a total of 26 pathways across Chapters 3 to 7. Yet, of these, Path #5 (Innovations Systems) and Path #22 (Socioeconomic) are similar, and so are Paths #6 (Innovations Systems) and #16 (NRM, Policy). This brings the total number of unique pathways to 24.

14 The formula to calculate the theoretically possible number of pathways is 2 to the power of the number of conditions. Here that is 2^8 = 256 (cf. Schneider and Wagemann 2013).

15 Here we are deliberately careful. After all, with 49 projects included in the QCAs, we could only have empirically observed 49 pathways towards the outcomes, representing 19% (= 49/256) of the theoretically possible number of pathways (cf. Schneider and Wagemann 2013).

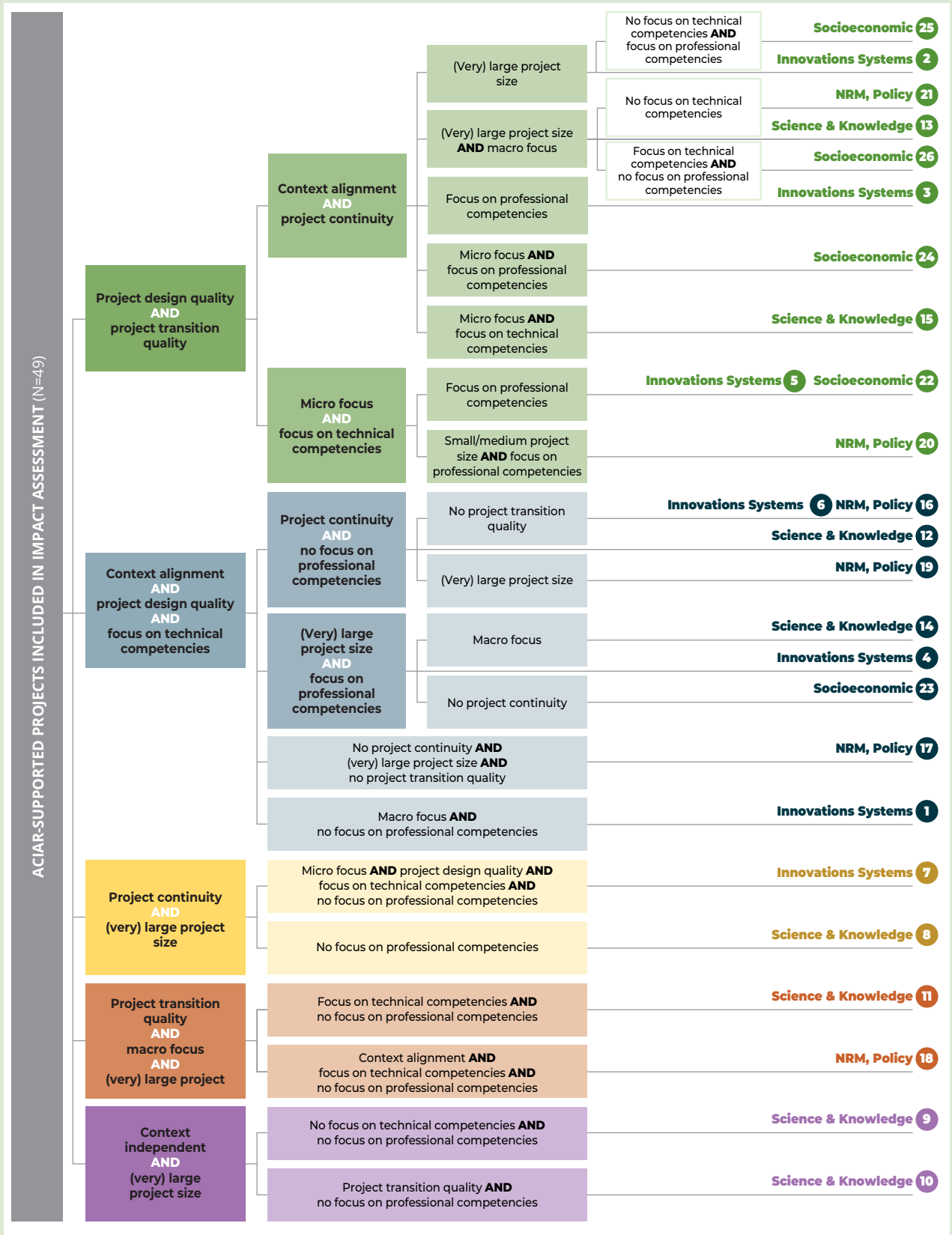


Figure 6 Paths to project outcomes

NRM = Natural Resource Management

Notes: Figure 6 illustrates the full set of 24 unique pathways uncovered and the set of 5 main clusters of pathways uncovered. Each pathway is illustrated as a configuration of conditions. The pathways are clustered based on the most common combinations of conditions observed. The numbers of the pathways correspond with the numbers used throughout the report. For each pathway, Figure 6 illustrates to which outcomes it has led.

The word 'no' indicates that the condition is absent in the path.

Figure 6 provides an illustration of the 24 pathways and the 5 clusters (the numbers of the paths in the figure correspond with the numbers of the paths in the previous chapters). Each pathway in the figure can be read as a configuration of causal conditions that contribute to an outcome. For example, Path #2 indicates that of the projects analysed those that have a strong design quality *and* a strong project transition quality *and* context alignment *and* project continuity *and* a (very) large project size have resulted in strong Innovations Systems outcomes.

The first 2 clusters are most dominant in the ACIAR-supported projects that have achieved strong project outcomes, and they help explain why *all* 5 outcomes have been achieved. The other 3 pathways are targeted more towards the achievement of particular outcomes, as is illustrated in Figure 6.

The first 2 clusters provide, in absolute terms, considerably more variety in pathways towards strong project outcomes than the other 3. This could indicate that the first 2 clusters allow for more flexibility in project development, strategy and implementation. The first cluster covers 10 distinct pathways and the second 8. The remaining 3 clusters cover only 2 pathways each.[16]

Notably, the first 2 clusters each have 2 sub-clusters. Of these, the combination of context alignment and project continuity (in the cluster 'theory and practice of change') stands out specifically. It binds together 8 of the 24 unique pathways uncovered. It can be considered as another starting point towards strong project outcomes when combined with strong design quality and strong project quality.

8.3 Unique ACIAR point of difference

The 5 clusters of pathways that we have uncovered in this study all have their basis in the set of 49 ACIAR-supported projects used in the various QCA analyses. It is relevant to note that they all confirm the broader AR4D literature also (see Appendix 1). This allows us to conclude that the ACIAR mode of operation reflects the sort of good AR4D practice discussed in the international, largely academic, literature.

At the same time, **the 5 clusters highlight the unique ACIAR point of difference in the aid program and profile the contribution ACIAR has made in certain areas**. Considering the 5 outcomes that are the central focus of this study, we have observed an overall strong performance of the 49 ACIAR-supported projects included in this study:

- We observed strong and moderately strong **Innovations Systems** outcomes in the majority of the projects included in the QCA (37 projects, 76%).
- We observed strong and moderately strong **Science and Knowledge** outcomes in the majority of the projects included in the QCA (37 projects, 76%).
- We observed strong and moderately strong **Natural Resource Management** outcomes in approximately half of the projects included in the QCA (24 projects, 49%).
- We observed strong and moderately strong **Policy** outcomes in well over a third of the projects included in the QCA (19 projects, 39%).
- We observed strong and moderately strong **Socioeconomic** outcomes in approximately half of the projects included in the QCA (24 projects, 49%).

Thus, the sort of project outcomes that ACIAR can most directly influence (that is, Innovations Systems and Science and Knowledge) were achieved in the majority of supported projects. The outcomes were spread evenly across all thematic areas of research supported by ACIAR, across all geographical locations supported by ACIAR, and across the time period covered by impact assessment. This allows us to conclude that ACIAR has, overall, been highly successful in achieving both these AR4D project outcomes throughout the period covered by this study.[17]

16 Here we should note that of course the limited variety of the final 3 clusters of pathways may simply be explained by limited variety in our data. Although the pathways uncovered have proven to be successful in achieving desirable ACIAR project outcomes, by no means should the full set of pathways uncovered be considered as being the only theoretically possible pathways towards outcomes.

17 We have already stressed that the selection process that has led to the 49 projects for the QCA analyses may have been biased towards projects with successful outcomes. The quantitative conclusions about the success achieved that we present here should be understood in that light (see also footnote 10).

The sort of project outcomes that ACIAR can influence less directly were achieved in nearly half of the projects for NRM and Socioeconomic outcomes and well over a third for Policy outcomes. The outcomes were spread evenly across all thematic areas of research supported by ACIAR, across all geographical locations supported by ACIAR, and across the time period covered by impact assessment. Acknowledging that such outcomes are affected by a much broader range of factors than AR4D support, we conclude that ACIAR has, overall, been successful in contributing to these 3 AR4D project outcomes throughout the period covered by this study.[18]

What has made the ACIAR mode of operating successful thus far?

When stepping back and overviewing the whole of the 24 paths towards desired project outcomes and the 5 clusters that bind them (see Figure 6), the successful ACIAR mode of operating appears thus far to be the result of **bounded variety in project support** – a happy balance between individual project variety and project-portfolio boundedness:

- **Project variety:** the 24 paths towards desired project outcomes indicate that the ACIAR mode of operating allows project teams (including commissioned partners, national partners, next users and end users) considerable freedom in how to develop and implement AR4D projects. There is no one-size-fits-all project format that project teams are expected to follow – such an approach would, effectively, stifle innovations systems and restrict the possibility for original research and projects that are tailored to their contexts and partners. Rather, the ACIAR mode of operating allows for substantial project variety, which is indeed supported by the broad range of thematic areas of research supported by ACIAR, and the broad range of all geographical locations supported by ACIAR.
- **Project-portfolio boundedness:** the 5 clusters, however, indicate that not 'everything goes' within the broader ACIAR project-portfolio. The consistent recurrence of the 5 clusters across the 5 project outcomes indicates that there has been a consistent 'ACIAR way' of project support throughout the period covered by this impact assessment. They indicate that the ACIAR mode of operating allows ACIAR to steer, to a certain extent, project teams to develop and implement AR4D projects in a way that makes them more likely to achieve successful outcomes.

The 5 clusters can be understood as the fundamentals of the ACIAR mode of operating that have resulted in successful project outcomes in the past. Whether the clusters were adopted intentionally or have evolved organically, they have given direction to portfolio management and have put boundaries around the types of projects that ACIAR supports. It may be helpful to think of the clusters as the borders of a playing field. The playing field made up by the 5 clusters is, however, vast and allows the partners of ACIAR considerable freedom to undertake a broad variety of research projects within its borders, as is illustrated by the 24 paths.

It is recommended that both ACIAR and its partners keep these 5 clusters in mind in future research projects. ACIAR could allocate future project funding (partly) informed by the 5 clusters and give preference to those projects that explicitly build on or include one or more of these evidence-based starting points. Likewise, partners could embrace the clusters as starting points for their future research projects. For example, if a partner finds that existing causal conditions set limits to their project (for example, due to the local context or the next users involved), then the clusters indicate which outcome(s) the project may most successfully pursue. Or, if a partner designs a project with a specific outcome in mind (for example, scaling up), then the clusters help to identify which set(s) of causal conditions are promising to achieve that outcome.

In sum, by no means do the 5 clusters force partners into a straitjacket or rule out 'blue sky' experimentation in their research projects. As Figure 6 illustrates, a wide variety of projects unfolds from each of the 5 evidence-based starting points provided by the clusters. A practical way of thinking about the clusters is that they bridge the ambition of partners to carry out projects that have meaningful and lasting impacts with the ambition of ACIAR to support projects that achieve successful outputs and enduring outcomes.

18 For the quantitative conclusions about the success achieved that we present here the same qualifier holds as the one we express in footnote 17.

8.4 Future-focused lessons

In the preceding sections, we have made several recommendations about how the lessons from this study can be used in future ACIAR project support. In Section 8.5, we will present some more recommendations targeted towards ACIAR specifically. Here we will present **the main future- focused lessons in relation to effective AR4D project support that have surfaced from past ACIAR experience**. These lessons obviously have relevance for future ACIAR project support, but they may also have relevance for other A4RD organisations and other areas of development.

Lesson 1: Embrace bounded variety (and equifinality and conjunctural causation)

A first and central lesson that stands out for ACIAR and the partners it works with, is to embrace equifinality, conjunctural causation and bounded variety. In terms of equifinality, there are various pathways towards desirable project outcomes. No one pathway of those that we have observed in this study appears to have dominance over the others. This indicates that there is no 'single best way' of achieving project outcomes. In practical terms, if one pathway is not an option (for example, it is not possible to combine a strong project design with a strong project transition strategy) then other pathways can be followed towards desirable project outcomes.

In a similar vein, for ACIAR and the partners it works with, it is relevant to embrace conjunctural causation. None of the individual causal conditions that we have explored in this study were found to be necessary for any of the outcomes. For every outcome, and in every path towards the outcomes, we observed complex configurations of causal conditions. This indicates that there is no 'most important condition' for achieving desired project outcomes. In practical terms, the absence of any individual condition (for example, no context alignment or no project continuation) does not impede the achievement of desirable project outcomes.

At the same time, it is important to acknowledge that this does not mean that 'anything goes'. We have observed a limited number of pathways towards the outcomes that cluster in only 5 broad categories. For ACIAR and the partners it works with, it is important to embrace the 'bounded variety' of configurations of conditions that define these categories as starting points for future project design and implementation. The categories themselves provide no guarantee for successful project outcomes, but they are the essential parts of project design and implementation that explain why ACIAR-supported projects have achieved successful project outcomes over the past 40 years.

Lesson 2: Always expect a Theory of Change

While the impact assessment does not point at a single causal condition that stands out as the most important one for achieving desired project outcomes, the importance of a strong ToC needs to be stressed. The condition 'project design quality' (effectively, a ToC) is a central part of 2 of the 5 clusters of conditions, and it plays a role in 18 of the 24 paths (75%) that we have identified. None of the other conditions recurs that often in paths towards desirable project outcomes. Additionally, none of the pathways towards success is characterised by the absence of project design quality or by weak project design quality.

That the use of strong ToCs has played such an important role in ACIAR-supported research projects does not come as a surprise. The broader AR4D literature has long pointed at ToCs as being central to the success of AR4D initiatives and projects (see Appendix 1). Combined, these insights indicate that ACIAR should always expect a strong ToC from the partners it works with in future projects. However, in evaluating the project documentation for this study, we observed that it may not always be clear to the partners of ACIAR what elements a ToC should contain. ACIAR could develop a template for the ToCs it expects or a set of clear and explicit evaluation criteria. For example, it could apply the 'typical' SMART-criteria to evaluating ToCs (Specific, Measurable, Achievable, Realistic and Timely).

Still, having a strong ToC by itself is no guarantee for desirable project outcomes. The impact assessment has shown that combining it with strong 'project transition quality' (effectively, the Practice of Change, or PoC) has been a promising starting point for ACIAR-supported projects over the past 40 years. This insight also confirms the broader AR4D literature (see Appendix 1), and it indicates that ACIAR should expect from its partners that they couple a ToC with a PoC in future projects. Again, ACIAR could develop a template or a set of clear and explicit evaluation criteria for the PoCs it expects.

Lesson 3: Pursue multiple project outcomes strategically

Very few projects have achieved all 5 outcomes that were central to this study (only 5 did, or 10%), just over a third have achieved 4 outcomes or more (17 did, or 35%), and a small majority has achieved 3 outcomes or more (30 did, or 61%).[19] These numbers are surprising given our QCA findings and they provide a third relevant lesson. Two of the clusters identified ('theory and practice of change' and 'classic AR4D project') were found to contribute to all 5 outcomes across different projects.

19 At the same time, only 2 projects have achieved none of the outcomes (4%), and just over a third achieved 2 or fewer outcomes (18 did, 37%).

This means that, in theory, pursuing one outcome by using the configuration of conditions that characterises these 2 clusters does not rule out the achievement of any of the other outcomes.

However, from reading the project documentation, it has become clear that many projects pursue only a single or, at best, 2 of the project outcomes that are central to this study. For those, achieving more than what they pursue appears to be a 'lucky bonus' (something that is often not observed until the project has been completed and evaluated). Future project teams could be more strategic in pursuing multiple project outcomes through the 24 pathways and 5 clusters uncovered here. They could identify one of the clusters that this study has found to contribute to the outcome they want to achieve, and then investigate whether and how that cluster (through its detailed pathways) creates possibilities for them to pursue additional outcomes. This may require a little more planning in the design and early phases of projects, but the payoff (that is, the achievement of several project outcomes) could be substantial.

This is not to say that all future projects should be expected to achieve a broad suite of project outcomes. In particular, projects that pursue the scaling out or scaling up of AR4D knowledge, technology, practice, skills, and so on, may be restricted in the sort and quantity of outcomes they can achieve.

Lesson 4: Set clear project quality and assessment criteria (and administer them)

A lesson that results from the raw input data, rather than from the QCA findings, is that it is exceptionally relevant for ACIAR to set clear criteria for the quality of project documentation and to administer these. The variety in content and quality of project documentation was, to put it mildly, surprising. We have come across Project Documents of little more than a dozen pages, as well as ones that reached well over a hundred. In a similar vein, we have come across Project Documents that did not provide us with the minimum information required to code our outcomes and causal conditions (for example, gender issues and project management practices), and we have come across Project Documents that had so much information that we could not see the forest for the trees.

To aid future application of QCA (or other data analysis methods) to sets of ACIAR-funded projects, it is relevant for ACIAR to pursue a stricter range of the quality and quantity of the data in project documentation. Practically speaking, the templates for the various Project Documents need to be updated, tightened, made fit for purpose, and made fit for contemporary AR4D project support. At the same time, the criteria for project documentation provided by its partners need to be administered and imposed when necessary. We acknowledge, however, that templates for ACIAR Project Documents that are too strict will hamper ACIAR partners in explaining and justifying their projects. In short, a rethink of the ACIAR project commissioning and management process is warranted to ensure that future project documentation will be more comparable across the ACIAR project portfolio (which can help to improve, among others, the accountability and transparency of project support).[20]

The same holds true for project documentation related to project evaluation. Again, we observed a broad variety in the quantity and quality of End of Project Reviews, Adoption Studies and Final Reports. Here we highlight a considerable number of missing or incomplete Adoption Studies in particular, as well as external review reports that had to fully rely on self-reported findings from project teams. Thus, a rethinking of the 'evaluation side' of project funding also appears warranted, to ensure that future project documentation will be more comparable across the ACIAR project portfolio.

Lesson 5: Evaluate, learn, adapt

A final lesson for ACIAR is to institutionalise a process of ongoing evaluations of sets of projects, to draw lessons from these and disseminate these lessons widely within the ACIAR network (that is, to learn), and finally, to adapt its practice of project support to the lessons learnt. This trinity ('evaluate, learn, adapt') is a well-known recipe for building a learning organisation (Örtenblad 2004; Serrat 2017).

We cannot emphasise enough the value of the *process* of undertaking this study. The outcomes it has yielded are relevant, but so are the steps we needed to take to come to these outcomes. The process of arriving at the outcomes that are central to this study asked ACIAR staff and its stakeholders to reflect on essential questions such as: what does ACIAR want to achieve and why?

20 We suggest that, at the very least, 2 practices that we observed in project documentation are weeded out. First, the practice of 'dumping' a vast quantity of information in project documents and expecting ACIAR administrators to make sense of it. Second, the practice of some partners to mainly state their past performance as the motivator for why their project should be supported, but without providing ACIAR with the 'bare bones' of their suggested project to make sense of it.

The process of coming to the causal condition of the impact assessment asked ACIAR staff and its stakeholders to reflect on essential questions such as: how is ACIAR contributing to AR4D, and how do we want it to contribute in the future? The process of data collection has asked ACIAR staff to reflect on essential questions such as: does ACIAR know what it is achieving and how can it improve this knowledge? Thus, the process of arriving at the outcomes of the impact assessment has asked ACIAR staff and its stakeholders to critically reflect on the 'known knowns' and the 'known unknowns' of the organisation.

Answering these questions on an ongoing basis is part of being a learning organisation. Unfortunately, the challenge organisations often face in becoming a learning organisation is how to start. This study has exposed ACIAR to a methodology and a logic that can be used as the starting point for an ongoing evaluation process, to keep reflecting on these 'known knowns' and 'known unknowns', whilst at the same time uncovering, documenting and learning from their 'unknown knowns' (for example, the 24 pathways and the 5 clusters that typify the ACIAR mode of operation).[21]

8.5 Final reflections: the value of QCA for future ACIAR impact assessments

In Chapter 2, we explained that a secondary aim of this study was to better understand the value of QCA for future ACIAR impact assessments, and to build QCA capacity within ACIAR. Obviously, our main experience is positive. The application of QCA in this study has been valuable in uncovering how the ACIAR mode of operation has contributed to successful project outputs and enduring outcomes in different contexts. No other data-analysis method would have allowed us to trace the general performance patterns in the database whilst maintaining the richness of the ACIAR-supported projects (Ragin 2008; Rihoux and Ragin 2009; Schneider and Wagemann 2013).

Still, it should be stressed that coming to the 24 paths and the 5 clusters that binds them together has been a lengthy process. We started this study in June 2020 and completed it in January 2022. This lengthy process is partly the result of a period in which ACIAR staff were being trained in QCA logic and tools, and a period in which the method was presented to and discussed with ACIAR stakeholders, including ARPMs, RPMs, the Capacity Building team and representatives of the Country Network.

Future application of QCA in ACIAR impact assessments will likely be less time-consuming now that ACIAR has this first large-scale QCA study to fall back on.[22]

The main part of the QCA process that will likely take less time in the future is coming to the set of outcomes and causal conditions to be included and their calibration descriptors. For this study we have relied on a combination of 'theoretical selection' and 'experiential selection' that has taken from June 2020 to June 2021 (see Chapter 2). Effectively, this process asked the ACIAR QCA Team and ACIAR stakeholders to retroactively develop a general ToC for ACIAR-supported projects that linked a set of causal conditions to a set of desired project outcomes. It is likely that less 'soul searching' will be required for future application of QCA in ACIAR impact assessments because there are the insights and outcomes from this study to serve as a starting point.

Another part of the QCA process that will likely take less time in the future is the 'cleaning up' of input data. For this study, we started with a database of 106 ACIAR-supported projects. Due to data quality challenges, however, we could only include 49 studies for which we had full data in the formal analyses (see Chapter 2). Obviously, had we started off with the final set of 49 studies, we would have saved considerable time on assessing and coding, either partially or in full, project documents for more than 50 projects that, in the end, we could not include. Again, future application of QCA in ACIAR impact assessments will likely be less time-consuming now that ACIAR has a good understanding of the quality of data in project documentation needed and how to select projects with high-quality data (from a QCA perspective) from the database.

Last but not least, the value of QCA is that it allows for finding patterns in medium-n sets of projects (that is, datasets of 10 to 50 projects) whilst maintaining the richness of the projects. In this study, we have, arguably, pushed what QCA can deliver by including an exceptionally broad range of project research areas, geographical locations, designs, approaches to implementation, size, and so on. Naturally, this required us to use broadly defined causal conditions and outcomes to capture all that variety (and to some readers, the causal conditions and outcomes used may have felt too general). To better maintain the richness of the projects included in the QCA analyses, future ACIAR impact assessments could be targeted to an area of research or geographical region. This will also make it less challenging to develop a set of outcomes, conditions, and calibration descriptors that capture both the variety and details of projects included.

21 An 'unknown known' because the knowledge of the 24 pathways and the 5 clusters was present in the database – it 'just' needed to be lifted out of the database.

