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Knowledge systems and RAPID framework for impact assessments

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Research that works for developing countries and Australia

Knowledge systems and RAPID framework for impact assessments

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Foreword

Formal assessment of the impact of ACIAR's research investments is central to ensuring the Centre's public accountability. The results also give an opportunity to review processes of project development and implementation, and to hone setting of priorities for future action. Until now the majority of ACIAR's impact assessments have followed the benefit-cost and results-mapping approach, developed and refined by former ACIAR Program Manager Dr Jeff Davis and colleagues.

ACIAR's guidelines highlight that the impact of research investments can be classified into three broad categories: technologies—the improved products and approaches provided by investments; capacity building—the scientific knowledge and skills at both individual and organisational levels; and policy—the knowledge, models and frameworks to aid policy- and decision-making. However, a gap remains between these and the assessment of the less-quantifiable social and policy impacts that can be attributed to ACIAR investments.

This report presents a new approach designed to bridge this gap. It involves an integration of two fresh components—knowledge systems and a framework termed RAPID (research and policy in development). These tools can enable assessors to document the extent that scientific knowledge emanating from a project is absorbed and used by different actors, and also identify the development factors that influence change in specific contexts.

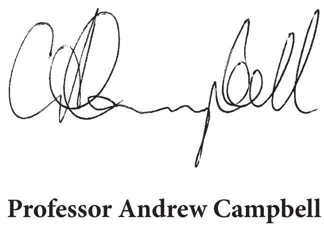
These less-tangible outcomes can augment and amplify the impacts derived from the assessments undertaken in ACIAR's standard approach. They include public-good benefits, intermediate steps towards longer term economic gain, capacity development, and knowledge absorption by private and public institutions. While they cannot be easily quantified, they can be analysed through understanding how knowledge users have engaged with or used project outputs since the completion of projects.

The report comprises an in-depth introduction to the knowledge systems and the RAPID framework, and the rationale for its implementation in terms of the ACIAR impact assessment methodology. The case study designed to demonstrate the application of this framework provides a valuable example to assist in more fully understanding this new approach.

It is gratifying that the case study, which examined the effectiveness of research to reduce hazardous aflatoxin levels in peanuts in both Indonesia and Australia, found long-lasting benefits for both countries. On-farm and technical monitoring tools developed during the project have made a strong contribution to aflatoxin awareness in Australia and to enforcement of regulations in postharvest handling of peanuts.

In Indonesia great advances were made in detection of the presence of aflatoxin at stages along the postharvest chain, in particular highlighting poor practices of storage in wet markets. Both researchers and policymakers now have their voices heard through the Aflatoxin Forum of Indonesia. Of particular significance are the self-sustaining activities that have endured well beyond the life of the ACIAR projects, including an increase in postgraduate students undertaking aflatoxin research and the recognition that Indonesian research centres are now regional leaders in their own right.

The addition of this new approach has indeed shown how it will add extra validation to the impact assessment processes we undertake.



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Contents

Figures

Tables

Acronyms

ACIAR	Australian Centre for International Agricultural Research
AFI	Aflatoxin Forum of Indonesia
AIAT	Assessment Institute for Agricultural Technology
APSIM	agricultural production systems simulator
ASEAN	Association of South-East Asian Nations
BALITVET	Balai Besar Penelitian Veteriner
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ELISA	enzyme-linked immunosorbent assay
GMU	Gajah Mada University
GRDC	Grains Research and Development Corporations
IAS	Impact Assessment Series
ILETRI	Indonesian Legumes and Tuber Crops Institute
MFI	Mycotoxin Forum of Indonesia
NADFC	National Agency of Drug and Food Control
ODI	Overseas Development Institute
PPB	parts per billion
RAPID	research and policy in development
SEAMEO BIOTROP	South-East Asian Regional Centre for Tropical Biology
SNI	Indonesian National Standard

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Executive summary

The Australian Centre for International Agricultural Research (ACIAR) has a range of tools to assess the impact of research investments. The majority of ACIAR impact assessments follow the common guidelines compiled by Davis et al. (2008), which emphasise a benefit–cost and results–mapping approach to assessing project impact. Despite the advantages of economic approaches to impact assessments, Linder (2011) argues that in order to understand decision-making processes, impact assessments need less linear and deterministic methodologies that can embrace the social and policy dimensions of impact.