22 We also acknowledge the role the various COVID-19 lockdowns have played and the delays they have caused.

Appendices

Appendix 1: Systematic literature review

It is strongly advised in the methodological literature on QCA that:

> *the researcher engages in a dialogue between cases and relevant theories. Indeed, the choice of the variables (conditions and outcomes) for the analysis must be theoretically informed. In this sense, there is a deductive aspect to QCA; however, QCA techniques can also be used more inductively, gaining insights from case knowledge to identify the key 'ingredients' to be considered.* (Berg-Schlosser et al. 2009: 6)

In this study, we have closely followed this advice. As explained in Chapter 2, the outcomes and conditions that are central to this study come from a combination of 'theoretical selection' and 'experiential selection'. The theoretical selection builds on an evidence synthesis of the broader AR4D literature – an evidence synthesis is a standardised form of systematic literature review (Cooper et al. 2019; Eklund Karlson and Takahashi 2017). This appendix presents the results from the evidence synthesis.

Methods

The aim of the evidence synthesis was to trace the common outcomes of AR4D programs and interventions, and their causal conditions as discussed in AR4D literature. We have focused on (i) medium-n or large-n empirical studies that assess the outcomes and causal conditions of AR4D programs or interventions and (ii) meta-research (including narrative reviews, evidence synthesis, and meta-analysis) on AR4D programs or interventions.

Selection criteria

Source documents were selected following PICO criteria (participants, interventions, comparators, outcomes) (Methley et al. 2014):

- **Participants**: no restrictions were set to the background or type of studies.
- **Interventions**: included were studies that empirically observe the outcomes and causal conditions of AR4D across at least 5 real-world examples and meta-research studies (including narrative reviews, evidence synthesis, and meta-analysis) of research on AR4D research support.
- **Comparators**: no restrictions were set as to the type of comparisons made in source documents.
- **Outcomes**: no restrictions were set as to the type of outcomes or causal relationships observed in source documents.

Inclusion criteria

We have only included source documents written in English in the evidence synthesis. We have included published peer-reviewed articles, books and book chapters, including 'online first', 'early access' and 'unpublished' publications. We have also opened the evidence synthesis to include non-academic literature. Yet, publications were sourced from databases with an 'academic orientation' (WorldCat, Scopus and Web of Science).

Search strategy

For each database, a targeted search strategy was used:

- **WorldCat**: all publications with the words 'agricultural research for development' or 'AR4D' in any searchable field, published in English, since 1980. This resulted in 240 documents.
- **Scopus**: all publications with the words 'agricultural research for development' or 'AR4D' in their titles, abstracts, or keywords, published in English, since 1980. This resulted in 120 documents.
- **Web of Science**: all publications with the words 'agricultural research for development' or 'AR4D' in any searchable field, published in English, since the 1980s. This resulted in 89 documents.

Exclusion criteria

After removing duplicates, this search resulted in 343 documents. Publication titles, abstracts or summaries, and keywords were screened by 2 reviewers. This screening process excluded documents that do not report on medium-n or large-n studies or meta-research studies. This resulted in a 91% agreement percentage on which documents to exclude and include, with a Cohen's Kappa of 0.61 (indicating that the inter-rater reliability is substantial).

After resolving conflicts in coding, a set of 45 documents were included for full analysis. These documents were read in full and the outcomes of AR4D programs or interventions and the causal conditions discussed in these documents were coded. Within the literature sections of these 45 documents, we discovered another 3 relevant documents to include in this evidence synthesis, which were also coded.

We have synthesised the coded set of 48 documents to trace the major outcomes and causal conditions, as well as complementary ones that are potentially relevant for the ACIAR impact assessment. We have also traced the most common causal relationships between outcomes and conditions mentioned in the literature. Finally, we have summarised a set of motivations, discussed in this literature, for applying QCA in AR4D programs or interventions.

Findings

Keeping in line with the QCA method used in this study, we will first present the clusters of outcomes observed in the AR4D literature and then the clusters of causal conditions observed in the literature.

Clusters of outcomes observed in the literature

The outcomes that result or may result from AR4D programs or initiatives are often not clearly delineated in the literature. However, for analytical clarity we have unpacked the outcomes observed in the literature and have grouped them into the following clusters:

Innovations systems: the notion of improved or enhanced innovations systems as an outcome of AR4D projects and initiatives is a recurring theme in the literature. Improved or enhanced Innovations Systems are typically observed to have an increased systemic capacity for innovation (Barzola Iza et al. 2020; Baur et al. 2003; Maru 2018; Maru, Sparrow, Stirzaker, et al. 2018; Seifu et al. 2020). For example, changes in behaviour, knowledge, attitudes, and skills of (particular sets of) beneficiaries and other stakeholders (Douthwaite et al. 2020).

Science and knowledge: the notion of academic and practical knowledge resulting from AR4D projects and initiatives is closely related to the notion of improved or enhanced innovations systems. It may be expected that without a well-functioning innovations system, it is unlikely that an AR4D project or initiative will result in knowledge creation, documentation, and dissemination. Science and knowledge outcomes can, however, be more than documented knowledge. It also includes technological and institutional agricultural innovation (Schut et al. 2018), as well as enhanced credibility of AR4D research (Dinesh et al. 2018).

Sustainable development: a major theme in the AR4D literature published over the last 15 years or so, is whether and how AR4D programs and interventions make progress towards the United Nations Sustainable Development Goals on environmental sustainability (Adewale et al. 2013; Anandajayasekeram et al. 2009; Barzola Iza et al. 2020; Bayala et al. 2017; Clavel 2014; Dinesh et al. 2018; Kubitza et al. 2020; Lele et al. 2010; Maru 2018; Mayne and Johnson 2015; Mayne and Stern 2013; McDonald 2019; Raitzer and Norton 2009; Stern et al. 2012; Temple et al. 2018). This includes reductions in the burning off of land, crops and waste; reduced soil erosion; increased tree planting; and reduced land degradation (Bayala et al. 2017; Kubitza et al. 2020). It also includes increased resilience to the consequences of climate change (Bayala et al. 2017; Shideed 2017).

Reduction of poverty: a more 'traditional' theme in the AR4D literature is whether and how AR4D programs and interventions contribute to the reduction of poverty (Adekunle et al. 2013; Adewale et al. 2013; Anandajayasekeram et al. 2009; Barzola Iza et al. 2020; Baur et al. 2003; Bayala et al. 2017; Dinesh et al. 2018; Kubitza et al. 2020; Lele et al. 2010; Maru 2018; Mayne and Johnson 2015; Mayne and Stern 2013; Raitzer and Norton 2009; Stern et al. 2012; Tomich, Lidder, Coley, et al. 2019; Tomich, Lidder, Dijkman, et al. 2019; Torres et al. 2000). This outcome is often further unpacked in improved income security (Schut et al. 2020), increased household income (Tomich, Lidder, Dijkman, et al. 2019), decreased food prices (Tomich, Lidder, Dijkman, et al. 2019) and increased rural prosperity (Tomich, Lidder, Coley, et al. 2019).

Reduction of hunger: another 'traditional' theme in the AR4D literature is whether and how AR4D programs and interventions contribute to the reduction of hunger (Adewale et al. 2013; Anandajayasekeram et al. 2009; Barzola Iza et al. 2020; Dinesh et al. 2018; Mayne and Johnson 2015; Schut et al. 2020; Stern et al. 2012). Increased food and nutrition security is an important aspect of this outcome (Barzola Iza et al. 2020; Jones et al. 2014; Mayne and Stern 2013; Schut et al. 2020; Temple et al. 2018; Thornton et al. 2006; Torres et al. 2000).

Health and wellbeing: yet another 'traditional' theme in the AR4D literature is whether and how AR4D programs and interventions contribute to improved health and wellbeing (Adewale et al. 2013; Clavel 2014; Jones et al. 2014; Mayne and Johnson 2015). This outcome is generally seen in relation to reduced hunger (more and higher quality food results in better health) and reduced poverty (increased wellbeing as a direct result of higher income, or increased wellbeing as an indirect result of fewer working hours). A slightly different take is a focus on accelerated and more inclusive growth (Maatman et al. 2011).

Productivity and income: closely related to these 'traditional' themes is a focus in the AR4D literature on whether and how AR4D programs and interventions contribute to growth in agricultural productivity (Adewale et al. 2013; Kubitza et al. 2020). This includes, but is not limited to, increased cropping intensity, crop variety, tillage, and crop residue cover; more efficient forms of irrigation; soil and water conservation (Kubitza et al. 2020; Tomich, Lidder, Dijkman, et al. 2019); and increased financial resilience of vulnerable households to climate change risks (Kramer et al. 2019). A slightly different take is a focus on whether solutions resulting from AR4D are fit and affordable for farmers and other actors in the value chain (Seifu et al. 2020).

Gender: a theme in the AR4D literature that is gaining momentum is whether and how AR4D programs and interventions make progress towards increased gender equality, including a reduction in gender disparities (Badstue et al. 2020; Dinesh et al. 2018; Kristjanson et al. 2017; Maru 2018).

Policy: while we did not observe any study that directly questioned or assessed whether and how an AR4D program or intervention has affected policy, the AR4D literature reviewed repeatedly touched on improved policies and increased political capacity as possible outcomes of AR4D programs or interventions. This includes the institutional anchoring of innovation or solution resulting from AR4D (Seifu et al. 2020), whether it is affordable for government (Seifu et al. 2020), or the extent to which it contributes to increased equity (Torres et al. 2000).

Clusters of conditions observed in the literature

Like the outcomes, the causal conditions towards AR4D outcomes are often not clearly delineated in the literature. However, for analytical clarity we have unpacked the causal conditions observed in the literature and have grouped them into the following clusters that broadly capture the design of programs and interventions, the actors (that is, the organisations and individuals) involved, and their context:

Theory of change (ToC): one of the most recurring conditions mentioned as being required for (or at least related to) successful AR4D programs or interventions is to have ToC at program or intervention level. A ToC is a set of hypotheses about how change can be brought about, stabilised and amplified (Cadilhon et al. 2015; Douthwaite et al. 2020; Maru 2018; Maru, Sparrow, Stirzaker, et al. 2018; Mayne and Johnson 2015; Mayne and Stern 2013; Mayne et al. 2013; McDonald 2019; Norton and Raitzer 2009; Schut et al. 2019; Vermeulen and Campbell 2015). Ideally, a ToC presents a clear set of relationships between the program or intervention and its intended outcome(s) and is communicated with stakeholders (Maru, Sparrow, Butler, et al. 2018).

It is suggested to use this ToC ex ante to plan the program (Douthwaite et al. 2020); to update the ToC during program implementation if necessary (Adewale et al. 2013; Baur et al. 2003; Douthwaite et al. 2020; Douthwaite et al. 2009; Maredia et al. 2014); and to use the ToC ex post in program evaluations (Douthwaite et al. 2020; Maredia et al. 2014). Ideally, a ToC is developed and applied in a participatory process with stakeholders and beneficiaries (Douthwaite et al. 2020; Maru, Sparrow, Butler, et al. 2018). A relevant aspect of the ToC is that it helps in planning and monitoring the progress of the program (Barzola Iza et al. 2020). A ToC should be program (or intervention) *and* context specific; there are no 'one size fits all' ToCs (Maredia et al. 2014).

Technical competencies: a deliberate focus on change in agricultural technology and practices is expected (and often found) to be central to successful AR4D programs and interventions. This includes the adoption of (improved and innovative) agricultural technology (Bayala et al. 2017; Cadilhon et al. 2015; Kramer et al. 2019; Maredia et al. 2014; Schut et al. 2020; Shideed 2017) and practices (Barzola Iza et al. 2020; Bayala et al. 2017; Cadilhon et al. 2015). It also includes the development of innovative technology and practices (Afriat et al. 2015; Tomich, Lidder, Dijkman, et al. 2019). Ideally, an integrated or collaborative approach to introducing new technologies is chosen (McDonald 2019). The type of innovation (continuous, discontinuous, or disruptive) may affect its uptake and impact on program or intervention outcomes (Sumberg et al. 2013).

Professional competencies: another obvious condition that is expected (and often found) to be central to successful AR4D programs and interventions is a deliberative change in agricultural skills and behaviour (Barzola Iza et al. 2020; Mayne and Johnson 2015; Oborn et al. 2017; Tomich, Lidder, Dijkman, et al. 2019). This includes the development of entrepreneurial and management skills of beneficiaries and communication skills and practices of stakeholders (Barzola Iza et al. 2020; Bayala et al. 2017).

System focus: while the previous 2 conditions are, effectively, about different parts of broader systems that are addressed by AR4D programs and interventions, the broader literature recommends to target systems as a whole, rather than in parts (Afriat et al. 2015; Barzola Iza et al. 2020; Maru 2018; Maru, Sparrow, Stirzaker, et al. 2018). An example of such a system is the value chain for products or services. To improve this system, it is advised to seek increased inclusion of beneficiaries in the whole value chain (Barzola Iza et al. 2020), raise their social capital across the whole value chain (Maru 2018), or aim to reduce market imperfections across the whole value chain (Tomich, Lidder, Dijkman et al. 2019).

Pull interventions: somewhat related to the above, the AR4D literature suggests that it is better to focus on pull programs and interventions rather than push programs and interventions (Anandajayasekeram et al. 2009; Schut et al. 2020). This includes self-organisation and a focus on internal motivations (Schut et al. 2020) and interactive problem solving processes (Seifu et al. 2020). For example, better program or intervention results may be expected when such programs and interventions are developed 'by' or 'with' users and beneficiaries than when they are developed 'for' them (Sumberg et al. 2013). The literature generally advises against traditional, top-down programs or interventions in which an aid organisation 'pushes' a solution (Cadilhon et al. 2015; Jones et al. 2014; Lele et al. 2010; Maredia et al. 2014). Another way of looking at this is to focus on 'demand driven research' (Dinesh et al. 2018; Maru, Sparrow, Stirzaker, et al. 2018). Ideally, AR4D research provides solutions opportunistically (in a positive sense of the word) to problems brought to the attention of aid organisations by beneficiaries, rather than aid organisations providing research in a top-down (supply driven) manner (Dinesh et al. 2018). For example, rather than starting new programs or interventions, aid organisations may join existing ones (Dinesh et al. 2018).

Program stability: another design condition that is repeatedly mentioned as a condition for success is the extent to which an A4RD program or initiative is stable. This includes stability in the staff and leadership of aid organisations and partner organisations (Schut et al. 2020), as well as coherent and consistent approaches to documentation, reporting, analysis, and feedback (Sartas et al. 2017). Standardised (or at least, similarly understood) vocabularies (over time and across geographies) and data or data conversion may aid program stability (Caracciolo and Keizer 2012; Norton and Raitzer 2009).

Program capacity: the extent to which an A4RD program or initiative has sufficient capacity is repeatedly mentioned as a condition for success (Caracciolo and Keizer 2012; Lele et al. 2010; Schut et al. 2017; Tomich, Lidder, Dijkman, et al. 2019). This asks for staff and leadership of aid organisations and partner organisations to have the skills and capacity to implement the program or intervention, and it asks for adequate funding for the implementation of the program (Schut et al. 2019). Capacity building of staff and leadership may be required over the duration of the program (Clavel 2014; Douthwaite et al. 2009; Mayne and Stern 2013; Temple et al. 2018); for example, increasing the capacity of participating (local) researchers (Dinesh et al. 2018; Mayne and Johnson 2015).

Quality of programs (and the platforms or networks through which they are delivered) matter: good communication, organisation, facilitation and documentation all affect the program or intervention's outcomes (Schut et al. 2018), and it is important that all participants have the capacity to critically reflect on program or intervention progress and performance (Badstue et al. 2020). It is recommended to not only invest in but to also monitor capacity enhancement (Dinesh et al. 2018).

Program incentives: a final design condition that is expected to contribute to the success of AR4D programs or interventions are program incentives (Dinesh et al. 2018). This includes financial and non-financial incentives the program provides to beneficiaries and stakeholders, as well as how well these incentives fit within the context of the program. Incentives can be direct monetary support, such as agricultural subsidies, but can also be something that helps in risk reduction, such as agricultural insurance (Kramer et al. 2019). Ideally, resources and incentives are allocated in (roughly) one-third to research, one-third to engaging with next users and one-third to improving the capacity of next users for research uptake (Adewale et al. 2013; Dinesh et al. 2018; Douthwaite et al. 2009; Vermeulen and Campbell 2015). An alternative view is to aim for 'best bet' programs or interventions (those that will yield the best outcomes within the shortest amount of time) rather than 'perfect' interventions (McDonald 2019; Raitzer and Norton 2009).

Multi-stakeholder networks or platforms: considering the actors involved in AR4D programs and interventions, a condition mentioned repeatedly for success is multi-stakeholder networks or platforms (Adewale et al. 2013; Anandajayasekeram et al. 2009; Barzola Iza et al. 2020; Bayala et al. 2017; Cadilhon et al. 2015; Douthwaite et al. 2009; Jones et al. 2014; Maatman et al. 2011; Mayne and Stern 2013; Oborn et al. 2017; Sartas et al. 2017; Schut et al. 2017; Schut et al. 2015; Schut et al. 2019; Schut et al. 2020; Tomich, Lidder, Dijkman, et al. 2019; Torres et al. 2000). This includes a focus on bilateral (rather than unilateral) partnerships and partnerships between more than 2 parties (Schut et al. 2020; Tomich, Lidder, Dijkman, et al. 2019). Multi-stakeholder networks or platforms can be virtual (for example, email, online forums, website), physical (for example, a space for regular meetings), or both, and should support knowledge sharing and decision-making across stakeholders (Barzola Iza et al. 2020; Caracciolo and Keizer 2012), as well as multi-actor learning (Schut et al. 2019; Seifu et al. 2020).

Network or platform partners could include the financial and insurance industry, social science and climate science scholars, and agriculture stakeholders (Kramer et al. 2019). Working with intermediaries (organisations and individuals that operate between aid organisations and beneficiaries) in these networks or platforms is recommended (Mayne and Johnson 2015). Ideally, such networks or platforms are developed to be fit for purpose (Adewale et al. 2013; Schut et al. 2017; Schut et al. 2019). This includes a focus on achieving and maintaining trust between partners, as well as a balancing of powers between partners (Schut et al. 2020). An important role for the aid organisation is to build common ground and networks among stakeholders (Barzola Iza et al. 2020). It is suggested to address individual and collective capabilities for agriculture and natural resource management in these networks or platforms, such as available technologies, jobs, education and ICT (Badstue et al. 2020).

Institutions and politics: related to the above, it is repeatedly suggested to pursue explicit political and institutional support within the local or regional context of the AR4D program or intervention (Cadilhon et al. 2015; Schut et al. 2020; Tomich, Lidder, Dijkman, et al. 2019) and to pursue change in that institutional environment (Afriat et al. 2015; Anandajayasekeram et al. 2009; Maru 2018; Schut et al. 2020; Vermeulen and Campbell 2015). For example, by addressing critical inflexion points (interventions with the largest input-impact ratio), using windows of opportunity, or strategic lobbying and negotiation at the level of key regime authorities (Dinesh et al. 2018; Norton and Raitzer 2009; Seifu et al. 2020), changes can be sought in the policy context as well as in regulatory regimes (Kramer et al. 2019). Public policy analysis can be used to identify relevant aspects of the institutional environment to target (Temple et al. 2018). It is suggested to focus on institutional constraints faced by smallholders in particular (Maru, Sparrow, Stirzaker, et al. 2018). It is noted that pursuing change in the institutional environment could imply a reduction in institutional barriers, as well as improved institutional capacities (Oborn et al. 2017). Political and institutional support may be sought and strengthened through co-learning and policy engagement throughout the program/intervention (Dinesh et al. 2018; Vermeulen and Campbell 2015). Political and institutional support is required at all levels (local, regional, national, and international), but not necessarily at all levels at the same time (Shideed 2017).

Context sensitivity: the extent to which an A4RD program or initiative is sensitive to its context is mentioned repeatedly as another condition for success (Adewale et al. 2013; Anandajayasekeram et al. 2009; Bayala et al. 2017; Maatman et al. 2011; Maru 2018; Schut et al. 2020; Tomich, Lidder, Coley, et al. 2019; Tomich, Lidder, Dijkman, et al. 2019). This requires that program or intervention designs need to be flexible to be adapted to local circumstances (Schut et al. 2020). For example, a variety of tools may be suggested both at the start and throughout the program or intervention to better reflect the (research) context (Sartas et al. 2017; Temple et al. 2018). Ideally, programs or interventions integrate scientific and local or Indigenous knowledge (Cadilhon et al. 2015; Oborn et al. 2017; Schut et al. 2018).

Multi-scalar programs or interventions: the AR4D literature suggests that it is better to address multiple levels than single ones through AR4D programs and interventions (Adewale et al. 2013; Douthwaite et al. 2009; Mayne and Stern 2013; Shideed 2017; Thornton et al. 2006; Tomich, Lidder, Coley, et al. 2019; Torres et al. 2000); in other words, combinations of the local, regional, national, and international levels (Shideed 2017). The logic underpinning this suggestion is that many of the problems that are being addressed through AR4D programs and interventions are complex and likely require simultaneous actions at different levels (Anandajayasekeram et al. 2009; Baur et al. 2003; Oborn et al. 2017).

Gender: as seen in the evaluated outcomes, various gender issues are gaining traction in more recent AR4D literature and are being discussed as a contributing condition to AR4D program or initiative success (Adewale et al. 2013; Afriat et al. 2015; Dinesh et al. 2018; Kristjanson et al. 2017; Maru 2018). These issues include local gender norms, visible symbols of gender inequality, the local climate for social inclusion or exclusion and the engagement of both women and men in AR4D programs or interventions (Badstue et al. 2020). These gender issues cut across the broad themes of program design conditions, actor conditions, and context conditions.

Complex causation

It was not the aim of the review to identify situations of conjunctural causation (a situation where multiple conditions interact towards an outcome; see Chapter 2) and equifinality (a situation where an outcome can be the result of different independent conditions, or different independent configurations of conditions; see Chapter 2) in the AR4D literature. However, we observed that all the outcomes identified were linked to different conditions (equifinality), to configurations of conditions (conjunctural causation), and often different configurations of conditions (multiple conjunctural causation; a combination of equifinality and conjunctural causation).

Table A1 provides an overview of the most common causal relationships between outcomes and conditions that were explicitly mentioned in the AR4D literature reviewed. The image of complex causation between conditions and outcomes in AR4D projects and intervention presented in Table A1 is supported by central insights presented in the literature reviewed.

To paraphrase some of these:

International AR4D is subject to a paradigm shift. The reduction of poverty and increased food security is now closely linked with environmental sustainability. This indicates that there are no 'easy' pathways to achieve individual outcomes. Uncertainty and complex causal relationships in the outcomes of AR4D programs or interventions do not allow for 'clear-cut' pathways or decisions (Raitzer and Norton 2009).

While it is generally assumed that user involvement will yield better AR4D outcomes, it depends on how user involvement interacts with other (sometimes tightly coupled) factors (Sumberg et al. 2013).

Causal relations between AR4D programs and interventions and any observed impact are complex. AR4D efforts are often likely a contributory rather than a sole cause. They are part of a sufficient causal package of conditions that contribute to the desired result (Mayne and Johnson 2015).

Table A1 Most common causal relationships between conditions and outcomes explicitly mentioned in the literature

	Outcomes								
Conditions	**Innovations systems**	**Science and knowledge**	**Sustainable development**	**Reduction of poverty**	**Reduction of hunger**	**Health and wellbeing**	**Productivity and income**	**Gender**	**Political**
Theory of Change		x	x			x			x
Technical competencies		x	x	x	x		x		
Professional competencies		x		x					
System focus				x		x			
Pull interventions	x			x	x				
Program stability				x	x				
Program capacity		x	x	x	x			x	
Program incentives			x	x	x		x	x	
Multi-stakeholder networks or platforms		x	x	x	x		x		x
Multi-scalar programs or interventions			x	x			x		
Institutions and politics	x	x	x	x	x				x
Context sensitivity		x	x	x	x				
Gender	x		x	x		x		x	

Note: all causal relationships identified assume a positive interaction between condition and outcome(s).

It is relevant to improve our understanding of impact pathways of AR4D programs and interventions because of the complex interactions the diverse actors involved in AR4D programs and interventions and the impact of context on the success of these programs or interventions (Temple et al. 2018).

Similar AR4D programs and interventions may have different levels of success depending on contextual conditions and these contextual conditions can change the impact of programs and interventions over time (Tomich, Lidder, Coley, et al. 2019).

It is unlikely to find independent, linear pathways that explain how AR4D programs and interventions achieve their outcomes. It is better to think of these and represent them as causal relationships across complementary AR4D factors (Tomich, Lidder, Dijkman, et al. 2019).

Conclusion

The previous sections have presented the findings from an evidence synthesis of the AR4D literature that aimed to distil the most commonly mentioned AR4D project and intervention outcomes and their causal conditions. The outcomes and conditions identified here, together with those of the 'experiential selection' (see Chapter 2), have resulted in the final set used throughout this study. Table A2 summarises how the insights from the AR4D literature have informed the final set of conditions and outcomes.

Three insights are worth stressing here. First, the overall coherence in outcomes and conditions observed in the literature. Second, the explicit and repeated referral to complex causation in AR4D programs and interventions. Third, a call on researchers to use innovative methods, such as QCA, to better understand how conditions combine to bring about the outcomes of AR4D programs and interventions (Mayne and Stern 2013; Raitzer and Norton 2009; Stern et al. 2012; Temple et al. 2016).

Table A2 Relationship between outcomes and conditions mentioned in the literature and those used in this study

Outcomes and conditions	Informed by literature on…
Outcomes used	
Innovations Systems	Innovations systems
Science and Knowledge	Science and knowledge
Natural Resource Management	Sustainable development
Policy	Political topics
Socioeconomic	Reduction of poverty, reduction of hunger, health and wellbeing
Causal conditions used	
Context alignment	Pull interventions, institutions and politics, context sensitivity
Project continuity	Program stability
Project focus	System focus, multi-scalar programs or interventions
Project size	Program capacity, program incentives
Project design quality	Theory of Change
Project transition quality	Program capacity, multi-stakeholder networks or platforms
Technical competencies	Technical competencies
Professional competencies	Professional competencies

Note: Source documents for the impact assessment provided too little data to allow for an inclusion of gender related conditions or outcomes (see Chapter 2).

Appendix 2: A stepwise explanation of the application of QCA in this study

In Chapter 2 we explain our rationale for choosing QCA and in Appendix 4 through Appendix 6 we present the findings for the various QCA analyses and the data they build on. Because QCA will be a novel approach to data analysis for some readers, we present here a slightly more extensive discussion of the various steps taken in the various analyses. This appendix also targets those readers with a good understanding of QCA who may feel that Appendix 4 through Appendix 6 lack some depth. For them, we include a crisp-set QCA (csQCA) of the outcome 'Science and Knowledge'. The csQCA for this outcome can be considered a robustness test for the study (Schneider and Wagemann 2013).[23]

The fundamentals and background of the method are explained and documented in a series of textbooks (Goertz and Mahony 2012; Ragin 2008; Rihoux and Ragin 2009; Schneider and Wagemann 2013). These handbooks are useful references for those unfamiliar with the foundations of the method and who wish to learn more. The handbooks provide guidelines for QCA practice (Ragin 2008: see in particular the 'practical appendices'; Rihoux and Ragin 2009: Chapter 5; Schneider and Wagemann 2013: Chapter 11), which we have followed closely in conducting the analyses discussed in this report. One of the fundamental points for QCA practice is for the researcher to provide as much transparency in the analysis as possible.

Providing transparency is what we seek to provide by means of this appendix. We follow the 'flowchart' of Jerry Mendel and Mohammad Korjani (Mendel and Korjani 2013) who, supported by Charles Ragin, have mathematically summarised QCA as a collection of 13 steps. We do, however, take the liberty of using the jargon from the handbooks (as opposed to the mathematical jargon introduced by Mendel and Korjani) to clarify and reduce the steps to 10 stages.

In addition to Mendel and Korjani's steps regarding *how* the QCA analysis is carried out, it is, of course, of importance to consider *why* QCA was chosen in the first place. While researchers often support their choice for QCA with a practical motivation (for example, claiming they have a medium number of cases that are likely to allow for systematic cross-case analysis, but not for sophisticated statistical analysis), QCA is ideally chosen because of a theoretical motivation (Schneider and Wagemann 2013). We have added a step that recognises motivations for choosing QCA, which is the issue we begin with in what follows.

Step 1: Why apply QCA in this study?

As explained in Chapter 2, the broader AR4D literature indicates that AR4D outcomes are often the result of a range of conditions working together, or working together with contextual conditions (see Appendix 1). These causal conditions all contribute to AR4D outcomes (or lack thereof) but do not cause the outcomes themselves. This is known as conjunctural causation. At the same time, the broader AR4D literature indicates that a single AR4D outcome (for example, innovations networks, science and knowledge products, improved natural resource management, changed policy or improved socioeconomic status of farmers) may be caused by different sets of interacting conditions. In other words, there may be different pathways of interacting conditions leading to the same AR4D outcome. This is known as equifinality. ACIAR staff and stakeholders confirmed that in ACIAR practice they also experience conjunctural causation and equifinality to be at play.

QCA is typically chosen as a data analysis methodology because it assists researchers in 'unravelling causally complex patterns in terms of equifinality, conjunctural causation, and asymmetry' (Schneider and Wagemann 2013: 8). QCA helps to trace patterns of association between these conditions in a highly systemised manner. It enables systematic comparison between empirical observations (cross-case) while allowing for in-depth, within-case understanding of individual observations (Rihoux and Ragin 2009). As we have already explained in Chapter 2, QCA differs from other data analysis methods in its focus:

> *The key issue [for QCA] is not which variable is the strongest (that is, has the biggest net effect) but how different conditions combine and whether there is only one combination or several different combinations of conditions (causal recipes) of generating the same outcome.* (Ragin 2008: 114)

We have chosen fuzzy-set QCA (fsQCA) for our analyses because it allows us to best capture the qualitative differences in project outcomes and conditions of the ACIAR-supported projects that we have included in the impact assessment. The size of our dataset, 49 ACIAR-supported projects, is suitable for fsQCA application (Berg-Schlosser 2012).

23 This outcome was chosen for the robustness test because the fuzzy-set QCA (fsQCA) for it resulted in the broadest variety of pathways, all of which recur in the concluding chapter (see further Chapter 4 and Chapter 8).

Please note: in this appendix we present a crisp-set QCA (csQCA) as a robustness test for the fsQCA findings that we present in the main text of this report. The steps taken are the same for both types of analyses. Effectively, csQCA is a special form of fsQCA that works with dichotomised (rather than fuzzy) data (Schneider and Wagemann 2013).

Step 2: Selection of outcome of interest and cases to study

In Chapter 2 we explain the motivations for the 5 outcomes of interest that are central to this study: Innovations Systems, Science and Knowledge, Natural Resource Management, Policy, and Socioeconomic.

In Chapter 2 we also explain how we have arrived at the final set of 49 projects from the original database of 106 ACIAR-supported projects.

Step 3: Select *k* causal conditions

In Chapter 2 we explain the motivations for the 8 causal conditions that are central to this study: context alignment, project continuity, project focus, project size, project design quality, project transition quality, technical competencies, and professional competencies.

Step 4: Calibration of set-membership scores for outcomes and conditions

An important step in every QCA application is to transform the raw input data to data that can be processed with QCA tools; this process is known as 'data calibration'. In practical terms, this means that (i) each case (here, ACIAR-funded projects) is unpacked into the outcomes and the conditions of interest, *and* (ii) for each case, its outcomes and conditions are assigned to a category (a 'set') that best captures their qualitative (and sometimes quantitative) status. For example, a real-world case may be unpacked analytically as having 'low quality status for condition A', 'high quality status for condition B', 'medium quality status for condition C', and 'moderate presence of outcome X'. Thus, this case is part of the set of cases in the full dataset that all have a low quality status for condition A, while other sets of cases in that same dataset could have a modest, moderate, or high quality status for condition A.

It is essential that the sets to which the outcomes and conditions of cases can be assigned allow for capturing the qualitative differences among all the cases in the full dataset. Established QCA practice requires the researcher to be clear about how they calibrate their data. In particular, they need to explain the 2 extremes of the observed data (that is, maximum and minimum parameters in a category), and the crossover point in the data (that is, the stage at which the data is considered to have maximum ambiguity – when it is as much within a determined category as it is external to it) (Rihoux and Ragin 2009; Schneider and Wagemann 2013). In Chapter 2 we explain how we have come to the calibration descriptors for this study, and in Appendix 3 we present these descriptors.

Step 5: Create a raw data matrix

Now that the various qualitative differences of the outcomes and conditions have been distinguished, the data can be transformed into a raw data matrix. The raw data matrix illustrates to which sets the outcomes and conditions observed in cases have been assigned. Because we have used 4 qualitative categories to distinguish qualitative differences in our data, the raw data matrices in Appendix 4 through Appendix 7 present 4 numerical descriptors that represent these qualitative differences ('0.00', '0.33', '0.67', and '1.00'). It is important to stress that these numerical descriptors are *qualitative descriptors* of the data rather than a 'mere' quantification of the data (Schneider and Wagemann 2013).

Because csQCA only uses dichotomous input data, the raw data matrix for a csQCA uses 2 numerical descriptors that illustrate to which sets the outcomes and conditions observed in cases have been assigned ('0' or '1'). For the robustness test of the findings for the outcome Science and Knowledge, we have transformed our fsQCA data to csQCA data in a straightforward manner: we have clustered the 2 sets on each side of the crossover point into a single set. Thus, outcomes and conditions that were observed to show the small, medium, weak, low, and modest qualitative statuses represented by the numerical descriptor '0.00' or '0.33' are now represented by the numerical descriptor '0' (indicating that it is more absent that present, or even fully absent). Outcomes and conditions that were observed to show the (very) large, moderate, high, and strong qualitative statuses represented by the numerical descriptor '0.67' or '1.00' are now represented by the numerical descriptor '1' (indicating that it is more present than absent, or even fully present).[24] Table A3 presents the raw data matrix using fsQCA scores and Table A4 using csQCA scores.

24 For the condition Project Focus, the '0' descriptor indicates 'more micro than macro' and the '1' descriptor indicates 'more macro than micro'.

Table A3 Raw data matrix for fsQCA

	Conditions												Outcomes	
Project	Cont	PrC	PrF	PDQ	PrS	PTQ	Tcom	Pcom	InSy	NRM	Pol	SoEc	ScKn	NoP
ADP/1998/095	1.00	0.33	0.33	0.67	0.33	0.33	0.67	0.33	0.33	0.00	0.33	0.00	0.00	0.33
ADP/2007/055	1.00	1.00	0.33	1.00	0.33	0.67	0.33	0.67	0.67	0.33	0.67	0.00	0.67	0.67
AGB/2002/086	0.67	1.00	0.33	1.00	1.00	0.33	1.00	1.00	0.67	0.00	0.00	0.33	0.67	0.00
AH/2002/038	0.67	1.00	0.33	0.67	0.33	1.00	1.00	0.67	0.67	0.00	0.33	0.33	1.00	0.33
AH/2010/019	0.67	1.00	0.33	1.00	1.00	1.00	0.33	0.33	0.67	0.00	0.67	0.33	1.00	0.67
AS1/1997/069	0.67	0.00	0.67	0.33	1.00	0.33	0.33	0.00	0.00	0.33	0.00	0.00	0.33	0.33
AS1/1998/010	0.00	0.67	0.00	0.33	1.00	0.00	0.33	0.33	0.33	0.00	0.00	0.67	0.67	0.00
ASEM/1995/119	1.00	0.33	0.33	1.00	1.00	0.33	1.00	1.00	0.67	0.67	0.00	1.00	0.67	0.67
ASEM/1996/044	1.00	0.00	0.67	0.67	0.33	0.33	0.67	0.00	0.67	0.00	0.33	0.00	0.67	0.33
ASEM/1998/060	1.00	1.00	0.67	0.33	0.67	0.33	0.33	0.00	0.33	0.00	0.33	0.00	0.67	0.33
ASEM/2002/051	1.00	1.00	0.33	1.00	0.67	1.00	0.33	1.00	1.00	1.00	1.00	1.00	0.67	1.00
ASEM/2003/015	1.00	1.00	0.67	0.67	0.33	0.67	1.00	1.00	0.67	0.67	0.00	0.67	0.67	0.67
ASEM/2004/042	1.00	0.33	0.67	1.00	0.33	1.00	0.33	0.33	0.33	0.00	0.00	0.67	0.00	0.00
CIM/2006/094	1.00	0.67	1.00	1.00	0.00	1.00	0.33	1.00	0.67	0.67	0.00	0.67	0.67	0.67
CP/1996/091	0.00	1.00	0.00	0.33	0.67	0.33	0.67	0.00	0.67	0.67	0.00	1.00	0.67	0.67
CP/1997/017	0.67	0.67	0.67	0.67	1.00	0.67	1.00	0.33	0.67	0.00	1.00	0.33	1.00	1.00
CP/2000/044	1.00	0.00	0.67	0.33	0.67	0.67	0.33	0.00	0.33	0.67	0.00	0.67	0.00	0.67
CS1/1994/039	0.00	1.00	0.00	0.33	1.00	0.00	0.67	0.00	0.33	0.33	0.00	0.00	0.67	0.00
CS1/1997/114	0.67	1.00	0.00	0.67	0.33	0.67	0.67	0.00	0.33	0.67	0.00	0.33	1.00	0.67
CS2/1996/176	0.00	0.33	0.33	0.33	1.00	0.33	0.33	0.33	0.67	0.33	0.00	0.00	1.00	0.00
CSE/2006/041	1.00	0.67	0.67	0.67	1.00	1.00	0.67	1.00	0.67	0.00	0.67	0.67	1.00	0.67
FIS/1998/024	0.67	0.00	0.67	1.00	0.67	0.67	1.00	0.00	0.67	0.67	1.00	0.00	0.67	1.00
FIS/2006/141	0.67	0.33	0.00	0.33	1.00	0.67	1.00	0.00	0.67	1.00	0.00	0.67	1.00	1.00
FST/1994/041	0.67	0.33	0.00	0.33	0.67	0.33	0.33	0.00	0.67	0.67	0.00	0.33	0.33	0.67
FST/2000/001	1.00	0.33	0.33	0.67	0.67	0.00	1.00	0.67	0.67	0.67	0.67	0.67	1.00	0.67
FST/2004/050	0.67	0.67	1.00	1.00	1.00	1.00	1.00	0.33	0.67	0.00	0.67	0.33	0.67	0.67
FST/2005/177	0.67	0.33	0.67	1.00	1.00	0.33	1.00	0.67	1.00	0.00	0.67	0.67	0.67	0.67
FST/2006/117	0.33	0.67	0.67	0.67	1.00	0.33	0.67	0.00	1.00	0.67	0.00	1.00	1.00	0.67
FST/2007/119	0.67	1.00	0.33	0.67	1.00	0.33	0.67	0.00	0.67	0.00	1.00	0.67	1.00	1.00
HORT/2000/043	0.67	1.00	0.00	0.67	0.00	0.33	0.67	0.00	0.67	0.67	0.33	0.00	1.00	0.67
LPS/2003/054	1.00	0.67	1.00	0.67	0.00	1.00	0.67	0.67	1.00	0.00	0.67	0.67	0.67	0.67
LWR1/1994/046	0.33	0.00	0.00	1.00	1.00	1.00	0.67	0.33	1.00	0.67	0.33	0.00	1.00	0.67
LWR1/1994/054	0.67	1.00	0.00	1.00	1.00	0.33	0.67	0.33	0.67	1.00	0.67	0.67	1.00	1.00
LWR/1997/016	0.67	0.00	0.00	0.67	0.67	0.33	1.00	0.00	0.33	0.67	1.00	0.00	0.00	1.00
LWR/1998/003	0.67	0.00	0.33	0.67	1.00	1.00	1.00	0.33	0.67	0.00	0.67	0.33	0.67	0.67
LWR/1998/124	0.67	0.00	0.00	0.67	1.00	0.67	1.00	0.33	0.33	0.67	0.33	0.33	0.67	0.67

Table A3 Raw data matrix for fsQCA *(continued)*

	Conditions												Outcomes	
Project	**Cont**	**PrC**	**PrF**	**PDQ**	**PrS**	**PTQ**	**Tcom**	**Pcom**	**InSy**	**NRM**	**Pol**	**SoEc**	**ScKn**	**NoP**
LWR/2001/003	1.00	0.00	0.67	1.00	1.00	0.67	1.00	0.33	0.67	1.00	0.33	0.67	0.00	1.00
LWR/2002/094	0.33	0.33	0.67	1.00	0.67	0.67	0.67	0.00	0.67	0.33	0.33	0.00	0.67	0.33
LWR/2005/146	1.00	0.33	0.67	1.00	1.00	1.00	1.00	0.67	0.67	0.67	0.67	1.00	1.00	0.67
LWR/2006/158	1.00	0.67	0.00	0.67	1.00	0.67	0.67	0.33	0.67	1.00	0.67	1.00	1.00	1.00
LWR2/1994/032	0.67	0.00	0.67	0.33	1.00	0.33	0.33	0.00	0.33	0.00	0.00	0.00	0.33	0.00
LWR2/1994/035	0.33	0.33	0.67	0.33	1.00	1.00	0.67	0.33	0.67	0.33	0.67	0.33	1.00	0.67
LWR2/1996/080	0.33	0.00	0.00	0.67	0.67	1.00	0.67	0.00	0.33	0.67	0.00	0.00	1.00	0.67
PHT/1996/004	0.33	0.33	0.00	0.33	1.00	1.00	1.00	0.33	1.00	0.00	0.67	0.67	1.00	0.67
SMAR/2006/096	1.00	0.67	1.00	1.00	1.00	1.00	0.33	1.00	1.00	0.00	0.67	0.67	0.33	0.67
SMC/2003/011	0.33	0.00	0.67	0.67	0.00	1.00	0.67	0.67	0.67	0.67	0.00	0.67	0.33	0.67
SMCN/2002/033	0.67	0.33	0.33	0.33	0.67	0.33	0.33	0.00	0.67	0.00	0.33	0.00	1.00	0.33
SMCN/2002/085	0.33	0.67	0.67	0.67	0.00	0.67	0.67	0.67	1.00	1.00	0.00	0.67	0.33	1.00
SMCN/2003/010	1.00	0.33	1.00	1.00	0.67	1.00	1.00	0.00	1.00	0.67	0.00	1.00	0.00	0.67

Abbreviations: Cont = Context alignment; PrC = Project Continuity; PrF = Project Focus; PDQ = Project Design Quality; PrS = Project Size; PTQ = Project Transition Quality; Tcom = Technical competencies; Pcom = Professional competencies; InSy = Innovations Systems; NRM = Natural Resource Management; Pol = Policy; SoEc = Socioeconomic; ScKn = Science and Knowledge; NoP = Natural Resource Management (NRM) or Policy

Table A4 Raw data matrix for csQCA

	Conditions												Outcomes	
Project	Cont	PrC	PrF	PDQ	PrS	PTQ	Tcom	Pcom	InSy	NRM	Pol	SoEc	ScKn	NoP
ADP/1998/095	1	0	0	1	0	0	1	0	0	0	0	0	0	0
ADP/2007/055	1	1	0	1	0	1	0	1	1	0	1	0	1	1
AGB/2002/086	1	1	0	1	1	0	1	1	1	0	0	0	1	0
AH/2002/038	1	1	0	1	0	1	1	1	1	0	0	0	1	0
AH/2010/019	1	1	0	1	1	1	0	0	1	0	1	0	1	1
AS1/1997/069	1	0	1	0	1	0	0	0	0	0	0	0	0	0
AS1/1998/010	0	1	0	0	1	0	0	0	0	0	0	1	1	0
ASEM/1995/119	1	0	0	1	1	0	1	1	1	1	0	1	1	1
ASEM/1996/044	1	0	1	1	0	0	1	0	1	0	0	0	1	0
ASEM/1998/060	1	1	1	0	1	0	0	0	0	0	0	0	1	0
ASEM/2002/051	1	1	0	1	1	1	0	1	1	1	1	1	1	1
ASEM/2003/015	1	1	1	1	0	1	1	1	1	1	0	1	1	1
ASEM/2004/042	1	0	1	1	0	1	0	0	0	0	0	1	0	0
CIM/2006/094	1	1	1	1	0	1	0	1	1	1	0	1	1	1
CP/1996/091	0	1	0	0	1	0	1	0	1	1	0	1	1	1
CP/1997/017	1	1	1	1	1	1	1	0	1	0	1	0	1	1
CP/2000/044	1	0	1	0	1	1	0	0	0	1	0	1	0	1
CS1/1994/039	0	1	0	0	1	0	1	0	0	0	0	0	1	0
CS1/1997/114	1	1	0	1	0	1	1	0	0	1	0	0	1	1
CS2/1996/176	0	0	0	0	1	0	0	0	1	0	0	0	1	0
CSE/2006/041	1	1	1	1	1	1	1	1	1	0	1	1	1	1
FIS/1998/024	1	0	1	1	1	1	1	0	1	1	1	0	1	1
FIS/2006/141	1	0	0	0	1	1	1	0	1	1	0	1	1	1
FST/1994/041	1	0	0	0	1	0	0	0	1	1	0	0	0	1
FST/2000/001	1	0	0	1	1	0	1	1	1	1	1	1	1	1
FST/2004/050	1	1	1	1	1	1	1	0	1	0	1	0	1	1
FST/2005/177	1	0	1	1	1	0	1	1	1	0	1	1	1	1
FST/2006/117	0	1	1	1	1	0	1	0	1	1	0	1	1	1
FST/2007/119	1	1	0	1	1	0	1	0	1	0	1	1	1	1
HORT/2000/043	1	1	0	1	0	0	1	0	1	1	0	0	1	1
LPS/2003/054	1	1	1	1	0	1	1	1	1	0	1	1	1	1
LWR1/1994/046	0	0	0	1	1	1	1	0	1	1	0	0	1	1
LWR1/1994/054	1	1	0	1	1	0	1	0	1	1	1	1	1	1
LWR/1997/016	1	0	0	1	1	0	1	0	0	1	1	0	0	1
LWR/1998/003	1	0	0	1	1	1	1	0	1	0	1	0	1	1
LWR/1998/124	1	0	0	1	1	1	1	0	0	1	0	0	1	1

Table A4 Raw data matrix for csQCA *(continued)*

	Conditions											Outcomes		
Project	**Cont**	**PrC**	**PrF**	**PDQ**	**PrS**	**PTQ**	**Tcom**	**Pcom**	**InSy**	**NRM**	**Pol**	**SoEc**	**ScKn**	**NoP**
LWR/2001/003	1	0	1	1	1	1	1	0	1	1	0	1	0	1
LWR/2002/094	0	0	1	1	1	1	1	0	1	0	0	0	1	0
LWR/2005/146	1	0	1	1	1	1	1	1	1	1	1	1	1	1
LWR/2006/158	1	1	0	1	1	1	1	0	1	1	1	1	1	1
LWR2/1994/032	1	0	1	0	1	0	0	0	0	0	0	0	0	0
LWR2/1994/035	0	0	1	0	1	1	1	0	1	0	1	0	1	1
LWR2/1996/080	0	0	0	1	1	1	1	0	0	1	0	0	1	1
PHT/1996/004	0	0	0	0	1	1	1	0	1	0	1	1	1	1
SMAR/2006/096	1	1	1	1	1	1	0	1	1	0	1	1	0	1
SMC/2003/011	0	0	1	1	0	1	1	1	1	1	0	1	0	1
SMCN/2002/033	1	0	0	0	1	0	0	0	1	0	0	0	1	0
SMCN/2002/085	0	1	1	1	0	1	1	1	1	1	0	1	0	1
SMCN/2003/010	1	0	1	1	1	1	1	0	1	1	0	1	0	1

Abbreviations: As per Table A3.