This report contributes towards the focus on the social and policy dimensions of impact. The report has two major parts. First, a new framework for impact assessments is presented. The framework integrates two distinct literatures that link research with policy outcomes. Knowledge systems (Cash et al. 2003) and the research and policy for development (RAPID) literatures (Overseas Development Institute 2004) are proposed as tools to analyse how knowledge flows among different actors in development contexts. This framework adds to ACIAR's impact assessment methodologies and can be used in parallel, or combination with, the common approach developed by Davis et al. (2008).

In the second part the framework is applied to an ACIAR-funded aflatoxin-reducing project in Indonesia (CP/1997/017). The framework identifies that ACIAR investments produce scientific outputs that can lead to tangible impacts on social networks and policy developments, and that the capacity and knowledge flows facilitated by ACIAR investments have had longer term development impacts through influencing policies, knowledge flows and networks.

A knowledge systems and RAPID framework for impact assessments

The knowledge systems approach tracks knowledge flows and processes among actors involved in projects. It assesses the extent to which those flows support observable action in decision-making and policy changes. Boundary organisations are groups that bring actors together and act as a highway of knowledge between those involved in researching and those addressing specific problems. In order to make the approach context appropriate, we use RAPID to situate science–policy linkages in development contexts.

The RAPID approach, developed by the Overseas Development Institute (ODI), provides the contextual analysis required for an impact assessment. It promotes a greater understanding of how research can contribute to poverty reduction policies and improve the use of research and evidence in development policy and practice. A RAPID approach requires researchers to ask questions regarding the factors that influence development—links, evidence, political context and external pressures.

Integration of the knowledge systems and RAPID approaches in a framework provides documentation of how the scientific knowledge was absorbed and used by different actors, while acknowledging the development factors that influence change in specific contexts.

Case study application—aflatoxin-reducing investments in Indonesia

To demonstrate the application of this framework, we carried out semi-structured interviews with different actors involved in aflatoxin-reducing projects in Indonesia (CP/1997/017).

The main objective for this impact assessment was to determine how the project outputs from CP/1997/017 are being used by regulatory policymakers, research centres and the peanut industry in Indonesia and Australia, and the ultimate impact this has had on aflatoxin risk mitigation.

The three subobjectives for this impact assessment were to:

1. assess the extent to which the project outputs have contributed towards greater awareness of the risks of aflatoxin in Australia and Indonesia
2. examine the impacts that CP/1997/017 has had on relationships among different stakeholders involved in regulating and managing the risks of aflatoxin
3. determine the extent to which project outputs have led to sustained adoption, and changes in institutions and industry, to reduce aflatoxin problems in Indonesia.

Project outputs for CP/1997/017

CP/1997/017 produced a range of technical outputs, including:

- an enzyme-linked immunosorbent assay (ELISA) model to identify aflatoxin development
- development of biocontrol management strategies in Australia and trialling on selected Indonesian sites
- the Peanut Whopper Cropper tool, which factors in a range of conditions, allowing producers to make decisions on their production practices
- experiments that investigated the effect of harvesting time and different seed-storage systems
- development and subsequent widespread use of the AFLOMAN tool for Australian growers to assess the risk of aflatoxin development
- a survey of Indonesian value-chain actors, indicating the nature of their knowledge about the presence of aflatoxin.

Outputs and impact in Australia

The major outputs from CP/1997/017 of interest for Australia were the technical tools such as AFLOMAN and the Peanut Whopper Cropper, and the biocontrol on-farm management strategies.