Step 6: Analysis of necessary conditions

Following established QCA practice, the data are first analysed for necessary conditions before exposing them to more complex analysis in order to identify configurations of sufficient conditions (Rihoux and Ragin 2009: Chapter 5, Box 8.1; Schneider and Wagemann 2013: Chapter 11). For a condition to be necessary for causing the outcome, the membership scores of the outcome need to be a perfect subset of the membership scores of the condition.

The results for the analyses of necessary conditions for the 5 outcomes are presented in Appendix 4 through Appendix 7. None of the conditions was found to be necessary for any of the outcomes. The results for the analysis of necessary conditions for the outcome Science and Knowledge that uses csQCA calibrated data are presented in Table A5.

Table A5 presents the results for the analysis of necessary conditions for the outcome Science and Knowledge using the csQCA calibrated data. For comparison, the original results based on the fsQCA calibrated data are presented in brackets in Table A5 also. Table A5 indicates that none of the conditions meets the suggested cut-off point for consistency of 0.90. Similar to the original analysis (see Chapter 4 and Appendix 5), none of the conditions is considered necessary for the outcome Science and Knowledge.

Step 7: Analysis of sufficient conditions (1): create a truth table

Having studied the data for necessary conditions, the next step is to examine the data for sufficient conditions. For a condition, or a configuration of conditions, to be sufficient for the outcome, the set membership scores of the condition (or the configuration of conditions) need to constitute a perfect subset of the membership scores of the outcome. The analysis of configurations of sufficient conditions for the outcomes under scrutiny follows 3 sub-steps. The first sub-step is to create a truth table. The truth tables for the 5 outcomes are presented in Appendix 4 through Appendix 7.

For the robustness test, Table A6 provides the truth table for the analysis of sufficient conditions for the outcome Science and Knowledge, based on the csQCA calibrated data. The truth table is created using the software FS/QCA (version 3.0). A similar process was followed for creating the truth tables for the other outcome observations presented in the other appendices.

Table A5 Results of the analysis of necessary conditions, Science and Knowledge (csQCA)

Condition	Consistency	Coverage
Context alignment (Cont)	0.73 *(0.71)*	0.73 *(0.70)*
~Context alignment (~Cont)	0.27 *(0.41)*	0.83 *(0.87)*
Project continuity (PrC)	0.57 *(0.62)*	0.91 *(0.84)*
~Project continuity (~PrC)	0.43 *(0.48)*	0.62 *(0.65)*
Project focus (PrF)	0.38 *(0.44)*	0.61 *(0.70)*
~Project focus (~PrF)	0.62 *(0.71)*	0.88 *(0.83)*
Project design quality (PDQ)	0.76 *(0.76)*	0.78 *(0.74)*
~Project design quality (~PDQ)	0.24 *(0.38)*	0.69 *(0.84)*
Project size (PrS)	0.78 *(0.81)*	0.78 *(0.76)*
~Project size (~PrS)	0.22 *(0.28)*	0.67 *(0.68)*
Project transition quality (PTQ)	0.59 *(0.71)*	0.76 *(0.76)*
~Project transition quality (~PTQ)	0.41 *(0.44)*	0.75 *(0.80)*
Technical competencies (Tcom)	0.78 *(0.79)*	0.83 *(0.77)*
~Technical competencies (~Tcom)	0.22 *(0.37)*	0.57 *(0.80)*
Professional competencies (Pcom)	0.32 *(0.40)*	0.80 *(0.77)*
~Professional competencies (~Pcom)	0.68 *(0.69)*	0.74 *(0.72)*

Note: The numbers in brackets represent the original results based on fsQCA coded data (see Chapter 4 and Appendix 5); ~ indicates the negate of the condition.

Table A6 Truth table for the outcome Science and Knowledge (csQCA)

Row	Conditions								Freq.	Outcome	Raw consistency
	Cont	PrC	PrF	PDQ	PrS	PTQ	Tcom	Pcom			
1	0	1	0	0	1	0	1	0	2	1	1.00
2	1	1	0	1	1	0	1	0	2	1	1.00
3	0	0	0	1	1	1	1	0	2	1	1.00
4	1	0	0	1	1	1	1	0	2	1	1.00
5	1	1	1	1	1	1	1	0	2	1	1.00
6	1	0	0	1	1	0	1	1	2	1	1.00
7	1	1	1	1	0	1	1	1	2	1	1.00
8	0	0	0	0	1	0	0	0	1	1	1.00
9	0	1	0	0	1	0	0	0	1	1	1.00
10	1	1	1	0	1	0	0	0	1	1	1.00
11	1	1	0	1	1	1	0	0	1	1	1.00
12	1	1	0	1	0	0	1	0	1	1	1.00
13	1	0	1	1	0	0	1	0	1	1	1.00
14	0	1	1	1	1	0	1	0	1	1	1.00
15	1	1	0	1	0	1	1	0	1	1	1.00
16	0	0	0	0	1	1	1	0	1	1	1.00
17	1	0	0	0	1	1	1	0	1	1	1.00
18	0	0	1	0	1	1	1	0	1	1	1.00
19	1	1	0	1	1	1	1	0	1	1	1.00
20	0	0	1	1	1	1	1	0	1	1	1.00
21	1	1	0	1	0	1	0	1	1	1	1.00
22	1	1	1	1	0	1	0	1	1	1	1.00
23	1	1	0	1	1	1	0	1	1	1	1.00
24	1	1	0	1	1	0	1	1	1	1	1.00
25	1	0	1	1	1	0	1	1	1	1	1.00
26	1	1	0	1	0	1	1	1	1	1	1.00
27	1	0	1	1	1	1	1	1	1	1	1.00
28	1	1	1	1	1	1	1	1	1	1	1.00
29	1	0	0	0	1	0	0	0	2	0	0.50
30	1	0	1	1	1	1	1	0	3	0	0.33
31	1	0	1	0	1	0	0	0	2	0	0.00
32	1	0	1	1	0	1	0	0	1	0	0.00
33	1	0	1	0	1	1	0	0	1	0	0.00
34	1	0	0	1	0	0	1	0	1	0	0.00
35	1	0	0	1	1	0	1	0	1	0	0.00
36	1	1	1	1	1	1	0	1	1	0	0.00
37	0	0	1	1	0	1	1	1	1	0	0.00
38	0	1	1	1	0	1	1	1	1	0	0.00

Rows 39-256: Logical remainders
Abbreviations: conditions, see Table A9; Freq. = frequency count.

The truth table is a data matrix with 2^k rows that represent all possible configurations of conditions that are logically possible (for an elaborate discussion, see Schneider and Wagemann 2013: Chapter 7). Thus, with the 8 conditions here, the number of logically possible configurations is 256; that is, 2^8. The empirical observations are included in this table. As the truth table indicates, out of 256 logically possible configurations, 38 were empirically observed (rows 1 to 38).

The truth table reports data using the crossover points set; that is, '1' indicates full membership, and '0' indicates full non-membership. Each row should therefore be understood as an 'ideal type', that is, a hypothetical case whose conditions and outcomes perfectly fit into the sets represented by the membership scores. The number column ('Freq.') indicates how many cases are observed to fit best with this ideal type. For example, row 1 indicates that 2 cases were found to fit the ideal type it represents, and row 8 indicates that only one case fits the ideal type it represents. It is also normal for the truth table to contain rows of possible combinations without empirical observations (here, these are rows 39-256).

In the second sub-step the truth table is logically minimised based on 2 conditions. First, the researcher sets a threshold for 'logical remainders'. Logical remainders are those configurations of conditions that 'lack enough empirical evidence to be subjected to a test of sufficiency' (Schneider and Wagemann 2013: 152). It depends on the size of the research project (that is, the number of cases included) when determining what is to be considered as 'enough empirical evidence'. Most often a threshold of one observation (thus, at least one case) is used, but for larger numbers of cases a higher threshold can be applied (Ragin 2008; Schneider and Wagemann 2013). Following this practice, we have specified a threshold of at least one observation.

Second, the researcher has to set a 'consistency threshold for distinguishing [configurations of conditions] that are subsets of the outcome from those that are not' (Ragin 2008: 143). In other words, how well do the configurations of conditions fit the outcome? This is what the 'raw consistency' score in the truth table indicates. The higher the score, the better the fit, with 1.00 indicating perfect fit. Ragin (2008) advises a consistency score of at least 0.75, which we have followed throughout the impact assessment. For the truth table presented here, 28 rows meet this threshold (rows 1-28). In FS/QCA 3.0, cases that met the consistency threshold were labelled '1' in the outcome column, and those that did not were labelled '0' (cf., Ragin 2008: 144).

Close readers will observe that we have used different consistency thresholds for the different analyses (see Appendix 4 through Appendix 7). This is explained as follows:

- Innovations Systems: we have used a raw and PRI consistency threshold of 0.80. PRI stands for Proportional Reduction in Inconsistency. This score is used to 'avoid simultaneous subset relations of configuration in both the outcome and its absence' (Greckhamer et al. 2018: 489). A PRI consistency threshold that is at least 0.5 *and* is close to the raw consistency scores is both recommended and ideal (Greckhamer et al. 2018). For this outcome, we observed high raw consistency scores overall, which warranted the use of a high PRI consistency score. We observed a 'jump' in the PRI consistency score between 0.85 and 0.75 (see Table A10) and we have followed Ragin (2008) to set the consistency threshold at this point.
- Science and Knowledge: we have used a raw consistency threshold of 0.80 and a PRI consistency threshold of 0.75. Effectively, this follows conventional QCA practice.
- Natural Resource Management: we have followed the approach described under Innovations Systems.
- Policy: we have followed the approach described under Innovations Systems.
- Socioeconomic: we have used a raw consistency threshold of 0.75 and a PRI consistency threshold of 0.45. Whilst this choice deviates slightly from conventional QCA practice, our decision was based on the observation that a higher raw or a higher PRI consistency threshold would have resulted in a solution coverage score smaller than 0.65, which we find unacceptable. With these thresholds, only one row in the truth table has a PRI score lower than 0.50 and it only represents one case (see Table A29). The case was assessed once more and was found to fit the configuration represented by the truth table and to have the outcome more present than absent.

Close readers will also observe that Table A6 indicates a raw consistency score of 0.50 for row 29 and 0.33 for row 30. In a raw data matrix based on csQCA calibrated data, a raw consistency score that is not a perfect '1.00' or '0.00' indicates that the row represents observed cases both with and without the outcome (this does not hold for raw data matrix based on fsQCA calibrated data). This indicates a logical contradiction: the same set of conditions cannot lead to both the outcome and its absence (Ragin 2008). Those familiar with QCA may argue that good QCA practice expects researchers to resolve these conflicts before moving on. Here we have, however, decided not to resolve these conflicts because the aim of the csQCA presented here is to provide a robustness test. We have processed the data in the same manner as we have our fsQCA calibrated data – meaning, we used a raw consistency threshold of 0.80 and a PRI consistency threshold of 0.75.

Step 8: Analysis of sufficient conditions (2): logical remainders and choice of solution term

Having carried out this minimisation of the truth table, a standard analysis can be run in FS/QCA 3.0 (the third sub-step). This standard analysis is best understood as the identification of 'the combinations of attributes [that is, configurations of necessary conditions] associated with the outcome of interest using Boolean algebra and algorithms that allow logical reduction of numerous, complex causal [configurations of] conditions into a reduced set of configurations that lead to the outcome' (Fiss 2011: 402). Normally, a standard analysis results in a solution that consists of several 'paths' (configurations of conditions) that lead to the outcome. Please note, we use the terms 'paths' and 'pathways' interchangeably.

The standard analysis produces 3 types of logically reduced configurations of conditions that are sufficient for the outcome under scrutiny: a complex solution, an intermediate solution, and a parsimonious solution. The complex solution is exclusively based on the empirical information at hand. The complex solution can, however, be further simplified by using counterfactuals for the logical remainders. Distinction is made between 'easy counterfactuals' and 'difficult counterfactuals' (for an explanation, see Fiss 2011). Easy counterfactuals are based on theoretical assumptions or on other substantive knowledge held by the researcher. The inclusion of easy counterfactuals in the standard analysis leads to an intermediate solution.

The parsimonious solution (that is, the simplest solution) results from using difficult counterfactuals. Applying difficult counterfactuals is the inverse of applying easy counterfactuals. That is, assumptions are made about the outcome of a configuration if the counterfactual condition is redundant. This is a more complicated and hazardous undertaking, since typical expectations are that conditions are present, not absent. Note, however, that a parsimonious solution may look 'simpler' than an intermediate or complex solution, but in fact provides less categorical delineation. There is also a risk that parsimonious solutions may be 'unrealistically simplistic' (Ragin 2008: 175).

In this study we present both the parsimonious solution and the intermediate solution in Appendix 4 through Appendix 7. In the main text of the impact assessment, we rely on the intermediate solution. The assumed causal directions used for the intermediate solution are presented in Table A7. These come from the systematic review of the AR4D literature (see Appendix 1) and the experiences of ACIAR staff and stakeholders.

Table A7 Assumed causal direction of conditions

Condition	Assumed causal direction
Context alignment	Contributes to outcome if present
Project continuity	Contributes to outcome if present
Project focus	Contributes to outcome if present
Project size	Contributes to outcome if present
Project design quality	Contributes to outcome if present
Project transition quality	Contributes to outcome if present
Technical competencies	Unknown
Professional competencies	Unknown

Step 9: Presentation of results

After carrying out the standard analysis, results can be presented in various forms. We have chosen an accepted tabulated form in Appendix 4 through Appendix 7. The various consistency and coverage scores provide, for example, an indication of how much data variance can be explained, or how closely solutions relate to the outcomes that have been empirically observed. The precise meaning for each outcome is explained in full in Chapters 3 through 7.

Table A8 adopts a straightforward notation and presentation of causal configurations ('paths') that are sufficient enough to cause the outcome of interest (Science and Knowledge) based on the data calibrated for csQCA. The tilde symbol (~) indicates that a condition is of a low qualitative state or even fully absent in a causal configuration. The multiplication symbol (*) indicates the logical AND. The first 2 paths (PrC*PrS*~Pcom and ~Cont*PrS*~Tcom*~Pcom) can be read as:

- The outcome Science and Knowledge was observed in projects characterised by project continuity, and a (very) large project size, and not a focus on professional competencies.
- The outcome Science and Knowledge was observed in projects characterised by context independence (~Cont), and a (very) large project size, and not a focus on technical competencies, and not a focus on professional competencies.

Table A8 indicates that 9 such configurations are related to the outcome. The table also indicates a logically redundant configuration (it has a unique coverage of 0.00, which indicates all cases in it are explained by other paths). The solution coverage is high (0.95), and it indicates that the solution relates favourably to the outcome observed. The solution consistency (1.00) is high and indicates that the solution is of high empirical importance in reaching the outcome (see Chapter 2 for an explanation of these parameters of fit).

Step 10: Interpreting results and testing robustness

Of course, QCA analysis is but a means to an end, and is not an end in itself. Critical to interpretation is the process of returning to the data collected and assessing whether the solutions and paths uncovered reflect the empirical reality of the data collected. This may be understood as a fundamental robustness test in QCA (Rihoux and Ragin 2009). We interpret the solutions and paths in Chapters 3 through 8.

Table A8 Results of the analysis of sufficient conditions for the outcome Science and Knowledge (csQCA), intermediate solution

INTERMEDIATE SOLUTION

Model: InSy = f(Cont, PrC, PrF, PDQ, PrS, PTQ, Tcom, Pcom)

Algorithm: Quine-McCluskey

Frequency cutoff: 1

Consistency cutoff: 0.80 (raw)

Assumptions: Cont (present), PrC (present), PrF (present), PDQ (present), PrS (present), PTQ (present)

	Coverage			
Path	raw	unique	Consistency	Path name
PrC*PrS*~Pcom	0.2973	0.1081	1.0000	#27
~Cont*PrS*~Tcom*~Pcom	0.0541	0.0270	1.0000	#28
~Cont*PrS*PTQ*~Pcom	0.1351	0.0541	1.0000	#29
~PrF*PrS*PTQ*Tcom*~Pcom	0.1892	0.0811	1.0000	#30
Cont*PrC*PDQ*Tcom*~Pcom	0.1892	0.0541	1.0000	#31
Cont*PDQ*PrS*Tcom*Pcom	0.1622	0.1622	1.0000	#32
Cont*PrF*PDQ*~PrS*Tcom*~Pcom	0.0270	0.0270	1.0000	#33
Cont*PrC*PDQ*~PrS*PTQ*Pcom	0.1351	0.0811	1.0000	#34
Cont*PrC*~PrF*PDQ*PrS*PTQ	0.0811	0.0000	1.0000	#35
Cont*PrC*~PrF*PDQ*PTQ*Pcom	0.0811	0.0000	1.0000	Log.red

Abbreviations: see Table A3 Log.red = logically redundant path
Solution coverage: 0.95
Solution consistency: 1.00

Alternative robustness tests involve the application of slightly varying calibrations, or an increase in the frequency threshold for the number of cases to include in the analysis for sufficient conditions (Greckhamer et al. 2018; Skaaning 2011). Here we have assessed the robustness of the results by calibrating the data for both fsQCA and csQCA and by conducting analyses of necessity and sufficiency with both sets of calibrated data. In this appendix, we have presented the results of the analysis of necessity and sufficiency for the outcome Science and Knowledge using csQCA-calibrated data.

We have already concluded that the analysis for necessity does not indicate any relevant differences between the data that is coded based on the csQCA-calibrated data and the data that is coded based on the fsQCA-calibrated data. The analysis for sufficiency based on the csQCA-calibrated data produces highly similar results to the one that is based on fsQCA-calibrated data (see Table A17). The minor differences between the 2 are largely explained by the loss of nuance in the csQCA calibration. If we group the paths resulting from the analysis of sufficiency in the same way we do in Appendix 4 to Appendix 6, the similarities between the 2 analyses are obvious. Figure A1 groups the intermediate solution by the most common conditions.

In sum, if we compare Table A8 with Table A17 and Figure A1 with Figure A3 then the following observations stand out:

- Table A8 indicates that 9 paths are related to the outcome; Table A17 indicates that 8 paths are related to the outcome. This is explained by Path #33 that covers only one project (ASEM/1996/044). This project was one of the unexplained projects in the solution captured in Table A17 (that is, a project with the outcome present, but not part of the solution).
- Seven of the paths observed in Table A17 recur in Table A8. The only path that does not recur is Path #15 (PDQ*PTQ*Cont*PrC*PrF*Tcom). Path #34 does, however, explain most of cases that were explained by Path #15. Path #15 and Path #34 also share the same set of conditions that we have observed across the cluster 'theory and practice of change' (that is, PDQ*PTQ*Cont*PrC).
- Figure A1 indicates that the paths resulting from the analysis that uses the csQCA-calibrated data group in the same manner as the paths that result from the analysis that uses the fsQCA data (see Figure A3).

In short, the analysis of necessity does not indicate any relevant differences between the data that is coded based on the csQCA-calibrated and fsQCA-calibrated data. The analysis of sufficiency indicates minor differences, but these do not impact our overall findings. We therefore conclude that the findings presented in Chapters 3 through Chapter 7 and Appendix 4 through Appendix 7 are appropriately robust.

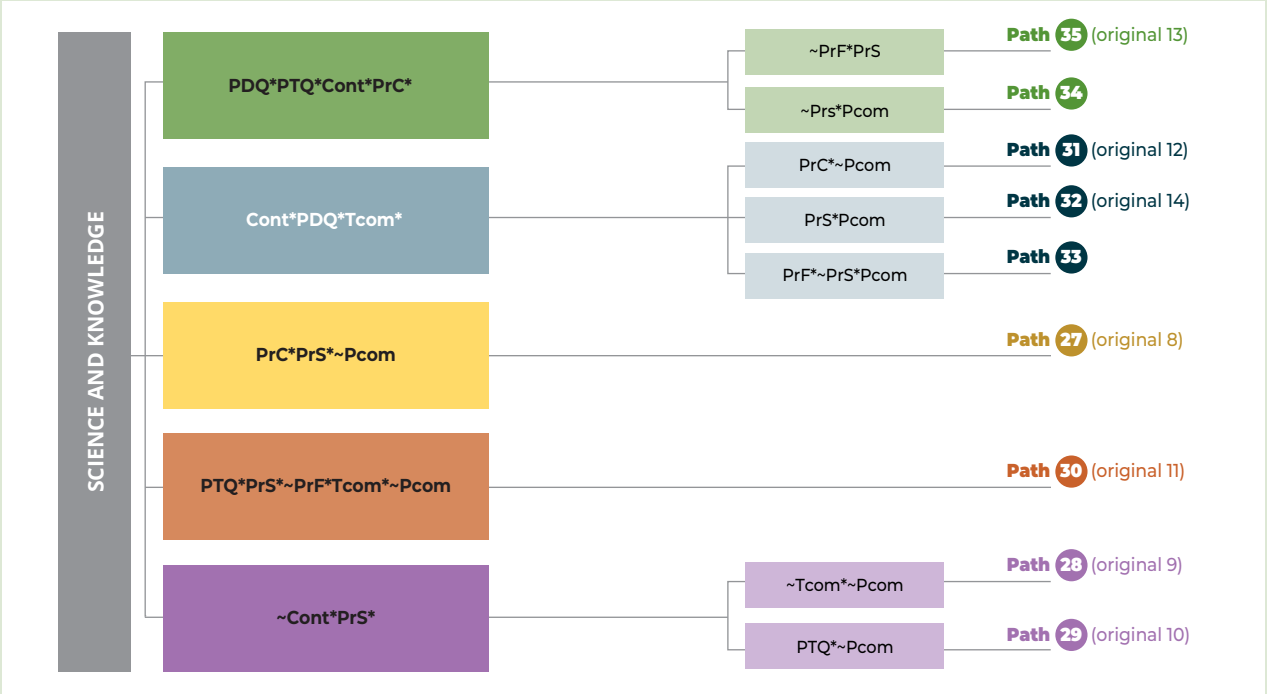


Figure A1 Paths grouped by most common conditions for the outcome Science and Knowledge (csQCA)

Abbreviations: conditions, see Table A14. Note: Path #32 is modestly simpler than Path #14 (Path #14 also includes ~PrF). The differences between this figure and Figure A3 are due to the different types of QCA applied: crisp-set (csQCA) here, and fuzzy-set (fsQCA) throughout the report (including Figure A3). The detailed differences between the figures are explained in Step 10 in this appendix.

Appendix 3: Calibration descriptors

As we have explained in Chapter 2, an important part of 'good' QCA practice is to provide full transparency about the calibration of the raw data. In this appendix, we provide the full set of calibration descriptors that we have used for the outcomes and causal conditions. Please note, some of the text may come across as clipped or 'jumpy'. This is because we have not changed our original calibration descriptors to improve their readability in this appendix. Please note also, the calibration descriptors use the Boolean operators 'AND' and 'OR'.

Outcomes

Innovations Systems

Full membership (1.00): The ACIAR-supported project is considered a **best-practice** in how it has contributed towards innovations systems. Best practice here indicates that the project has achieved the following enduring[25] results:

1. **Increased capacity of the project team members**, which includes, among others, (i) improved skill development of an individual, (ii) career progression of an individual (that is, a promotion), (iii) an individual on the project team was awarded an ACIAR fellowship, including a John Allwright Fellowship or John Dillon Fellowship, (iv) an individual gained an external grant for professional development.
2. **Improved capacity of national partner at organisational level**, which includes, among others, (i) improved research processes and procedures, (ii) improved administrative processes and procedures, (iii) improved organisational leadership.
3. **Improved capacity of groups and/or individuals engaged by the project (that were not part of the research team)**, which includes, among others, (i) improved skills development within the engagement target area of the project; (ii) completion of training programs as part of the project that are relevant to their employment/daily activities, (iii) completion of a formal qualification relevant to their employment/daily activities.
4. **Improved capacity of groups and/or individuals in the local community**[26] **(members who were not directly engaged with the project)**, which includes, among others, (i) the community has increased knowledge and resources relevant to the environment or their socioeconomic position, (ii) the community has improved skills to continue the project.

More in than out (0.67): The ACIAR-supported project has made an **overall beneficial contribution** towards positive innovations systems impacts. **The project has achieved at least results 1 OR 4, AND at least one of results 2-3 AND these are enduring.**

More out than in (0.33): The ACIAR-supported project has made an overall beneficial contribution towards positive innovations systems impacts. **The project has achieved at least one of results 1-4 AND these are enduring.**

Full non-membership (0.00): The ACIAR-supported project has not made an overall beneficial contribution towards positive innovations systems impacts (operationalised as per 'more in than out'). This is not to say that the project has not made any contributions towards positive innovations systems impacts. **The project has not achieved any of results 1-4 OR none of the results achieved are enduring.**

Crossover point: The ACIAR-supported project has made multiple beneficial contributions towards positive innovations systems impacts (that is, achieved more than one of the underlined results discussed under full membership), unless it is at the expense of the items mentioned under 'more out than in' membership.

25 Enduring here implies that the outcome was present at the time the Adoption Study was produced.

26 Local community here refers to all persons in the region where the project took place but outside of the immediate project activities.

Science and Knowledge

Full membership (1.00): The ACIAR-supported project is considered a **best-practice** in how it has contributed towards science and knowledge outcomes. Best practice here indicates that the project has achieved at least one of the following results:

1. **Furthering science for science:** at least 10 articles in English-language (that is, international) peer-reviewed journals AND at least one training manual, handbook, technical guide, etc., that translates project findings for application in context in the local language; OR at least 5 articles in English-language (that is, international) peer-reviewed journals and at least 5 articles are in local-language science journals AND at least one training manual, handbook, technical guide, etc., that translates project findings for application in context in the local language.
2. **Development of high-quality knowledge unique for application in context:** at least 2 training manuals, handbooks, technical guides, etc. (any combination), that translate project findings for application in context in the local language AND translation of project findings for next users in at least 6 local-language newspaper articles, blogs, contributions to professional/policy outlets, etc. (any combination) AND at least one article in a scientific journal (English or local language).

More in than out (0.67): The ACIAR-supported project has made an **overall beneficial contribution** towards positive science and knowledge impacts. The project has achieved at least one the following results:

1. **Furthering science for science:** at least 5 articles in English-language (that is, international) peer-reviewed journals AND at least one training manual, handbook, technical guide, etc., that translates project findings for application in context in the local language; OR a combination of at least 8 articles in English-language (that is, international) peer-reviewed journals and local-language science journals AND at least one training manual, handbook, technical guide, etc., that translates project findings for application in context in the local language.
2. **Development of broad knowledge for a wide range of audiences:** a combination of at least 4 articles in English-language (that is, international) peer-reviewed journals and local-language science journals AND a combination of at least 10 conference contributions, newspaper articles, blogs, contributions to professional/policy outlets, etc. (any combination) AND at least one training manual, handbook, technical guide, etc., that translates project findings for application in context in the local language.
3. **Development of high-quality knowledge unique for application in context:** one training manual, handbook, technical guide, etc., that translates project findings for application in context in the local language AND translation of project findings for next users in at least 3 local-language newspaper articles, blogs, contributions to professional/policy outlets, etc. (any combination) AND at least one article in a scientific journal (English or local language).

More out than in ('0.33'): The ACIAR-supported project has made some contribution toward positive science and knowledge impacts. The project has achieved at least one the following results:

1. **Development of broad knowledge for a wide range of audiences:** at least 2 articles in scientific journals (English language or local language) AND a combination of at least 5 conference contributions, newspaper articles, blogs, contributions to professional/policy outlets, etc. (any combination).
2. **Development of knowledge unique for application in context:** a training manual, handbook, technical guide, etc., that translates project findings for application in context in the local language AND at least one article in a scientific journal (English or local language).

Full non-membership (0.00): The ACIAR-supported project has **not made an overall beneficial contribution** towards positive science and knowledge impacts. The project has fewer than 2 articles in scientific journals (English language or local language) OR the project has one article in a scientific journal but no translation of project findings for application in context in the local language.

Crossover point: Overall beneficial contribution towards positive science and knowledge impacts. The project has achieved *at least* the results discussed under 'more in than out' membership.

Note (to coders): In Adoption Studies or publication lists, it may not always be clear if English-language journals have a process of peer-review. As a rule of thumb, any journal by a major academic publisher subjects manuscripts to peer-review (this includes Sage, Elsevier, Wiley, Blackwell, Kluwer, Routledge, Polity Press, Taylor and Francis, Springer, and any 'known' university press). English-language journals by predatory publishers typically do not have a (rigorous) peer-review process (and we exclude publications in such journals from our count). Beall's list is the best starting point to assess if an article was possibly published in a predatory journal/by a predatory publisher: **Three quick ways to spot a predatory journal**. In Adoption Studies or publication lists, it may not always be clear if local language journals are scientific journals. For these, we make judgement calls based on the journal's website.

Natural Resource Management (NRM)

Full membership (1.00): The ACIAR-supported project is considered a **best-practice** in how it has contributed towards enduring positive natural resource impacts. Best practice here indicates that the project has achieved a combination of enduring results, with at least 2 of:

1. **Reduced production and/or better management of pollutants**, which includes, among others, (i) reduction in the use of harmful chemicals (herbicides, pesticides etc), (ii) reduction in the overuse/run-off of nutrients, (iii) reduced discharge and/or better management of wastewater.
2. **More efficient and sustainable use of available water resources**, which includes, among others, (i) growing more food using less water (reducing agricultural water demand), (ii) reducing groundwater depletion.
3. **Increased natural resource stocks**, which includes, among others, (i) improved soil health (that is, improved soil structure, pH level, nutrient levels), (ii) increased forest/vegetation cover, (iii) increased wild aquatic species stocks.
4. **Increased ecological resilience**, which includes, among others, (i) increased or restored ecosystem biodiversity (incl. increased soil carbon), (ii) rehabilitated ecosystems (that is, coral reef systems/wetlands).
5. **Improved biosecurity**, which includes, among others, better management of pests and diseases (animal, plant and human).
6. **Improved climate change mitigation**, which includes, among others, (i) an observed improvement of natural resources (that is, increased forest cover, improved soil carbon), (ii) a reduced energy consumption (for example, solar water pumps), (iii) establishment of new climate mitigation incentive schemes, support mechanism, extension at an institutional level.
7. **Establishment of a Sustainable Natural Resource Management system** that institutionalises/ implements sustainable and equitable practices and management of common natural resources (that is, groundwater systems, salinity management, forest resources, waterways, biodiversity).

More in than out (0.67): The ACIAR-supported project has made an **overall beneficial contribution** towards enduring positive natural resource impacts. **The project has achieved one of results 1-7 AND these are enduring.**

More out than in (0.33): The ACIAR-supported project has made an overall beneficial contribution towards positive natural resource impacts. The project has achieved at least one of results 1-7 **but it is/they are not enduring** OR it is/they are enduring but has/have come **at the expense of** one or more of the following:

1. **Reduced climate change mitigation**, which includes, among others, (i) an observed reduction of natural resources (that is, reduced forest cover, reduced soil carbon), (ii) an increased non-renewable energy consumption (for example, the use of fossil fuels).
2. **Reduced ecological resilience** which includes, among others, the project resulting in (i) decreased ecosystem biodiversity (ii) an increased pressure on remaining natural resources (that is, forests and water), (iii) decreased wild aquatic species stocks, (vi) degraded ecosystems and/or habitat destruction (that is, coral reef systems/wetlands).

Full non-membership (0.00): The ACIAR-supported project has **not made an overall beneficial contribution** towards enduring positive natural resource impacts (that is, it has achieved none of the underlined results discussed under full membership).

Crossover point: The ACIAR-supported project has made multiple beneficial contributions towards enduring positive natural resource impacts (that is, achieved more than one of the underlined results discussed under full membership), unless it is at the expense of underlined results mentioned under 'more out than in' membership.

Note (to coders): Adoption Studies may lack an explicit mentioning of achieved (and enduring) NRM outcomes. We acknowledge that projects may have achieved better results than their Adoption Studies report. We aim to identify explicitly reported positive NRM outcomes. Because we do not focus the 40-year review on 'what did not work', false negatives (that is, projects that have achieved positive NRM outcomes that are not observed in the Adoption Studies) will not have a major impact on our findings. Put differently, we do not 'read between the lines' to find more NRM outcomes than what is explicitly reported in the Adoption Studies.

Policy

Full membership (1.00): The ACIAR-supported project is considered a **best-practice** in how it has contributed towards enduring positive policy outcomes. Best practice here indicates that the project has achieved the following enduring results:

1. Implementation of a policy that draws on the project. This must be (i) in such a way that the policy is explicitly mentioned by name OR described in some detail in the Adoption Study, OR (ii) confirmed by a reputable stakeholder.

AND at least one of:

2. **Direct referencing of research in publicly available policy documents**, which includes, among others, (i) reference to project outcomes in policy documents, (ii) sections of project research text directly incorporated into policy documents, (iii) footnoting of research documents in policy documents, (iv) reference to the project in Ministerial statements and/or speeches.
3. **Policy actors acknowledge that there was a contribution to the policy formation process from the research outputs**, which includes, among others, acknowledgement by policy makers reported in (i) the Adoption Study (or other project documentation), for example reference to interviews that the research was 'one of many influences' towards policy changes; (ii) correspondence received by researchers from individual policy actors demonstrating engagement with research.
4. **The research team self-reports that policy-relevant findings were produced and communicated to known actors within the policy-making realm**, which includes, among others, the following activities being undertaken during the life of the project: (i) policy dialogues convened, (ii) policy briefs produced and distributed, (iii) high level stakeholder meetings held to discuss policy-relevant findings.

More in than out (0.67): The ACIAR-supported project has made an **overall beneficial contribution** towards positive policy impacts. **The project has at least achieved policy result 1 AND it is enduring.**

More out than in (0.33): The ACIAR-supported project has made some contribution toward positive policy impacts. The project has achieved one or more of the enduring policy results 2-4 (but not 1) OR the project has achieved policy result 1 but at the cost of the following:

1. Demonstrated negative or adverse effects from policy implementation,

OR

2. The policy influence was fleeting. For example, the Adoption Study reports that the policy has been reversed or watered down.

Full non-membership (0.00): The ACIAR-supported project has **not made an overall beneficial contribution** towards positive policy impacts (that is, it has achieved none of the underlined results discussed under full membership).

Crossover point: The ACIAR-supported project has at least achieved policy result 1, unless it is at the expense of results mentioned under 'more out than in' membership.

Note (to coders): Adoption Studies may lack an explicit mentioning of achieved (and enduring) policy outcomes. We acknowledge that projects may have achieved better results than their Adoption Studies report. We aim to identify explicitly reported positive NRM outcomes. Because we do not focus the 40-year review on 'what did not work', false negatives (that is, projects that have achieved positive NRM outcomes that are not observed in the Adoption Studies) will not have a major impact on our findings. Put differently, we do not 'read between the lines' to find more policy outcomes than what is explicitly reported in the Adoption Studies.

Socioeconomic

Full membership (1.00): The ACIAR-supported project is considered a **best-practice** in how it has contributed towards the enhanced socioeconomic resilience of farming and rural households. Best practice here indicates that the project has achieved the following enduring results:

1. **Increased socioeconomic returns**, which includes, among others, (i) increased benefit flows for same cost outlay, (ii) sustainment of benefit flows with decreased cost outlays, (iii) increased benefit flows and decreased cost outlays. (Examples include (1) 'more with same', such as increased availability of food or resources to the household from same outlay of effort, (2) 'same with less', labour-saving techniques allow same income to be achieved with less time, and (3) 'more with less', new crop variety generates higher incomes with less labour time and land.)

AND more than one of:

2. **Improved access to socioeconomic institutions and organisations**, (for example, markets, social organisations, producer groups, cooperatives, unions, etc.) which includes, among others, (i) a reduction in barriers to access (that is, regulatory, logistical, informational), (ii) the enhanced capacity to meet requirements for participation (that is, quality and food safety standards in markets).
3. **Expanded range of socioeconomic opportunities**, which are realistic and appropriate for the context, and includes (i) expanded range of employment opportunities, (ii) expanded range of agricultural production options, (iii) expanded range of post-harvest value-add options, (iv) expanded range of options to extract/harvest natural resources (that is, forests and fisheries).
4. **Reduced barriers to switching between alternative socioeconomic activities**, which includes, among others, (i) reduction in social barriers (for example, gender norms, stigmas, status, etc.), (ii) improved knowledge which facilitates switching (that is, from cropping to livestock raising), (iii) decreased financial barriers to switching (that is, better access to micro-credit, or improved application of government subsidies), (iv) reduced regulatory/legal barriers to switching.
5. **Reduced exposure to risk**, (for example, human health risk, production risk, social risk) which includes, among others, (i) improved risk management/response, (ii) increased avoidance of risks, (iii) improved opportunities to mitigate risk through community, government or financial arrangements (that is, crop insurance).
6. **Increased socioeconomic agency**, which includes, among others, an increase in an individual's ability to choose the socioeconomic activities in which they participate.
7. **Improved socioeconomic equity**, which includes, among others, an improvement in an individual's equity share in their outputs (for example, rates at which women are paid better reflect their contribution to value generation).

More in than out (0.67): The ACIAR-supported project has made an **overall beneficial contribution** towards the enduring enhanced socioeconomic resilience of farming and rural households. **The project has achieved 2 of results 1-7 AND these are enduring.**

More out than in (0.33): The ACIAR-supported project has made an **overall beneficial contribution** towards the enhanced socioeconomic resilience of farming and rural households. **The project has achieved one of results 1-7 AND it is enduring.**

Full non-membership (0.00): The ACIAR-supported project has **not made an overall beneficial contribution** towards the enduring enhanced socioeconomic resilience of farming and rural households (that is, it has achieved none of the underlined results discussed under full membership).

Crossover point: The ACIAR-supported project has made multiple beneficial contributions towards enduring enhanced socioeconomic resilience of farming and rural households (that is, achieved more than one of the underlined results discussed under full membership).

Note (to coders): Adoption Studies may lack an explicit mentioning of achieved (and enduring) socioeconomic outcomes. We acknowledge that projects may have achieved better results than their Adoption Studies report. We aim to identify explicitly reported positive NRM outcomes. Because we do not focus the 40-year review on 'what did not work', false negatives (that is, projects that have achieved positive NRM outcomes that are not observed in the Adoption Studies) will not have a major impact on our findings. Put differently, we do not 'read between the lines' to find more socioeconomic outcomes than what is explicitly reported in the Adoption Studies.

Causal conditions

Context alignment

Full membership (1.00): The initial project documents include an explicit analysis, knowledge, and articulation of why the project is proposed for (i) the country/context (or countries/contexts) where the project will be implemented AND (ii) the national partner (or partners). This could include a mapping of key economic indicators; a mapping of relevant policy processes, actors and considerations; and a mapping of relevant operational risks (such as political stability, or socio-cultural or economic barriers to adoption).

In brief: projects that are explicitly tailored to their context(s) AND their national partner(s).

More in than out (0.67): The initial project documents include an explicit analysis, knowledge, and articulation of why the project is proposed for (i) the country/context (or countries/contexts) where the project will be implemented OR (ii) the national partner (or partners). This could include a mapping of key economic indicators; a mapping of relevant policy processes, actors and considerations; and a mapping of relevant operational risks (such as political stability, or socio-cultural or economic barriers to adoption).

In brief: projects that are explicitly tailored to their context(s) OR their national partner(s), but not both.

More out than in (0.33): The initial project documents include a broad motivation of why the project is proposed for the country/context (or countries/contexts) where the project will be implemented.

In brief: projects that are loosely related to their context(s) but could also have been applied in a comparable context elsewhere.

Fully out (0.00): The initial project documents do not include motivation of why the project is proposed for the country/context (or countries/contexts) where the project will be implemented.

In brief: projects that could have been applied in a wide range of other contexts.

Crossover point: A lack of detail in the explanation why the project is proposed for the country/context (or countries/contexts) where the project will be implemented.

Project continuation

Full membership (1.00): The project is an explicit continuation or follow-up of one or more existing or earlier ACIAR-funded research projects in the same country AND the same agricultural area. Project documentation explicitly mentions the existing or earlier ACIAR-funded research project or projects the current project builds on.

More in than out (0.67): The project strongly relates to more than one existing or earlier ACIAR-funded research project in the same country AND the same agricultural area, but it is not a direct continuation or follow-up of these. Project documentation explicitly mentions the existing or earlier ACIAR-funded research projects the current project relates to.

More out than in (0.33): The project loosely relates to more than one existing or earlier ACIAR-funded research project in the same country but not the same agricultural area, OR the same agricultural area but not the same country. Project documentation mentions the existing or earlier ACIAR-funded research projects it loosely relates to but does not necessarily make explicit linkages between those and the current project.

Full non-membership (0.00): The project does not relate to existing or earlier ACIAR-funded research projects, or the project documentation does not make any links between those and the current project.

Crossover point: Project documentation that explicitly links the current project to at least 2 earlier or current ACIAR-funded projects in the same country AND the same agricultural area.

Note (to coders): A one-year SRA does not count for strong embeddedness under any of the categories. Also, this condition is a 'proxy' for the earlier conditions 'equitable partnership' and 'sustained partnership' and assumes that a project that strongly builds on earlier ACIAR-funded research in the same country and the same agricultural area will benefit from the partnerships of those earlier projects (and will likely build on them, or even expand/strengthen them).

Project focus

Full membership (1.00): The research design has a focus on examining/intervening at the micro-level. Projects at the micro-level are interventions that seek to increase the skills or knowledge at the 'ground level', or the technologies or strategies used at that level. They aim to change patterns of behaviour, action, and interaction between users at the 'ground level'. Micro-level projects target individuals or smaller groups, including households, families, unions and communities, but also small(er) firms, farms, mills, factories, etc. Note, this includes projects that target a (very) large number of such smaller groups. The ongoing interaction between these groups is the foundation of 'informal norms', and, in the ACIAR context, would equal changed behaviour. These projects treat the smaller groups they target as the agents of change and culture. From the perspective of final users, the focus of these projects is largely within their sphere of control (for example, how can an individual/a household/a firm/a farm/etc. do XYZ better?).

More in than out (0.67): The research design combines an examining/intervening at micro- and macro-levels; the (assumed) causal direction is that change at the macro-level is caused/driven by accumulated change at the micro-level.

More out than in (0.33): The research design combines an examining/intervening at macro- and micro-levels; the (assumed) causal direction is that change at the micro-level is caused/driven by change at the macro-level.

Full non-membership (0.00): The research design has a focus on examining/intervening at the macro-level. Projects at the macro-level target or focus on the institutional or system level and seek to address system-level constraints (for example, agroecological dependencies, insufficient knowledge on crop disease, misalignments across the whole value chain). This includes projects that address norms and values in policy, markets, bureaucracy, and other institutions. These projects look at systemic change rather than 'ground level' change. From the perspective of final users, the focus of the research is largely beyond their sphere of control.

Crossover point: The point where the assumed causal direction that micro change results in macro change flips to an assumed causal direction that macro change results in micro change.

Project design quality

Full membership (1.00): The initial project documents include a set of well-articulated end of project outcomes, and a detailed explanation of how project outcomes will contribute to ongoing/durable impacts. The initial project documents include (i) a set of hypotheses (or similar) about how the project will bring about change, stabilise it, and amplify it; and (ii) a set of relationships between the program/intervention and its intended outcome(s).

In brief: the initial project documents present a detailed cause-and-effect narrative to explain how the proposed project interventions will result in the anticipated project outcomes.

More in than out (0.67): The initial project documents include a set of broadly defined end of project outcomes, and a broad explanation of how project outcomes will contribute to ongoing/durable impacts.

In brief: the initial project documents present a broad ('high level') narrative to explain how the (broadly defined) proposed project interventions will result in broadly defined project outcomes.

More out than in (0.33): The initial project documents loosely relate project interventions to expected project outcomes, OR the initial project documents present an exploratory research project with unspecified outcomes.

In brief: the initial project documents present a general narrative to explain how the proposed project interventions will result in the anticipated project outcomes; OR it does not specify project outcomes; OR no specific links between interventions ('explanatory variables') and outcomes ('dependent variables') are provided.

Full non-membership (0.00): The initial project documents do not explain how project interventions will yield project outcomes, OR the initial project documents do not discuss project outcomes at all.

Cross-over point: A cause-and-effect narrative that broadly links the proposed project interventions ('explanatory variables') with project outcomes ('dependent variables').

Project size

To capture the causal condition 'project size' we use project funding as a proxy.

Full membership (1.00): The budget funding of the project by ACIAR was A$801,000 or up.

More in than out (0.67): The budget funding of the project by ACIAR was between A$601,000 and A$800,000.

More out than in (0.33): The budget funding of the project by ACIAR was between A$401,000 and A$600,000.

Full non-membership (0.00): The budget funding of the project by ACIAR was a maximum of A$400,000.

Crossover point: The budget funding of the project by ACIAR was at least A$401,000.

Project transition quality

Full membership (1.00): Natural transition: strong involvement of next users in all phases of the project AND strong involvement of the national partner(s) in all phases of the project; OR designed transition: The final phase of the project has a strong focus on empowering the national partner(s) and/or next users to continue using the project intervention(s) and/or finding(s) post-project. For example, during the final phase, the training of national partner staff is increased, workshops are organised for local policymakers to share project results, etc.

More in than out (0.67): Natural transition: strong involvement of next users in all phases of the project; OR designed transition: The final phase of the project has a modest focus on empowering the national partner(s) and/or next users to continue using the project intervention(s) and/or finding(s) post-project. For example, during the final phase, project findings are documented in the local language and made accessible in an easy-to-understand manner (for example, animations) for next users.

More out than in (0.33): There is a clear identification of and engagement with/by next users in the final phase the project.

Full non-membership (0.00): There is no engagement with/by next users in the final phase of the project.

Cross-over point: Strong involvement of next users ('natural transition'); OR, next users are actively involved in the final phase of the project, AND project findings are captured and made accessible for a variety of next users (for example, academia and farmers) in the local language ('designed transition').