The impact included extensive knowledge flows, with 118 publications across different media, some of which had high numbers of readers outside the project. In Australia the ACIAR investments were made in a context where industry, research and government all had aligned interests in reducing the aflatoxin risk to consumers. Australia continues to have advanced knowledge and enforcement of aflatoxin regulation, and the CP/1997/017 on-farm and technical monitoring tools made a strong contribution to ongoing aflatoxin awareness across relevant actors. The context of Australia's peanut production, which is carried out by a small number of producers, makes managing and monitoring aflatoxin a possible task.

Outputs and impact in Indonesia

The major outputs from CP/1997/017 of interest for Indonesia included the ELISA tools, the skills built in Indonesian researchers, the identification of wet markets as the major risk point in the supply chain where aflatoxin occurs, and a general overview of the extent of aflatoxin awareness from survey results. An additional major output was the creation of the Aflatoxin Forum of Indonesia (AFI), which brought together researchers and policymakers to exchange knowledge on aflatoxin.

The forum expanded to the Mycotoxin Forum of Indonesia (MFI) to diversify the focus beyond aflatoxin.

There were three kinds of impact on Indonesia from the CP/1997/017 project. The first was the high level of technical capacity built between Indonesian institutions. Interviews indicated that Indonesian research centres are now regional leaders in aflatoxin research. The increase in postgraduate students shows the ongoing capacity of senior researchers to supervise students in technical aflatoxin projects. The monitoring tools developed were technical, and Indonesian research institutes now have a strong capacity in designing and furthering their own aflatoxin research.

The second kind of impact was the establishment of links and networks. The AFI was established during the project as one of the main objectives. This forum continues and has expanded to include mycotoxins due to the diverse nature of the problem in Indonesia. The AFI has enabled researchers from different institutes to exchange the latest knowledge on aflatoxin.

The third was the long-term policy impact of the knowledge and linkages built throughout CP/1997/017 and the broader history of aflatoxin research investments. ACIAR investments ended in 2006, yet the MFI has continued. In 2009 a major regulatory policy development occurred, in which the Indonesian National Standardization Agency launched a new standard for maximum mycotoxin levels, expanding from aflatoxin-only policies. Key informants identified that ACIAR's investments contributed to this change through both the research generated and the relationships developed through the project.

Lessons learned

Australian stakeholders identified the learning value that was directly attributed to ACIAR's project outputs. The capacity of Australian stakeholders to critically analyse aflatoxin problems from a supply-chain perspective is actively used by those still working in the field. The Australian regulatory and policy context supported the ongoing need for up-to-date knowledge to be available to producers, industry and policymakers to ensure an aflatoxin-free environment.

The capacity of Indonesian researchers was also built through the development and application of project outputs. The technical skills contributed towards Indonesian researchers' understanding of how to design and apply an ELISA, and this has led to longer term research in aflatoxin monitoring without Australian support. The new generation of PhD students being trained in aflatoxin reduction is an unintended, long-lasting benefit of ACIAR's investments. Through providing new knowledge to senior Indonesian researchers, ACIAR has played a role in establishing a knowledge base for ongoing aflatoxin work in Indonesia.

There are a number of suggested avenues for future aflatoxin risk reduction investments:

- a study into possible market incentives and penalties available to Indonesian policymakers for enforcement on peanut supply-chain actors, particularly at the high-risk points of wet markets
- low-cost storage systems that can be used in wet markets to keep peanuts dry and minimise aflatoxin risk
- capacity-building programs to integrate the three regulatory bodies involved in aflatoxin reduction; and workshops, conferences and capacity-building exercises that draw together the agriculture and health sectors to discuss aflatoxin challenges
- research on fragmented governance and associated institutional challenges, which may identify whether a single body would have greater capacity to enforce aflatoxin regulations
- trials of the extent to which QuickTest technologies can be easily used by wet market peanut sellers to identify aflatoxin, probably coupled with market incentives research
- a study into peanut waste products—mouldy and infected peanuts pose a risk to development, as poorer consumers may still buy them; and infected peanuts, if fed to livestock, can still cause liver cancer in humans
- detailed risk assessments for the different actors within the supply chain.