Note (to coders): For 'full membership' and for 'more in than out' we distinguish 'natural transition' as a result of a strong involvement of next users in all phases of the project (0.67), or a strong involvement of next users and the national partner(s) in all phases of the project (1.00); and 'designed' transition as the result of specific transition strategies that come into play in the final phase of the project. The final phase is defined as approximately the last 25% of project time. It is not necessary to distinguish between these 2 forms of transition for 'more out than in' and 'fully out', meaning: if 'natural transition' is not at least at the 'more in than out' level, we only assess the project for 'designed transition'.

Technical competencies

Full membership (1.00): The project has a strong, explicit focus on improving technical competencies and capacities, including technology, practices, and academic/policy/technical knowledge (that is, 'hard capacities'); improving technical competencies is a (or the) primary focus of the project. The initial project documents provide explicit qualitative and/or quantitative statements of the technical competencies the project is attempting to achieve AND provide a detailed explanation of how these results will be achieved.

More in than out (0.67): The project has a moderate focus on improving technical competencies and capacities; improving technical competencies is a (or the) primary focus of the project. The initial project documents provide broad statements of the technical competencies the project is attempting to achieve AND provide a broad explanation of how these results will be achieved.

More out than in (0.33): The project has a modest focus on improving technical competencies and capacities; improving technical competencies likely is not a (or the) primary focus of the project (that is, it could be a secondary focus or a side effect). The initial project documents do not specify the technical competencies the project is attempting to achieve OR do not provide an explanation of how these results will be achieved (that is, it only mentions that improved technical competencies are to be expected).

Full non-membership (0.00): The project has a weak or no hard focus on improving technical competencies and capacities. The initial project documents do not mention improved technical competencies and related results that could result from the project.

Crossover point: The project documentation includes an explicit strategy towards improved technical competencies and capacities that includes a discussion of the improved technical competencies to be expected, and how they will be achieved.

Professional competencies

Full membership (1.00): The project has a strong, explicit soft-capacity focus on improving professional competencies and capacities, including skills, behaviour, and practical knowledge such as laypeople's 'smarts and ingenuity' and 'knowing how to do something in practice' (that is, 'soft capacities'); improving professional competencies is a (or the) primary focus of the project. The initial project documents provide explicit qualitative and/or quantitative statements of professional competencies the project is attempting to achieve AND provide a detailed explanation of how these results will be achieved

More in than out (0.67): The project has a moderate focus on improving professional competencies and capacities; improving professional competencies is a (or the) primary focus of the project. The initial project documents provide broad statements of the professional competencies the project is attempting to achieve AND provide a broad explanation of how these results will be achieved.

More out than in (0.33): The project has a modest focus on improving professional competencies and capacities; improving professional capacities likely is not a (or the) primary focus of the project (that is, it could be a secondary focus or a side effect). The initial project documents do not specify the professional competencies the project is attempting to achieve OR do not provide an explanation of how these results will be achieved (that is, it only mentions that improved professional capacities are to be expected).

Full non-membership (0.00): The project has a weak or no focus on improving professional competencies and capacities. The initial project documents do not mention improved professional competencies that could result from the project.

Crossover point: The project documentation includes an explicit strategy towards improved professional competencies and capacities that includes a discussion of the improved professional competencies to be expected, and how they will be achieved.

Appendix 4: Detailed analyses for the Innovations Systems outcomes

Table A9 Results of the analysis of necessary conditions for the outcome Innovations Systems

Condition	Consistency	Coverage
Context alignment (Cont)	0.81	0.76
~Context alignment (~Cont)	0.41	0.83
Project continuity (PrC)	0.61	0.78
~Project continuity (~PrC)	0.57	0.73
Project focus (PrF)	0.58	0.87
~Project focus (~PrF)	0.68	0.76
Project design quality (PDQ)	0.88	0.81
~Project design quality (~PDQ)	0.40	0.84
Project size (PrS)	0.81	0.72
~Project size (~PrS)	0.37	0.85
Project transition quality (PTQ)	0.80	0.82
~Project transition quality (~PTQ)	0.47	0.80
Technical competencies (Tcom)	0.85	0.79
~Technical competencies (~Tcom)	0.41	0.85
Professional competencies (Pcom)	0.50	0.90
~Professional competencies (~Pcom)	0.69	0.68

Note: ~ indicates the negate of the condition.
Interpretation of results: none of the conditions meets the suggested cut-off point for consistency of 0.90. None of the conditions is considered necessary for the outcome 'Innovations Systems'.

Table A10 Truth table for the outcome Innovations Systems

Row	Conditions								Freq.	Outcome	PRI consistency
	Cont	PrC	PrF	PDQ	PrS	PTQ	Tcom	Pcom			
1	1	1	0	1	1	0	1	0	2	1	1.00
2	1	1	1	1	1	1	1	0	2	1	1.00
3	1	0	0	1	1	0	1	1	2	1	1.00
4	1	1	1	1	0	1	1	1	2	1	1.00
5	1	1	0	1	1	1	0	0	1	1	1.00
6	1	1	0	1	0	0	1	0	1	1	1.00
7	1	0	1	1	0	0	1	0	1	1	1.00
8	0	1	1	1	1	0	1	0	1	1	1.00
9	1	1	0	1	1	1	1	0	1	1	1.00
10	1	1	0	1	0	1	0	1	1	1	1.00
11	1	1	1	1	0	1	0	1	1	1	1.00
12	1	1	0	1	1	1	0	1	1	1	1.00
13	1	1	1	1	1	1	0	1	1	1	1.00
14	1	1	0	1	1	0	1	1	1	1	1.00
15	1	0	1	1	1	0	1	1	1	1	1.00
16	1	1	0	1	0	1	1	1	1	1	1.00
17	0	0	1	1	0	1	1	1	1	1	1.00
18	0	1	1	1	0	1	1	1	1	1	1.00
19	1	0	1	1	1	1	1	1	1	1	1.00
20	1	1	1	1	1	1	1	1	1	1	1.00
21	1	0	1	1	1	1	1	0	3	1	0.86
22	1	0	0	0	1	0	0	0	2	0	0.75
23	0	0	0	0	1	1	1	0	1	0	0.75
24	1	0	0	0	1	1	1	0	1	0	0.75
25	0	0	1	1	1	1	1	0	1	0	0.75
26	0	0	0	1	1	1	1	0	2	0	0.71
27	1	0	0	1	1	1	1	0	2	0	0.71
28	0	0	0	0	1	0	0	0	1	0	0.67
29	0	0	1	0	1	1	1	0	1	0	0.67
30	0	1	0	0	1	0	1	0	2	0	0.66
31	1	0	1	1	0	1	0	0	1	0	0.66
32	1	0	0	1	1	0	1	0	1	0	0.50
33	0	1	0	0	1	0	0	0	1	0	0.49
34	1	0	0	1	0	0	1	0	1	0	0.49
35	1	1	1	0	1	0	0	0	1	0	0.49
36	1	1	0	1	0	1	1	0	1	0	0.49
37	1	0	1	0	1	1	0	0	1	0	0.33
38	1	0	1	0	1	0	0	0	2	0	0.25

Rows 39-256: Logical remainders
Abbreviations: conditions, see Table A9; Freq. = frequency count.

Table A11 Results of the analysis of sufficient conditions for the outcome Innovations Systems, complex solution

COMPLEX SOLUTION
Model: InSy = f(Cont, PrC, PrF, PDQ, PrS, PTQ, Tcom, Pcom)
Algorithm: Quine-McCluskey
Frequency cut off: 1
Consistency cut off: 0.80 (PRI)

	Coverage		
Path	Raw	Unique	Consistency
Cont*PrC*PDQ*PTQ*~Tcom*Pcom	0.1800	0.0217	1.0000
Cont*PrC*PDQ*~PrS*PTQ*Pcom	0.1488	0.0325	1.0000
Cont*PrF*PDQ*PrS*PTQ*Tcom	0.3702	0.1179	0.9724
Cont*PrC*~PrF*PDQ*~PTQ*Tcom*~Pcom	0.2112	0.0430	1.0000
Cont*PrC*~PrF*PDQ*PrS*PTQ*~Pcom	0.2319	0.0322	1.0000
Cont*~PrF*PDQ*PrS*~PTQ*Tcom*Pcom	0.1586	0.0108	1.0000
Cont*~PrC*PDQ*PrS*~PTQ*Tcom*Pcom	0.1166	0.0108	1.0000
~Cont*PrF*PDQ*~PrS*PTQ*Tcom*Pcom	0.0532	0.0322	1.0000
Cont*~PrC*PrF*PDQ*~PrS*~PTQ*Tcom*~Pcom	0.0949	0.0108	1.0000
~Cont*PrC*PrF*PDQ*PrS*~PTQ*Tcom*~Pcom	0.0844	0.0213	1.0000

Abbreviations: see Table A9
Solution coverage: 0.7425
Solution consistency: 0.9864

Table A12 Results of the analysis of sufficient conditions for the outcome Innovations Systems, intermediate solution

INTERMEDIATE SOLUTION
Model: InSy = f(Cont, PrC, PrF, PDQ, PrS, PTQ, Tcom, Pcom)
Algorithm: Quine-McCluskey
Frequency cut off: 1
Consistency cut off: 0.80 (PRI)
Assumptions: Cont (present), PrC (present), PrF (present), PDQ (present), PrS (present), PTQ (present)

	Coverage			
Path	Raw	Unique	Consistency	Path name
Cont*PrF*PDQ*Tcom*~Pcom	0.3488	0.0959	0.9707	#1
Cont*PrC*PDQ*PrS*PTQ	0.3702	0.0217	1.0000	#2
Cont*PrC*PDQ*PTQ*Pcom	0.3284	0.0430	1.0000	#3
Cont*PDQ*PrS*Tcom*Pcom	0.3173	0.0644	0.9679	#4
PrF*PDQ*PTQ*Tcom*Pcom	0.3068	0.0217	1.0000	#5
Cont*PrC*PDQ*~PTQ*Tcom*~Pcom	0.2112	0.0430	1.0000	#6
PrC*PrF*PDQ*PrS*Tcom*~Pcom	0.2217	0.0108	1.0000	#7

Abbreviations: see Table A9
Solution coverage: 0.7655
Solution consistency: 0.9733

Table A13 ACIAR-supported projects in the paths for the outcome Innovations Systems

Path name	Project name	Freq.
#1	SMCN/2003/010, ASEM/1996/044, FIS/1998/024, CP/1997/017, FST/2004/050, LWR/2001/003	6
#2	AH/2010/019, ASEM/2002/051, CP/1997/017, CSE/2006/041, FST/2004/050, LWR/2006/158, SMAR/2006/096	7
#3	ASEM/2002/051, ADP/2007/055, AH/2002/038, ASEM/2003/015, CIM/2006/094, CSE/2006/041, LPS/2003/054, SMAR/2006/096	8
#4	ASEM/1995/119, AGB/2002/086, CSE/2006/041, FST/2000/001, FST/2005/177, LWR/2005/146	6
#5	ASEM/2003/015, CSE/2006/041, LPS/2003/054, LWR/2005/146, SMC/2003/011, SMCN/2002/085	6
#6	FST/2007/119, HORT/2000/043, LWR1/1994/054	3
#7	FST/2006/117, CP/1997/017, FST/2004/050	3
Unexplained	CP/1996/091, CS2/1996/091, FIS/2006/141, FST/1994/041, LWR1/1994/046, LWR/1998/003, LWR/2002/094, LWR2/1994/035, PHT/1996/004, SMCN/2002/033	10

Freq. = frequency count
Note: Projects that are not captured in the full solution are identified in the row 'unexplained'.

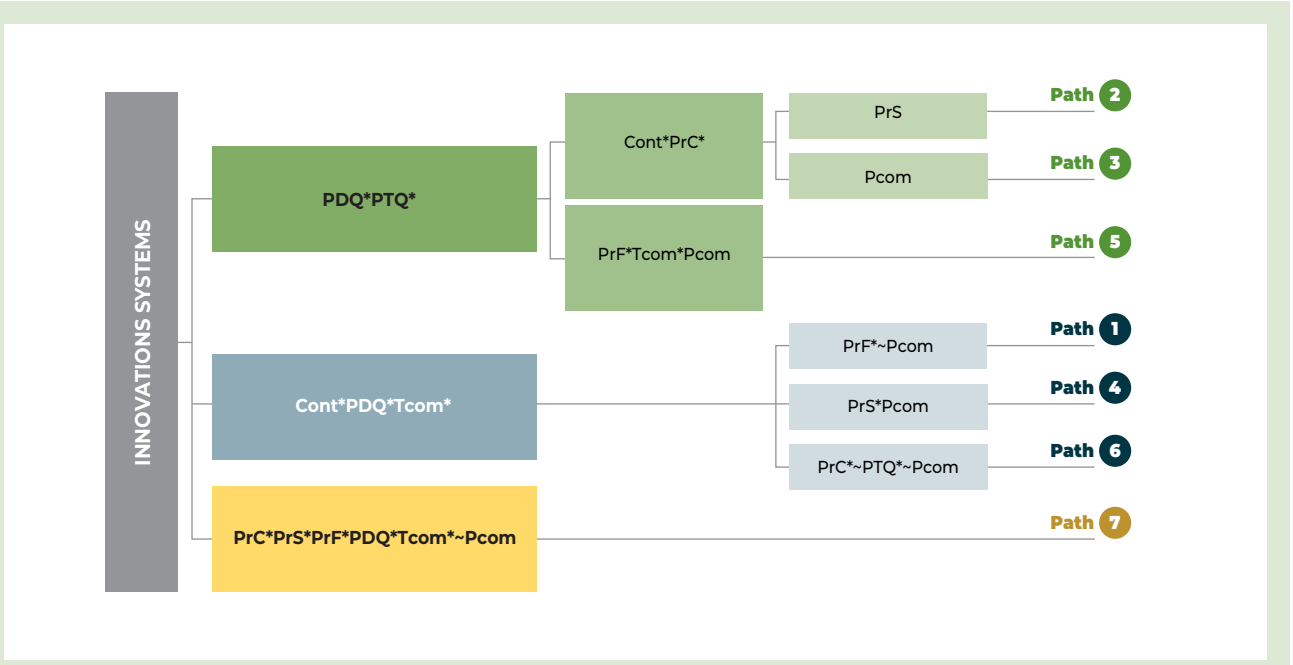


Figure A2 Paths grouped by most common conditions for the outcome Innovations Systems
Abbreviations: conditions, see Table A9

Appendix 5: Detailed analyses for the Science and Knowledge outcomes

Table A14 Results of the analysis of necessary conditions for the outcome Science and Knowledge

Condition	Consistency	Coverage
Context alignment (Cont)	0.71	0.70
~Context alignment (~Cont)	0.41	0.87
Project continuity (PrC)	0.62	0.84
~Project continuity (~PrC)	0.48	0.65
Project focus (PrF)	0.44	0.70
~Project focus (~PrF)	0.71	0.83
Project design quality (PDQ)	0.76	0.74
~Project design quality (~PDQ)	0.38	0.84
Project size (PrS)	0.81	0.76
~Project size (~PrS)	0.28	0.68
Project transition quality (PTQ)	0.71	0.76
~Project transition quality (~PTQ)	0.44	0.80
Technical competencies (Tcom)	0.79	0.77
~Technical competencies (~Tcom)	0.37	0.80
Professional competencies (Pcom)	0.40	0.77
~Professional competencies (~Pcom)	0.69	0.72

Note: ~ indicates the negate of the condition.
Interpretation of results: none of the conditions meets the suggested cut-off point for consistency of 0.90. None of the conditions is considered necessary for the outcome 'Science and Knowledge'.

Table A15 Truth table for the outcome Science and Knowledge

Row	Conditions								Freq.	Outcome	Raw consistency
	Cont	PrC	PrF	PDQ	PrS	PTQ	Tcom	Pcom			
1	0	1	0	0	1	0	1	0	2	1	1.00
2	0	0	0	0	1	0	0	0	1	1	1.00
3	0	1	0	0	1	0	0	0	1	1	1.00
4	0	1	1	1	1	0	1	0	1	1	1.00
5	0	0	1	0	1	1	1	0	1	1	1.00
6	0	0	1	1	1	1	1	0	1	1	1.00
7	0	0	0	1	1	1	1	0	2	1	0.95
8	1	1	0	1	1	0	1	0	2	1	0.94
9	0	0	0	0	1	1	1	0	1	1	0.93
10	1	1	0	1	0	0	1	0	1	1	0.91
11	1	1	0	1	1	0	1	1	1	1	0.91
12	1	1	0	1	1	1	1	0	1	1	0.90
13	1	1	1	1	1	1	1	1	1	1	0.88
14	1	1	0	1	1	1	0	0	1	1	0.87
15	1	1	1	0	1	0	0	0	1	1	0.83
16	1	1	1	1	1	1	1	0	2	1	0.83
17	1	1	0	1	0	1	1	0	1	1	0.83
18	1	0	0	0	1	1	1	0	1	1	0.83
19	1	1	1	1	0	1	1	1	2	1	0.82
20	1	0	0	1	1	1	1	0	2	1	0.81
21	1	0	0	1	1	0	1	1	2	1	0.80
22	1	1	0	1	1	1	0	1	1	1	0.80
23	1	0	1	1	0	0	1	0	1	0	0.78
24	1	0	1	1	1	1	1	1	1	0	0.77
25	1	1	1	1	0	1	0	1	1	0	0.75
26	1	1	0	1	0	1	1	1	1	0	0.75
27	1	0	0	1	1	0	1	0	1	0	0.74
28	1	0	0	0	1	0	0	0	2	0	0.73
29	1	0	1	1	1	0	1	1	1	0	0.72
30	1	1	0	1	0	1	0	1	1	0	0.67
31	1	0	1	1	1	1	1	0	3	0	0.67
32	1	0	1	0	1	1	0	0	1	0	0.66
33	1	1	1	1	1	1	0	1	1	0	0.66
34	0	0	1	1	0	1	1	1	1	0	0.66
35	0	1	1	1	0	1	1	1	1	0	0.66
36	1	0	0	1	0	0	1	0	1	0	0.63
37	1	0	1	1	0	1	0	0	1	0	0.60
38	1	0	1	0	1	0	0	0	2	0	0.55

Rows 39-256: Logical remainders
Abbreviations: conditions, see Table A14; Freq. = frequency count.

Table A16 Results of the analysis of sufficient conditions for the outcome Science and Knowledge, complex solution

COMPLEX SOLUTION
Model: InSy = f(Cont, PrC, PrF, PDQ, PrS, PTQ, Tcom, Pcom)
Algorithm: Quine-McCluskey
Frequency cut off: 1
Consistency cut off: 0.80 (raw)

	Coverage		
Path	Raw	Unique	Consistency
~PrC*~PrF*PrS*PTQ*Tcom*~Pcom	0.2615	0.0409	0.8397
~Cont*~PrC*PrS*PTQ*Tcom*~Pcom	0.2312	0.0206	0.9586
Cont*PrC*~PrF*PDQ*Tcom*~Pcom	0.2612	0.0512	0.9290
~Cont*~PrF*~PDQ*PrS*~PTQ*~Tcom*~Pcom	0.1304	0.0103	1.0000
~Cont*PrC*~PrF*~PDQ*PrS*~PTQ*~Pcom	0.1407	0.0206	1.0000
Cont*PrC*~PrF*PDQ*PrS*PTQ*~Tcom	0.1604	0.0206	0.8893
Cont*~PrF*PDQ*PrS*~PTQ*Tcom*Pcom	0.1308	0.0309	0.8675
Cont*PrC*PrF*PDQ*PTQ*Tcom*Pcom	0.2007	0.0406	0.9095
Cont*PrC*PrF*~PDQ*PrS*~PTQ*~Tcom*~Pcom	0.0502	0.0103	0.8342
~Cont*PrC*PrF*PDQ*PrS*~PTQ*Tcom*~Pcom	0.0802	0.0103	1.0000
Cont*PrC*PDQ*PrS*PTQ*Tcom*~Pcom	0.2206	0.0000	0.8804
Cont*PrC*PrF*PDQ*PrS*PTQ*Tcom	0.2206	0.0000	0.8804

Abbreviations: see Table A14
Solution coverage: 0.7179
Solution consistency: 0.9230

Table A17 Results of the analysis of sufficient conditions for the outcome Science and Knowledge, intermediate solution

INTERMEDIATE SOLUTION
Model: InSy = f(Cont, PrC, PrF, PDQ, PrS, PTQ, Tcom, Pcom)
Algorithm: Quine-McCluskey
Frequency cut off: 1
Consistency cut off: 0.80 (raw)
Assumptions: Cont (present), PrC (present), PrF (present), PDQ (present), PrS (present), PTQ (present)

	Coverage			
Path	Raw	Unique	Consistency	Path name
PrC*PrS*~Pcom	0.3629	0.0512	0.9008	#8
~Cont*PrS*~Tcom*~Pcom	0.1904	0.0103	1.0000	#9
~Cont*PrS*PTQ*~Pcom	0.2912	0.0206	0.9668	#10
~PrF*PrS*PTQ*Tcom*~Pcom	0.3517	0.0409	0.8757	#11
Cont*PrC*PDQ*Tcom*~Pcom	0.3018	0.0306	0.9097	#12
Cont*PrC*~PrF*PDQ*PrS*PTQ	0.2606	0.0103	0.9288	#13
Cont*~PrF*PDQ*PrS*Tcom*Pcom	0.2206	0.0309	0.8804	#14
Cont*PrC*PrF*PDQ*PTQ*Tcom	0.2712	0.0508	0.9005	#15

Abbreviations: see Table A14
Solution coverage: 0.7279
Solution consistency: 0.9124

Table A18 ACIAR-supported projects in the paths for the outcome Science and Knowledge

Path name	Project name	Freq.
#8	CS1/1994/039, FST/2007/119, ASEM/1998/060, CP/1996/091, FST/2006/117, AH/2010/019, AS1/1998/010, CP/1997/017, FST/2004/050, LWR1/1994/054, LWR/2006/158	11
#9	AS1/1998/010, CS2/1996/176	2
#10	LWR1/1994/046, LWR/2002/094, LWR2/1994/035, LWR2/1996/080, PHT/1996/004	5
#11	FIS/2006/141, LWR2/1996/080, LWR1/1994/046, LWR/1998/003, LWR/1998/124, LWR/2006/158, PHT/1996/004	7
#12	CS1/1997/114, FST/2007/119, HORT/2000/043, CP/1997/017, FST/2004/050, LWR1/1994/054, LWR/2006/158	7
#13	LWR/2006/158, AH/2010/019, ASEM/2002/051	3
#14	AGB/2002/086, ASEM/1995/119, FST/2000/001	3
#15	ASEM/2003/015, CP/1997/017, CSE/2006/041, FST/2004/050, LPS/2003/054	5
Unexplained	AH/2002/038, LWR/2005/146, SMCN/2002/033, ADP2007/055, ASWM/1996/044, CIM/2006/094, CS1/1994/039, FIS/1998/024, FST/2005/177	9

Freq. = frequency count
Note: Projects that are not captured in the full solution are identified in the row 'unexplained'.

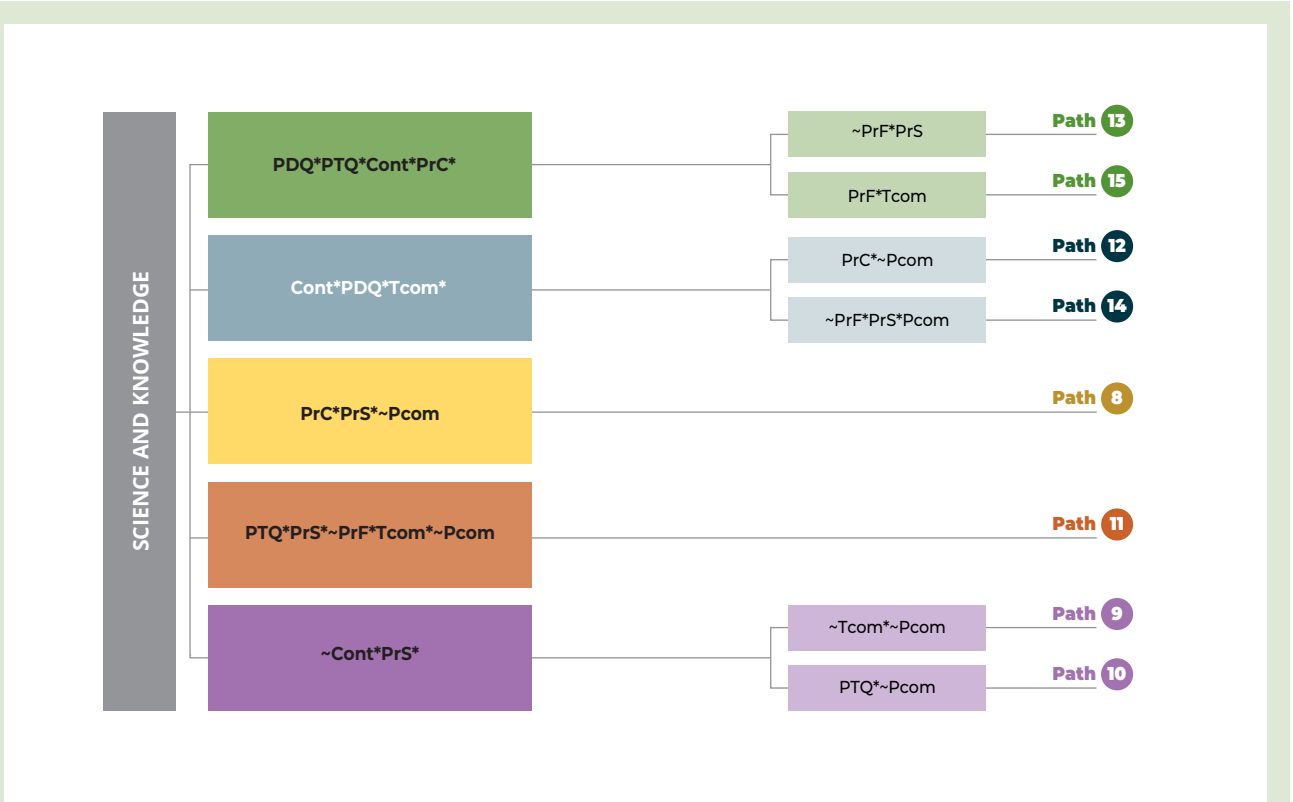


Figure A3 Paths grouped by most common conditions for the outcome Science and Knowledge (csQCA)

Abbreviations: conditions, see Table A14

Note: The differences between this figure and Figure A1 are due to the different types of QCA applied: fuzzy-set (fsQCA) here, and crisp-set (csQCA) in Figure A1. Appendix A gives a detailed explanation.

Appendix 6: Detailed analyses for the combined NRM and Policy outcomes

The analyses for Natural Resource Management (NRM) and Policy outcomes were carried out for the joint outcome 'NRM or Policy', in which 'or' is inclusive. We had to choose this option because the solution coverage and consistency scores for the individual analyses of sufficiency for NRM outcomes and Policy outcomes were too low to allow for a meaningful interpretation of their results (practically speaking, the findings of those analyses do not explain the empirics well). This is likely the result of the relatively low numbers of NRM or Policy outcomes observed in the full database of 106 projects and the 49 projects selected for the QCA (see Chapter 2), and likely more or other conditions are relevant towards achieving these outcomes than only the 8 we have included in our analytical model.

For full transparency: We have coded 6 projects as having achieved strong NRM outcomes and 19 as having achieved moderately strong NRM outcomes. The total of 25 projects represents 51% of the 49 projects included. The variety observed in projects with the outcome present and those without the outcome present (that is, 51% versus 49%) is appropriate to subject the data to the QCA process of logical minimisation (Schneider and Wagemann 2013). Essentially, with this data a QCA is technically possible, and we have no reason to believe that the low solution coverage and consistency scores for the analysis of sufficiency for this outcome are the result of the empirical data itself. Therefore, we assume that the scores are the result of the set of causal conditions we have used. It is likely that a larger or different set of causal conditions is required to better understand why some projects have achieved desirable NRM outcomes and others have not.

Table A19 Results of the analysis of necessary conditions, NRM outcomes

Condition	Consistency	Coverage
Context alignment (Cont)	0.80	0.48
~Context alignment (~Cont)	0.41	0.53
Project continuity (PrC)	0.45	0.55
~Project continuity (~PrC)	0.62	0.50
Project focus (PrF)	0.47	0.44
~Project focus (~PrF)	0.75	0.54
Project design quality (PDQ)	0.88	0.52
~Project design quality (~PDQ)	0.38	0.51
Project size (PrS)	0.80	0.45
~Project size (~PrS)	0.40	0.58
Project transition quality (PTQ)	0.75	0.49
~Project transition quality (~PTQ)	0.50	0.54
Technical competencies (Tcom)	0.87	0.52
~Technical competencies (~Tcom)	0.40	0.52
Professional competencies (Pcom)	0.42	0.48
~Professional competencies (~Pcom)	0.72	0.45

Note: ~ indicates the negate of the condition.
Interpretation of results: none of the conditions meets the suggested cut-off point for consistency of 0.90. None of the conditions is considered necessary for the outcome 'Natural Resource Management (NRM)'.

We have coded 4 projects as having achieved strong Policy outcomes and 15 as having achieved moderately strong Policy outcomes. The total of 19 projects represents 39% of the 49 projects included. Again, the variety observed in projects with the outcome present and those without the outcome present (that is, 31% versus 69%) is appropriate to expose the data to the QCA process of logical minimisation (Schneider and Wagemann 2013). Therefore, again, we assume that it is likely that a larger or different set of causal conditions is required to better understand why some projects have achieved desirable Policy outcomes and others have not.

The joint outcome 'NRM or Policy' provides us with meaningful results (also when compared to the findings that result from the other outcomes that are central to this study). For this joint outcome, we have combined the outcome scores of these 2 outcomes, so that the highest outcome score of an individual condition is the outcome score for the joint condition. In this appendix, we present the findings for the analysis of necessity for the individual outcomes 'NRM' and 'Policy' and the joint outcome 'NRM or Policy'. We present the analysis of sufficiency for only the joint outcome. For clarity, we illustrate the cases per path for the individual and joint outcomes. In Chapter 5 we interpret these findings for the NRM outcomes, and in Chapter 6 we interpret these findings for the Policy outcomes.

Table A20 Results of the analysis of necessary conditions, Policy outcomes

Condition	Consistency	Coverage
Context alignment (Cont)	0.89	0.47
~Context alignment (~Cont)	0.36	0.40
Project continuity (PrC)	0.66	0.48
~Project continuity (~PrC)	0.58	0.42
Project focus (PrF)	0.58	0.49
~Project focus (~PrF)	0.70	0.44
Project design quality (PDQ)	0.91	0.47
~Project design quality (~PDQ)	0.36	0.42
Project size (PrS)	0.87	0.43
~Project size (~PrS)	0.28	0.36
Project transition quality (PTQ)	0.81	0.47
~Project transition quality (~PTQ)	0.41	0.40
Technical competencies (Tcom)	0.89	0.46
~Technical competencies (~Tcom)	0.39	0.45
Professional competencies (Pcom)	0.56	0.58
~Professional competencies (~Pcom)	0.75	0.42

Note: ~ indicates the negate of the condition.
Interpretation of results: only 'project design quality' meets the suggested cut-off point for consistency (0.90). Its coverage score is low however (under the suggested cut-off point of 0.50). This condition is likely an irrelevant necessary condition. None of the other conditions is considered necessary for the outcome 'Policy'.

Table A21 Results of the analysis of necessary conditions, 'NRM or Policy' outcomes

Condition	Consistency	Coverage
Context alignment (Cont)	0.82	0.73
~Context alignment (~Cont)	0.38	0.72
Project continuity (PrC)	0.59	0.73
~Project continuity (~PrC)	0.59	0.72
Project focus (PrF)	0.54	0.76
~Project focus (~PrF)	0.68	0.73
Project design quality (PDQ)	0.86	0.76
~Project design quality (~PDQ)	0.38	0.75
Project size (PrS)	0.81	0.68
~Project size (~PrS)	0.36	0.78
Project transition quality (PTQ)	0.77	0.75
~Project transition quality (~PTQ)	0.41	0.67
Technical competencies (Tcom)	0.86	0.76
~Technical competencies (~Tcom)	0.38	0.74
Professional competencies (Pcom)	0.45	0.77
~Professional competencies (~Pcom)	0.72	0.67

Note: ~ indicates the negate of the condition.
Interpretation of results: none of the conditions meets the suggested cut-off point for consistency of 0.90. None of the conditions is considered necessary for the outcome 'NRM or Policy'.

Table A22 Truth table for the outcome 'NRM or Policy'

Row	Conditions								Freq.	Outcome	PRI consistency
	Cont	PrC	PrF	PDQ	PrS	PTQ	Tcom	Pcom			
1	1	1	0	1	1	0	1	0	2	1	1.00
2	1	0	0	1	1	0	1	1	2	1	1.00
3	1	1	0	1	0	0	1	0	1	1	1.00
4	1	0	1	1	1	0	1	1	1	1	1.00
5	0	0	1	1	0	1	1	1	1	1	1.00
6	0	1	1	1	0	1	1	1	1	1	1.00
7	1	0	0	1	1	0	1	0	1	1	0.88
8	1	1	0	1	1	1	1	0	1	1	0.86
9	1	0	0	0	1	1	1	0	1	1	0.83
10	1	1	1	1	1	1	1	0	2	1	0.80
11	1	1	1	1	0	1	1	1	2	1	0.80
12	1	0	0	1	1	1	1	0	2	1	0.80
13	1	1	0	1	1	1	0	0	1	1	0.80
14	1	1	0	1	1	1	0	1	1	1	0.80
15	1	0	1	1	1	1	1	0	3	0	0.75
16	0	0	0	1	1	1	1	0	2	0	0.75
17	0	1	1	1	1	0	1	0	1	0	0.75
18	1	1	0	1	0	1	0	1	1	0	0.75
19	1	1	1	1	0	1	0	1	1	0	0.75
20	1	0	1	1	1	1	1	1	1	0	0.75
21	1	0	0	1	0	0	1	0	1	0	0.74
22	1	1	0	1	0	1	1	0	1	0	0.67
23	1	1	1	1	1	1	0	1	1	0	0.67
24	0	0	0	0	1	1	1	0	1	0	0.67
25	1	0	1	1	0	0	1	0	1	0	0.66
26	1	1	1	1	1	1	1	1	1	0	0.60
27	1	1	0	1	1	0	1	1	1	0	0.60
28	1	0	1	0	1	1	0	0	1	0	0.51
29	0	0	1	0	1	1	1	0	1	0	0.50
30	1	0	0	0	1	0	0	0	2	0	0.50
31	0	1	0	0	1	0	1	0	2	0	0.50
32	1	1	0	1	0	1	1	1	1	0	0.50
33	1	1	1	0	1	0	0	0	1	0	0.49
34	0	0	1	1	1	1	1	0	1	0	0.40
35	1	0	1	1	0	1	0	0	1	0	0.33
36	0	1	0	0	1	0	0	0	1	0	0.20
37	1	0	1	0	1	0	0	0	2	0	0.00
38	0	0	0	0	1	0	0	0	1	0	0.00

Rows 39-256: Logical remainders
Abbreviations: conditions, see Table A19; Freq. = frequency count.

Table A23 Results of the analysis of sufficient conditions, complex solution for the outcome 'NRM or Policy'

COMPLEX SOLUTION
Model: InSy = f(Cont, PrC, PrF, PDQ, PrS, PTQ, Tcom, Pcom)
Algorithm: Quine-McCluskey
Frequency cut off: 1
Consistency cut off: 0.80 (PRI)

	Coverage		
Path	Raw	Unique	Consistency
Cont*PrC*~PrF*PDQ*~PTQ*Tcom*~Pcom	0.2230	0.0225	1.0000
Cont*~PrC*~PrF*PrS*PTQ*Tcom*~Pcom	0.2785	0.0114	0.9262
Cont*PrC*~PrF*PDQ*PrS*PTQ*~Tcom	0.1894	0.0340	0.9446
Cont*~PrC*PDQ*PrS*~PTQ*Tcom*Pcom	0.1231	0.0114	1.0000
~Cont*PrF*PDQ*~PrS*PTQ*Tcom*Pcom	0.0562	0.0225	1.0000
Cont*PrC*PDQ*PrS*PTQ*Tcom*~Pcom	0.2674	0.0451	0.9601
PrC*PrF*PDQ*~PrS*PTQ*Tcom*Pcom	0.1231	0.0562	0.9173
Cont*~PrF*PDQ*PrS*Tcom*~Pcom	0.4016	0.0000	0.9476
Cont*~PrC*~PrF*PDQ*PrS*~PTQ*Tcom	0.2341	0.0000	0.9547
Cont*PrC*~PrF*PDQ*~PTQ*Tcom*~Pcom	0.2230	0.0225	1.0000
Cont*~PrC*~PrF*PrS*PTQ*Tcom*~Pcom	0.2785	0.0114	0.9262

Abbreviations: see Table A19
Solution coverage: 0.6724
Solution consistency: 0.9680

Table A24 Results of the analysis of sufficient conditions, intermediate solution for the outcome 'NRM or Policy'

INTERMEDIATE SOLUTION
Model: InSy = f(Cont, PrC, PrF, PDQ, PrS, PTQ, Tcom, Pcom)
Algorithm: Quine-McCluskey
Frequency cut off: 1
Consistency cut off: 0.80 (PRI)
Assumptions: Cont (present), PrC (present), PrF (present), PDQ (present), PrS (present), PTQ (present)

	Coverage			
Path	Raw	Unique	Consistency	Path name
Cont*PrC*PDQ*~PTQ*Tcom*~Pcom	0.2230	0.0225	1.0000	#16
Cont*~PrC*PDQ*PrS*~PTQ*Tcom	0.2455	0.0568	0.9568	#17
Cont*~PrF*PrS*PTQ*Tcom*~Pcom	0.3676	0.0676	0.9431	#18
Cont*PrC*PDQ*PrS*Tcom*~Pcom	0.3014	0.0451	0.9645	#19
PrF*PDQ*~PrS*PTQ*Tcom*Pcom	0.1456	0.0901	0.9292	#20
Cont*PrC*~PrF*PDQ*PrS*PTQ*~Tcom	0.1894	0.0340	0.9446	#21

Abbreviations: see Table A19
Solution coverage: 0.6724
Solution consistency: 0.9680

Table A25 ACIAR-supported projects in the paths, NRM outcomes

Path name	Project name	Freq.
#16	HORT/200/043, LWR1/1004/054	2
#17	ASEM/1995/119, FST/2000/001, LWR/1997/016	3
#18	FIS/2006/141, LWR/1998/124, LWR/2006/158	3
#19	LWR1/1994/054, LWR/2006/158	2
#20	ASEM/2003/015, SMCN/2002/085, SMCN/2003/010	3
#21	ASEM/2002/051	1
Unexplained	CIM/2006/094, CP/1996/091, CP/2000/044, CS1/1997/114, FIS/1998/024, FST/1994/041, FST/2006/117, LWR1/1994/046, LWR/2001/003, LWR/2005/146, LWR2/1996/080, SMCN/2003/010	12

Freq. = frequency count
Note: Projects that are not captured in the full solution are identified in the row 'unexplained'.

Table A26 ACIAR-supported projects in the paths, Policy outcomes

Path name	Project name	Freq.
#16	FST2007/119, LWR/1994/054	2
#17	FST/2000/001, FST/2005/117, LWR/1997/016	3
#18	LWR/1998/003, LWR/2006/158	2
#19	CP/1997/017, FST/2004/050, LWR/2006/158	3
#20	LPS/2003/054	1
#21	AH/2010/019, ASEM/2002/051,	2
Unexplained	ADP/2007/055, CSE/2006/041, FIS/1998/024, LWR/2005/146, LWR2/1994/035, PHT/1996/004, SMAR/2006/096	7

Freq. = frequency count
Note: Projects that are not captured in the full solution are identified in the row 'unexplained'.

Table A27 ACIAR-supported projects in the paths, 'NRM or Policy' outcomes

Path name	Project name	Freq.
#16	FST/2007/119, HORT/2000/043, LWR1/1994/054	3
#17	ASEM/1995/119, FST/2000/001, FST/2005/177, LWR/1997/016	4
#18	FIS/2006/141, LWR/1998/003, LWR/1998/124, LWR/2006/158	4
#19	FST/2007/119, CP/1997/017, FST/2004/050, LWR1/1994/054, LWR/2006/158	5
#20	LPS/2003/054, SMC/2003/011, SMCN/2002/085, ASEM/2003/015	4
#21	AH/2010/019, ASEM/2002/051	2
Unexplained	ADP/2007/055, CIM/2006/094, CP/1996/091, CP/2000/044, CS1/1997/114, CSE/2006/041, FIS/1998/024, FST/1994/041, FST/2006/117, LWR1/1994/046, LWR/2001/003, LWR/2005/146, LWR2/1994/035, LWR2/1996/080, PHT/1996/004, SMAR/2006/096, SMCN/2003/010	17

Freq. = frequency count
Note: Projects that are not captured in the full solution are identified in the row 'unexplained'.

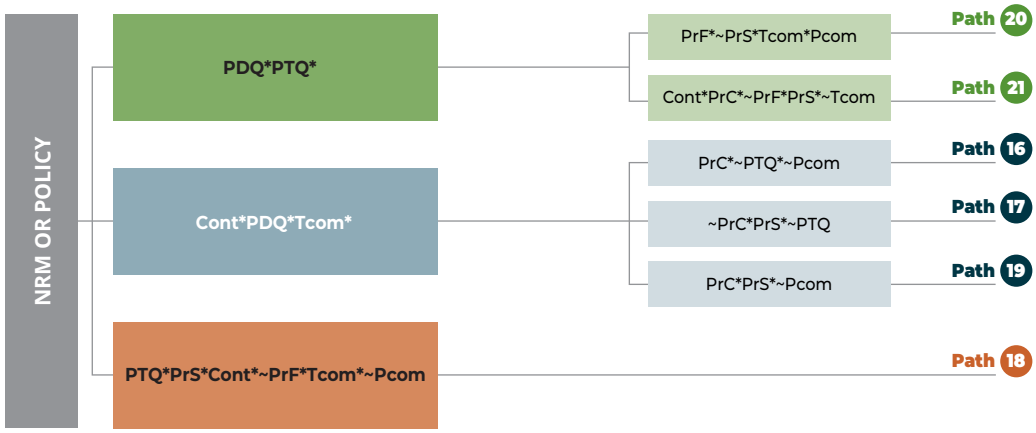


Figure A4 Paths grouped by most common conditions for the 'NRM or Policy' outcomes
Abbreviations: conditions, see Table A19

Appendix 7: Detailed analyses for the Socioeconomic outcomes

Table A28 Results of the analysis of necessary conditions for the outcome Socioeconomic

Condition	Consistency	Coverage
Context alignment (Cont)	0.85	0.55
~Context alignment (~Cont)	0.41	0.57
Project continuity (PrC)	0.68	0.60
~Project continuity (~PrC)	0.55	0.49
Project focus (PrF)	0.62	0.63
~Project focus (~PrF)	0.63	0.49
Project design quality (PDQ)	0.88	0.56
~Project design quality (~PDQ)	0.40	0.58
Project size (PrS)	0.80	0.49
~Project size (~PrS)	0.31	0.49
Project transition quality (PTQ)	0.78	0.55
~Project transition quality (~PTQ)	0.41	0.49
Technical competencies (Tcom)	0.85	0.54
~Technical competencies (~Tcom)	0.38	0.54
Professional competencies (Pcom)	0.61	0.77
~Professional competencies (~Pcom)	0.64	0.44

Note: ~ indicates the negate of the condition.
Interpretation of results: none of the conditions meets the suggested cut-off point for consistency of 0.90. None of the conditions is considered necessary for the outcome 'socioeconomic'.

Table A29 Truth table for the outcome Socioeconomic

Row	Conditions								Freq.	Outcome	Raw consistency
	Cont	PrC	PrF	PDQ	PrS	PTQ	Tcom	Pcom			
1	0	0	1	1	0	1	1	1	1	1	1.00
2	0	1	1	1	0	1	1	1	1	1	1.00
3	1	0	1	1	1	1	1	1	1	1	0.92
4	1	0	0	1	1	0	1	1	2	1	0.90
5	1	1	1	1	1	1	1	1	1	1	0.88
6	1	0	1	1	1	0	1	1	1	1	0.86
7	1	1	1	1	0	1	1	1	2	1	0.82
8	1	1	0	1	1	1	0	1	1	1	0.80
9	1	1	1	1	1	1	0	1	1	1	0.78
10	1	1	0	1	1	1	1	0	1	1	0.76
11	1	1	1	1	0	1	0	1	1	1	0.75
12	1	1	0	1	1	0	1	1	1	0	0.73
13	1	1	0	1	1	0	1	0	2	0	0.71
14	0	1	0	0	1	0	0	0	1	0	0.70
15	0	1	0	0	1	0	1	0	2	0	0.69
16	0	1	1	1	1	0	1	0	1	0	0.63
17	1	1	0	1	0	1	1	1	1	0	0.62
18	1	0	1	1	1	1	1	0	3	0	0.62
19	1	0	0	0	1	1	1	0	1	0	0.61
20	1	1	1	1	1	1	1	0	2	0	0.61
21	1	0	1	1	0	1	0	0	1	0	0.60
22	0	0	0	0	1	1	1	0	1	0	0.60
23	1	1	0	1	1	1	0	0	1	0	0.60
24	1	0	0	1	1	1	1	0	2	0	0.54
25	1	0	0	1	1	0	1	0	1	0	0.53
26	1	1	0	1	0	1	0	1	1	0	0.50
27	0	0	1	1	1	1	1	0	1	0	0.46
28	0	0	0	1	1	1	1	0	2	0	0.45
29	1	0	1	0	1	1	0	0	1	0	0.45
30	0	0	1	0	1	1	1	0	1	0	0.44
31	1	1	0	1	0	1	1	0	1	0	0.42
32	0	0	0	0	1	0	0	0	1	0	0.37
33	1	0	0	1	0	0	1	0	1	0	0.36
34	1	1	0	1	0	0	1	0	1	0	0.36
35	1	0	0	0	1	0	0	0	2	0	0.36
36	1	0	1	1	0	0	1	0	1	0	0.33
37	1	1	1	0	1	0	0	0	1	0	0.33
38	1	0	1	0	1	0	0	0	2	0	0.22

Rows 39-256: Logical remainders
Abbreviations: conditions, see Table A28; Freq. = frequency count.