Part 1—Knowledge Systems and RAPID Framework for Impact Assessments

1 Introduction

The Australian Centre for International Agricultural Research (ACIAR) has a strong record of delivering impact assessments of research and development investments. In 2008 ACIAR consolidated a common approach for conducting desktop reviews, adoption studies and full impact assessments (Davis et al. 2008), focusing on benefit–cost and results–mapping frameworks to track changes that can be attributed to ACIAR investments.

In this common approach the authors emphasise the importance of identifying links between inputs, outputs, and outcomes and benefits. Inputs are the funds from ACIAR and other organisations at one point in time on the particular issue being dealt with. Outputs are the deliverables from the investment, and include technologies, capacity and policies. Outcomes are the behavioural changes that result from the adoption of outputs. Benefits are defined in the ACIAR guidelines for Impact Assessment Series (IAS) report number 58 as 'measures of the welfare changes that result from the impacts over time' (Davis et al. 2008; p. 11).

While the approach developed by Davis et al. provides comparable measures of returns on investment, the benefits captured are most relevant to projects with readily quantifiable and economic outcomes. Their approach is theoretically grounded in tracking the return on investments for ACIAR, yet some outcomes, such as policy influence, capacity development and certain components of behavioural change, may not be captured by economic and quantitative analysis. Developing diverse methodologies able to analyse the contributions that ACIAR projects make towards these long-term, non-quantifiable changes is a new contribution to existing impact assessment tools.

Davis et al. (2008) have provided a valuable approach to understanding the economic benefits from ACIAR investments, yet limitations remain. The linear nature of the guidelines provide limited insight into how to explore 'softer', non-quantifiable outcomes such as social relationships, values attached to project outputs, and the broader factors that enable and inhibit the application of knowledge generated.

ACIAR's guidelines highlight that the impact of research investments can be classified into three broad categories:

1. technologies—the improved products and approaches provided by investments
2. capacity building—the scientific knowledge and skills at both individual and organisational levels
3. policy—the knowledge, models and frameworks to aid policy- and decision-making.

However, a gap remains in using a framework that is able to qualitatively examine the less-quantifiable social and policy impacts that can be attributed to ACIAR investments.

These less-tangible outcomes can be just as valuable as economic benefits when assessing the impact of research investments in an agricultural development context. Such outcomes, which include public-good benefits, intermediate steps towards a longer term economic gain, capacity development, and knowledge absorption by private and public institutions, cannot be easily quantified, yet they can be analysed through understanding how knowledge users have engaged with or used project outputs since the completion of projects.

1.1 Alternative impact assessment tools

As part of ACIAR's IAS, a range of methods papers have been developed that provide complementary approaches to measure the impact of ACIAR's investments. For example, Dugdale et al. (2012) produced a guide for measuring the perceived capacity built during a project. Carpenter and McGillivray (2012) presented an analytical framework for the poverty reduction impacts of ACIAR investments, and Pearce (2002) focused on the same aspects through attributing impact to economic development. Pearce and White (2012) identified the challenges of assessing the environmental outcomes of ACIAR investments.

The diversity of study areas for impact assessments demonstrates that ACIAR, as a knowledge-facilitating organisation, continues to explore new ways of understanding how their investments impact development. Pursuing new theoretical and practical ways of understanding research impact allows ACIAR to further their institutional understanding of how to direct future investments to achieve development outcomes.

The common guidelines from Davis et al. (2008) provide a broad guide to understanding how project outputs lead to impact. An example of an impact assessment based on Davis et al. (2008) is the work of Palis et al. (2013), where the evaluators used an impact pathway framework (outlined in Figure 1) to identify the contribution of investment in final users. Although the authors attempt to identify scientific and policy impacts through the impact pathway approach, the report applies broad assumptions regarding the links between scientific output and policy change, and these have been challenged in the literature as simplistic (Bocking 2004; van Kerkhoff and Lebel 2006).