Table A30 Results of the analysis of sufficient conditions for the outcome Socioeconomic, complex solution

COMPLEX SOLUTION
Model: InSy = f(Cont, PrC, PrF, PDQ, PrS, PTQ, Tcom, Pcom)
Algorithm: Quine-McCluskey
Frequency cut off: 1
Consistency cut off: 0.75 (raw)

	Coverage		
Path	Raw	Unique	Consistency
Cont*PrC*PrF*PDQ*PTQ*Pcom	0.3370	0.0775	0.9172
Cont*~PrC*PDQ*PrS*~PTQ*Tcom*Pcom	0.1535	0.0466	0.9098
~Cont*PrF*PDQ*~PrS*PTQ*Tcom*Pcom	0.0770	0.0466	1.0000
Cont*PrC*PDQ*PrS*PTQ*~Tcom*Pcom	0.1531	0.0157	0.8342
Cont*PrC*~PrF*PDQ*PrS*PTQ*Tcom*~Pcom	0.2439	0.1070	0.7622
Cont*~PrC*PrF*PDQ*PrS*Tcom*Pcom	0.2139	0.0000	0.9336
Cont*PrF*PDQ*PrS*PTQ*Tcom*Pcom	0.2748	0.0000	0.9003

Abbreviations: see Table A28
Solution coverage: 0.6602
Solution consistency: 0.8967

Table A31 Results of the analysis of sufficient conditions for the outcome Socioeconomic, intermediate solution

INTERMEDIATE SOLUTION
Model: InSy = f(Cont, PrC, PrF, PDQ, PrS, PTQ, Tcom, Pcom)
Algorithm: Quine-McCluskey
Frequency cut off: 1
Consistency cut off: 0.80 (raw)
Assumptions: Cont (present), PrC (present), PrF (present), PDQ (present), PrS (present), PTQ (present)

	Coverage			
Path	Raw	Unique	Consistency	Path name
PrF*PDQ*PTQ*Tcom*Pcom	0.3983	0.0466	0.8972	#22
Cont*~PrC*PDQ*PrS*Tcom*Pcom	0.2909	0.0466	0.9053	#23
Cont*PrC*PrF*PDQ*PTQ*Pcom	0.3370	0.0157	0.9172	#24
Cont*PrF*PDQ*PrS*Tcom*Pcom	0.3057	0.0000	0.9095	Log.red.
Cont*PrC*PDQ*PrS*PTQ*~Tcom*Pcom	0.1531	0.0157	0.8342	#25
Cont*PrC*~PrF*PDQ*PrS*PTQ*Tcom*~Pcom	0.2439	0.0917	0.7622	#26

Abbreviations: see Table A28; Log.red = logically redundant path
Solution coverage: 0.6602
Solution consistency: 0.8611

The intermediate solution includes one logically redundant path (Schneider and Wagemann 2013). All cases in it are explained by other paths. The path belongs to what we have termed the 'classic AR4D project' cluster (that at least has the configuration 'Cont*PDQ*Tcom') and as such does not add novel information or insight to this study. We have therefore excluded it from our interpretation of the findings.

Table A32 ACIAR-supported projects in the paths for the outcome Socioeconomic

Path name	Project name	Freq.
#22	ASEM/2003/015, CSE/2006/041, LPS/2003/054, LWR/2005/146, SMC/2003/011, SMCN/2002/085	6
#23	ASEM/1995/119, FST/2000/001, FST/2005/177, LWR/2005/146	4
#24	ASEM/2003/015, CIM/2006/094, CSE/2006/041, LPS/2003/054, SMAR/2006/096	5
Log.red.	CSE/2006/041, FST/2005/177, LWR/2005/146	Irrelevant
#25	ASEM/2002/051, SMAR/2006/096	2
#26	LWR/2006/158	1
Unexplained	AS1/1998/010, ASEM/2002/051, ASEM/2004/042, CP/1996/091, CP/2000/044, FIS/2006/141, FST/2006/117, FST/2007/119, LWR1/1994/054, LWR/2001/003, PHT/1006/004, SMCN/2003/010	12

Freq. = frequency count; Log.red = logically redundant path (see above)
Note: Projects that are not captured in the full solution are identified in the row 'unexplained'.

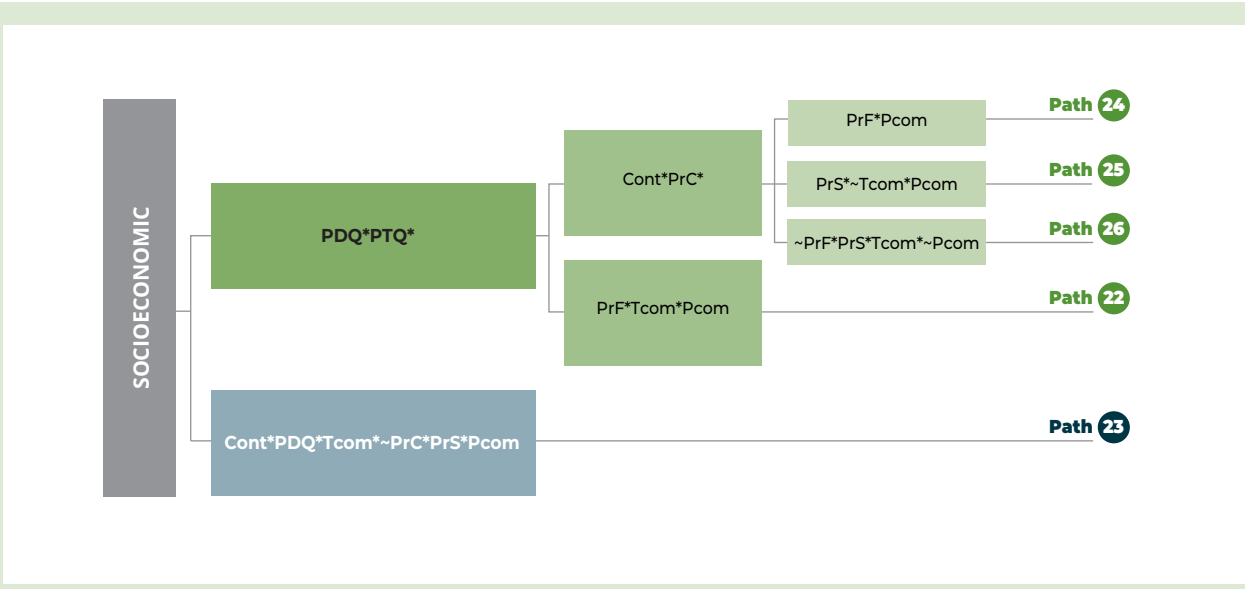


Figure A5 Paths grouped by most common conditions for the outcome Socioeconomic
Abbreviations: conditions, see Table A28

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1	Centre for International Economics 1998	Control of Newcastle disease in village chickens	AS1/1983/034, AS1/1987/017, AS1/1993/222
2	George P.S. 1998	Increased efficiency of straw utilisation by cattle and buffalo	AS1/1982/003, AS2/1986/001, AS2/1988/017
3	Centre for International Economics 1998	Establishment of a protected area in Vanuatu	ANRE/1990/020
4	Watson A.S. 1998	Raw wool production and marketing in China	ADP/1988/011
5	Collins D.J. and Collins B.A. 1998	Fruit fly in Malaysia and Thailand 1985–1993	CS2/1983/043, CS2/1989/019
6	Ryan J.G. 1998	Pigeonpea improvement	CS1/1982/001, CS1/1985/067
7	Centre for International Economics 1998	Reducing fish losses due to epizootic ulcerative syndrome—an ex ante evaluation	FIS/1991/030
8	McKenney D.W. 1998	Australian tree species selection in China	FST/1984/057, FST/1988/048
9	ACIL Consulting 1998	Sulfur test KCL–40 and growth of the Australian canola industry	PN/1983/028, PN/1988/004
10	AACM International 1998	Conservation tillage and controlled traffic	LWR2/1992/009
11	Chudleigh P. 1998	Postharvest R&D concerning tropical fruits	PHT/1983/056, PHT/1988/044
12	Waterhouse D., Dillon B. and Vincent D. 1999	Biological control of the banana skipper in Papua New Guinea	CS2/1988/002-C
13	Chudleigh P. 1999	Breeding and quality analysis of rapeseed	CS1/1984/069, CS1/1988/039
14	McLeod R., Isvilanonda S. and Wattanutchariya S. 1999	Improved drying of high moisture grains	PHT/1983/008, PHT/1986/008, PHT/1990/008
15	Chudleigh P. 1999	Use and management of grain protectants in China and Australia	PHT/1990/035
16	McLeod R. 2001	Control of footrot in small ruminants of Nepal	AS2/1991/017, AS2/1996/021
17	Tisdell C. and Wilson C. 2001	Breeding and feeding pigs in Australia and Vietnam	AS2/1994/023
18	Vincent D. and Quirke D. 2002	Controlling *Phalaris minor* in the Indian rice-wheat belt	CS1/1996/013
19	Pearce D. 2002	Measuring the poverty impact of ACIAR projects—a broad framework	
20	Warner R. and Bauer M. 2002	*Mama Lus Frut* scheme: an assessment of poverty reduction	ASEM/1999/084
21	McLeod R. 2003	Improved methods in diagnosis, epidemiology, and information management of foot-and-mouth disease in South-East Asia	AS1/1983/067, AS1/1988/035, AS1/1992/004, AS1/1994/038

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22	Bauer M., Pearce D. and Vincent D. 2003	Saving a staple crop: impact of biological control of the banana skipper on poverty reduction in Papua New Guinea	CS2/1988/002-C
23	McLeod R. 2003	Improved methods for the diagnosis and control of bluetongue in small ruminants in Asia and the epidemiology and control of bovine ephemeral fever in China	AS1/1984/055, AS2/1990/011, AS2/1993/001
24	Palis F.G., Sumalde Z.M. and Hossain M. 2004	Assessment of the rodent control projects in Vietnam funded by ACIAR and AusAID: adoption and impact	AS1/1998/036
25	Brennan J.P. and Quade K.J. 2004	Genetics of and breeding for rust resistance in wheat in India and Pakistan	CS1/1983/037, CS1/1988/014
26	Mullen J.D. 2004	Impact assessment of ACIAR-funded projects on grain-market reform in China	ADP/1997/021, ANRE1/1992/028
27	van Bueren M. 2004	Acacia hybrids in Vietnam	FST/1986/030
28	Harris D. 2004	Water and nitrogen management in wheat-maize production on the North China Plain	LWR1/1996/164
29	Lindner R. 2004	Impact assessment of research on the biology and management of coconut crabs on Vanuatu	FIS/1983/081
30	van Bueren M. 2004	Eucalypt tree improvement in China	FST/1984/057, FST/1987/036, FST/1988/048, FST/1990/044, FST/1994/025, FST/1996/125, FST/1997/077
31	Pearce D. 2005	Review of ACIAR's research on agricultural policy	
32	Tingsong Jiang and Pearce D. 2005	Shelf-life extension of leafy vegetables—evaluating the impacts	PHT/1994/016
33	Vere D. 2005	Research into conservation tillage for dryland cropping in Australia and China	LWR2/1992/009, LWR2/1996/143
34	Pearce D. 2005	Identifying the sex pheromone of the sugarcane borer moth	CS2/1991/680
35	Raitzer D.A. and Lindner R. 2005	Review of the returns to ACIAR's bilateral R&D investments	
36	Lindner R. 2005	Impacts of mud crab hatchery technology in Vietnam	FIS/1992/017, FIS/1999/076
37	McLeod R. 2005	Management of fruit flies in the Pacific	CS2/1989/020, CS2/1994/003, CS2/1994/115, CS2/1996/225
38	ACIAR 2006	Future directions for ACIAR's animal health research	

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39	Pearce D., Monck M., Chadwick K. and Corbishley J. 2006	Benefits to Australia from ACIAR-funded research	AS2/1990/028, AS2/1994/017, AS2/1994/018, AS2/1999/060, CS1/1990/012, CS1/1994/968, FST/1993/016, PHT/1990/051
40	Corbishley J. and Pearce D. 2006.	Zero tillage for weed control in India: the contribution to poverty alleviation	CS1/1996/013
41	ACIAR 2006	ACIAR and public funding of R&D. Submission to Productivity Commission study on public support for science and innovation	
42	Pearce D. and Monck M. 2006	Benefits to Australia of selected CABI products	
43	Harris D.N. 2006	Water management in public irrigation schemes in Vietnam	LWR1/1998/034, LWR2/1994/004
44	Gordon J. and Chadwick K. 2007	Impact assessment of capacity building and training: assessment framework and two case studies	CS1/1982/001, CS1/1985/067, LWR2/1994/004, LWR2/1998/034
45	Turnbull J.W. 2007	Development of sustainable forestry plantations in China: a review	
46	Monck M. and Pearce D. 2007	Mite pests of honey bees in the Asia–Pacific region	AS2/1990/028, AS2/1994/017, AS2/1994/018, AS2/1999/060
47	Fisher H. and Gordon J. 2007	Improved Australian tree species for Vietnam	FST/1993/118, FST/1998/096
48	Longmore C., Gordon J. and Bantilan M.C. 2007	Assessment of capacity building: overcoming production constraints to sorghum in rainfed environments in India and Australia	CS1/1994/968
49	Fisher H. and Gordon J. 2007	Minimising impacts of fungal disease of eucalypts in South-East Asia	FST/1994/041
50	Monck M. and Pearce D. 2007	Improved trade in mangoes from the Philippines, Thailand and Australia	CS1/1990/012, PHT/1990/051
51	Corbishley J. and Pearce D. 2007	Growing trees on salt-affected land	FST/1993/016
52	Fisher H. and Gordon J. 2008	Breeding and feeding pigs in Vietnam: assessment of capacity building and an update on impacts	AS2/1994/023
53	Monck M. and Pearce D. 2008	The impact of increasing efficiency and productivity of ruminants in India by the use of protected nutrient technology	AH/1997/115
54	Monck M. and Pearce D. 2008	Impact of improved management of white grubs in peanut-cropping systems in India	CS2/1994/050

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55	Martin G. 2008	ACIAR fisheries projects in Indonesia: review and impact assessment	FIS/1997/022, FIS/1997/125, FIS/2000/061, FIS/2001/079, FIS/2002/074, FIS/2002/076, FIS/2005/169, FIS/2006/144
56	Lindner B. and McLeod P. 2008	A review and impact assessment of ACIAR's fruitfly research partnerships—1984–2007	CP/1997/079, CP/2001/027, CP/2002/086, CP/2007/002, CP/2007/187, CS2/1983/043, CS2/1989/019, CS2/1989/020, CS2/1994/003, CS2/1994/115, CS2/1996/225, CS2/1997/101, CS2/1998/005, CS2/2003/036, PHT/1990/051, PHT/1993/87, PHT/1994/133
57	Montes N.D., Zapata Jr N.R., Alo A.M.P. and Mullen J.D. 2008	Management of internal parasites in goats in the Philippines	AS1/1997/133
58	Davis J., Gordon J., Pearce D. and Templeton D. 2008	Guidelines for assessing the impacts of ACIAR's research activities	
59	Chupungco A., Dumayas E. and Mullen J. 2008	Two-stage grain drying in the Philippines	PHT/1983/008, PHT/1986/008, PHT/1990/008
60	Centre for International Economics 2009	ACIAR Database for Impact Assessments (ADIA): an outline of the database structure and a guide to its operation	
61	Fisher H. and Pearce D. 2009	Salinity reduction in tannery effluents in India and Australia	AS1/2001/005
62	Francisco S.R., Mangabat M.C., Mataia A.B., Acda M.A., Kagaoan C.V., Laguna J.P., Ramos M., Garabiag K.A., Paguia F.L. and Mullen J.D. 2009	Integrated management of insect pests of stored grain in the Philippines	PHT/1983/009, PHT/1983/011, PHT/1986/009, PHT/1990/009
63	Harding M., Tingsong Jiang and Pearce D. 2009	Analysis of ACIAR's returns on investment: appropriateness, efficiency and effectiveness	
64	Mullen J.D. 2010	Reform of domestic grain markets in China: a reassessment of the contribution of ACIAR-funded economic policy research	ADP/1997/021, ANRE1/1992/028
65	Martin G. 2010	ACIAR investment in research on forages in Indonesia	AS2/2000/103, AS2/2000/124, AS2/2001/125, LPS/2004/005, SMAR/2006/061, SMAR/2006/096
66	Harris D.N. 2010	Extending low-cost fish farming in Thailand: an ACIAR–World Vision collaborative program	PLIA/2000/165
67	Fisher H. 2010	The biology, socioeconomics and management of the barramundi fishery in Papua New Guinea's Western Province	FIS/1998/024

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68	McClintock A. and Griffith G. 2010	Benefit–cost meta-analysis of investment in the International Agricultural Research Centres	
69	Pearce D. 2010	Lessons learned from past ACIAR impact assessments, adoption studies and experience	
70	Harris D.N. 2011	Extending low-chill fruit in northern Thailand: an ACIAR–World Vision collaborative project	PLIA/2000/165
71	Lindner R. 2011	The economic impact in Indonesia and Australia from ACIAR's investment in plantation forestry research, 1987–2009	FST/1986/013, FST/1990/043, FST/1993/118, FST/1995/110, FST/1995/124, FST/1996/182, FST/1997/035, FST/1998/096, FST/2000/122, FST/2000/123, FST/2003/048, FST/2004/058
72	Lindner R. 2011	Frameworks for assessing policy research and ACIAR's investment in policy-oriented projects in Indonesia	ADP/1994/049, ADP/2000/100, ADP/2000/126, AGB/2000/072, AGB/2004/028, ANRE1/1990/038, ANRE1/1993/023, ANRE1/1993/705, EFS/1983/062, EFS/1988/022
73	Fisher H. 2011	Forestry in Papua New Guinea: a review of ACIAR's program	FST/1994/033, FST/1995/123, FST/1998/118, FST/2002/010, FST/2004/050, FST/2004/055, FST/2004/061, FST/2006/048, FST/2006/088, FST/2006/120, FST/2007/078, FST/2009/012
74	Brennan J.P. and Malabayabas A. 2011	International Rice Research Institute's contribution to rice varietal yield improvement in South-East Asia	
75	Harris D.N. 2011	Extending rice crop yield improvements in Lao PDR: an ACIAR–World Vision collaborative project	CIM/1999/048, CS1/1995/100, PLIA/2000/165
76	Grewal B., Grunfeld H. and Sheehan P. 2011	The contribution of agricultural growth to poverty reduction	
77	Saunders C., Davis L. and Pearce D. 2012	Rice–wheat cropping systems in India and Australia, and development of the 'Happy Seeder'	LWR/2000/089, LWR/2006/132, CSE/2006/124
78	Carpenter D. and McGillivray M. 2012	A methodology for assessing the poverty-reducing impacts of Australia's international agricultural research	
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80	Fisher H., Sar L. and Winzenried C. 2012	Oil palm pathways: an analysis of ACIAR's oil palm projects in Papua New Guinea	ASEM/1999/084, ASEM/2002/014, ASEM/2006/127, CP/1996/091, CP/2007/098, PC/2004/064, PC/2006/063

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81	Pearce D. and White L. 2012	Including natural resource management and environmental impacts within impact assessment studies: methodological issues	
82	Fisher H. and Hohnen L. 2012	ACIAR's activities in Africa: a review	AS1/1983/003, AS1/1995/040, AS1/1995/111, AS1/1996/096, AS1/1998/010, AS2/1990/047, AS2/1991/018, AS2/1993/724, AS2/1996/014, AS2/1999/063, AS2/1996/090, AS2/1996/149, AS2/1996/203, AS2/1997/098, CP/1994/126, CS2/1990/007, EFS/1983/026, FST/1983/020, FST/1983/031, FST/1983/057, FST/1988/008, FST/1988/009, FST/1991/026, FST/1995/107, FST/1996/124, FST/1996/206, FST/2003/002, IAP/1996/181, LPS/1999/036, LPS/2002/081, LPS/2004/022, LPS/2008/013, LWR/2011/015, LWR1/1994/046, LWR2/1987/035, LWR2/1996/049, LWR2/1996/163, LWRS/1996/215, LWR2/1997/038, SMCN/1999/003, SMCN/1999/004, SMCN/2000/173, SMCN/2001/028
83	Palis F.G., Sumalde Z.M., Torres C.S., Contreras A.P. and Datar F.A. 2013	Impact pathway analysis of ACIAR's investment in rodent control in Vietnam, Lao PDR and Cambodia	ADP/2000/007, ADP/2003/060, ADP/2004/016, AS1/1994/020, AS1/1996/079, AS1/1998/036, CARD 2000/024, PLIA/2000/165
84	Mayne J. and Stern E. 2013	Impact evaluation of natural resource management research programs: a broader view	
85	Jilani A., Pearce D. and Bailo F. 2013	ACIAR wheat and maize projects in Afghanistan	SMCN/2002/028, CIM/2004/002, CIM/2007/065
86	Lindner B., McLeod P. and Mullen J. 2013	Returns to ACIAR's investment in bilateral agricultural research	
87	Fisher H. 2014	Newcastle disease control in Africa	AS1/1995/040, AS1/1996/096
88	Clarke M. 2015	ACIAR-funded crop–livestock projects, Tibet Autonomous Region, People's Republic of China	LPS/2002/104, CIM/2002/093, LPS/2005/018, LPS/2005/129, LPS/2006/119, LPS/2008/048, LPS/2010/028, C2012/228, C2013/017
89	Pearce D. 2016	Sustaining cocoa production: impact evaluation of cocoa projects in Indonesia and Papua New Guinea	SMAR/2005/074, HORT/2010/011, ASEM/2003/015, ASEM/2006/127, PC/2006/114

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91	Brown P. R., Nidumolu U. B., Kuehne G., Llewellyn R., Mungai O., Brown B. and Ouzman J. 2016	Development of the public release version of Smallholder ADOPT for developing countries	
92	Davila F., Sloan T. and van Kerkhoff L. 2016	Knowledge systems and RAPID framework for impact assessments	CP/1997/017
93	Mullen J.D., de Meyer J., Gray D. and Morris G. 2016	Recognising the contribution of capacity building in ACIAR bilateral projects: Case studies from three IAS reports.	FST/1986/030, FST/1993/118, FST/1998/096, FIS/2005/114
94	Davila F. Sloan T. Milne M. and van Kerkhoff L., 2017	Impact assessment of giant clam research in the Indo-Pacific region	FIS/1982/032, FIS/1987/033, EFS/1988/023, FIS/1995/042
95	Ackerman J.L. and Sayaka B. 2018	Impact assessment of ACIAR's Aceh aquaculture rehabilitation projects	FIS/2005/009, FIS/2006/002
96	Clarke M. and Mikhailovich K. 2018	Impact assessment of investment in aquaculture-based livelihoods in the Pacific islands region and tropical Australia	FIS/2001/075, FIS/2006/138
97	Mullen J.D., Malcolm B. and Farquharson R.J. 2019	Impact assessment of ACIAR-supported research in lowland rice systems in Lao PDR	CSI/1995/100, CIM/1999/048, CSE/2006/041
98	Clarke M. 2019	Impact assessment of ACIAR investment in citrus rootstock, scion and production improvement in China, Vietnam, Bhutan and Australia	CSI/1987/002, CS1/1996/076, HORT/2005/142, HORT/2010/089
99	Abell J., Chudleigh P. and Hardaker T., 2021	An impact assessment of conservation tillage research in China and Australia	LWR2/1992/009, LWR2/1996/143
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100 (2)	van der Heijden, J. 2022	The impact of ACIAR work in agricultural research for development 1982–2022: a qualitative comparative analysis	Selected projects since 1982
101	Davila F., Vanzetti D. and Sloan T., 2021	Mixed-methods impact assessment of sandalwood research in Vanuatu	FST/2002/097, FST/2008/010
102	Williams L.J., McMillan L., Van Wensveen M., Butler J.R.A., Camacho Jr J.D.V., Lapitan A., Datoon R., Gapas J., Pinca E., Macavinta-Gabunada F., Serino M.N.V., Nunez. L., Recto A.L., Ruales J.H., Enerlan W.C., Ani P.A.B and Aranas M.B. 2021	An integrated approach to ex-post impact assessment	ASEM/1998/052, ASEM/2002/051, ASEM/2009/044


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