Impact pathways for ACIAR investments are much more complex than a linear approach, and cannot be analysed without understanding the broader social relationships and institutional environment in which ACIAR investments take place.

The current report adds to ACIAR's literature on approaches to impact assessments. We present a framework that can be used in parallel, or combination with, the traditional economically focused approach developed by Davis et al. (2008). We draw from critical literature that explores how knowledge is acted upon across different contexts.

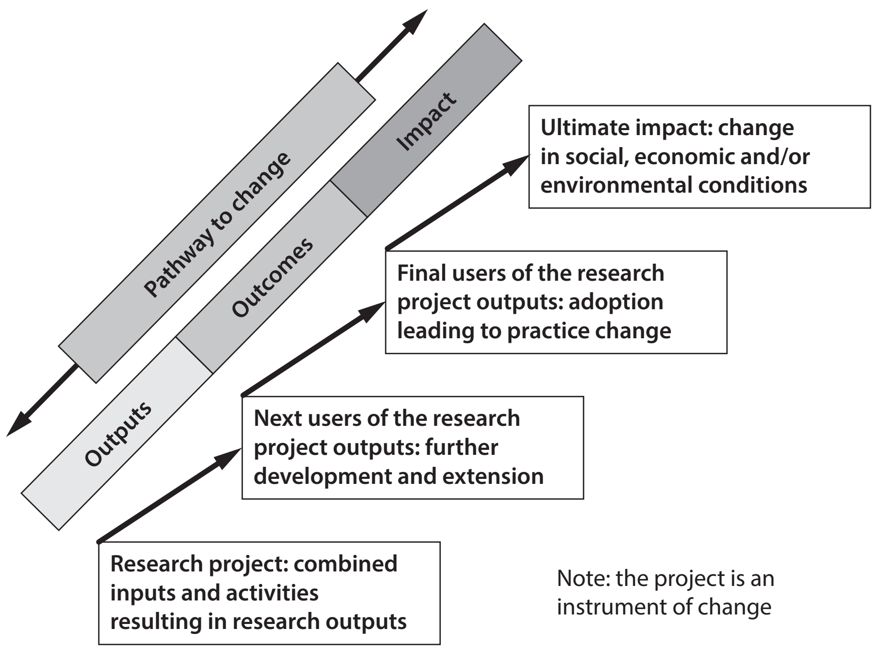

Figure 1: ACIAR impact pathways analysis (from Palis et al. 2013)

Our conceptual development builds from ACIAR's previous work on understanding the impact of policy research (Linder 2011). Throughout this report Linder argues that attributing policy and social change to research outcomes is a highly challenging task. A way of attempting to understand the impact of policy research is through quantifying outputs such as publications, trainings, conferences, press releases and capacity strengthening (Davis et al. 2008; Linder 2011). However, such metrics are limiting and cannot fully grasp the long-term social changes from policy research (Gardner 2008). We build on the critical insights from Linder (2011) and expand to broader research investments by ACIAR that are not necessarily targeted at changing policy and capacity in emerging economic institutions, but have great potential to do so.

Our method is novel and blends key elements of two research approaches developed in the 2000s. The first is knowledge systems, developed by Harvard University (Cash et al. 2003). A knowledge system is a dynamic network of actors connected by their interactions and engagement in knowledge-based processes, such as creating new knowledge, and sharing, accessing or applying that knowledge (van Kerkhoff and Szlezak 2010). Knowledge systems present a set of key questions for those interested in understanding how knowledge flows in specific systems and in the extent to which those flows support observable action in decision-making and policy changes.

The second approach is the research and policy in development (RAPID) framework, developed by the Overseas Development Institute (ODI). RAPID proposes that researchers and assessors explore factors that influence development: links, evidence, political context and external pressures.

The current report identifies gaps in both approaches and proposes a new framework that integrates key elements from each, to provide ACIAR with a novel framework that will support impact assessments seeking to understand policy and behavioural change stemming from research investments.

The framework developed throughout this project is grounded on the idea that ACIAR investments build capacity and generate new knowledge from inception, not after project outputs have been delivered. Figure 2 highlights how ACIAR projects and outputs operate within the broader capacity-building and policy environments. It is within this timeline of project delivery that we develop a tool for understanding knowledge flows within specific development contexts.

This report is separated into two parts. The first part (sections 2 and 3) develops the framework. Section 2 provides the literature context for a new impact assessment approach. The three sets of literature covered are the science–policy interface, knowledge systems, and RAPID. As we synthesise key messages from the literature, we distil key questions, tables and

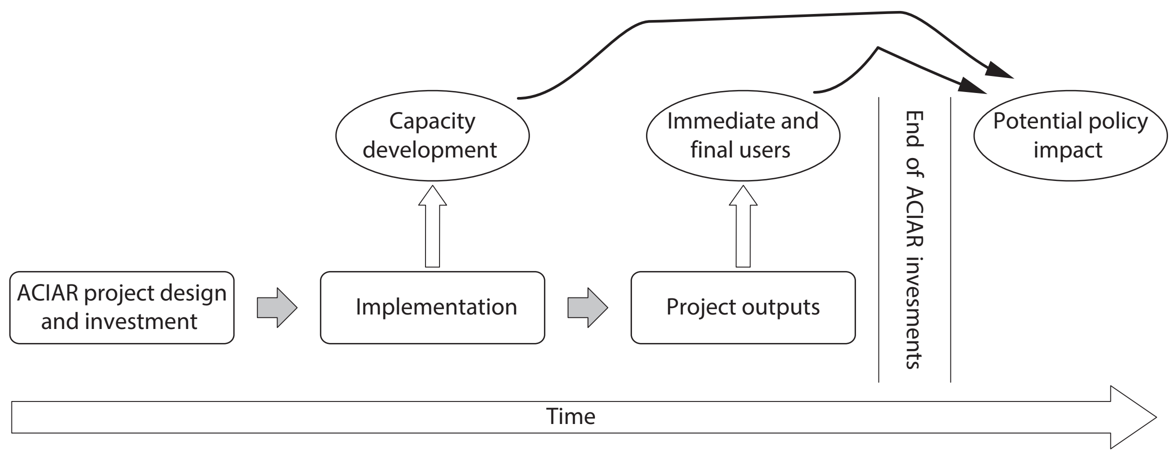

Figure 2: Impact pathways and associated ongoing impacts

visuals on different impact assessment frameworks that look at the influence of research on policy, and we construct a new framework in section 3 that contributes to the diverse approaches towards assessing impact. This framework can be used to identify long-term knowledge flows stemming from research investments and possible policy impacts. Section 3 provides new, critical insights into the traditional approaches that ACIAR undertakes. We present a visual and itemised guide with a set of questions that evaluators can use to understand the uptake of research findings in policy or practice, aligning this new approach with the traditional guidelines developed by Davis et al. (2008), and emphasising complementarity rather than contrasting methods.

The second part is an application of the framework to a case study of ACIAR investments in aflatoxin reduction in Indonesia. Sections 4 and 5 emphasise how ACIAR has invested in technical, scientific research into aflatoxin in Australia and Indonesia. Section 6 applies the framework from section 3, and sections 7 and 8 present findings from the case study. Finally, section 9 presents reflections on the advantages of using an integrated knowledge systems and RAPID approach to assessing the impact of research on policy in a development context.

2 Literature Overview

As a research-facilitating organisation, ACIAR's activities are fundamentally concerned with supporting the creation of scientifically rigorous knowledge. Understanding how this knowledge has contributed to economic development and social, environmental or policy change is central to evaluating research impact. To do this, evaluators require analytical tools to assess the flow-on effects of knowledge generated by ACIAR that is geared towards improving agricultural systems.

ACIAR has an explicit interest in how research influences policy. The 2014–18 strategic plan highlights the importance of analysing policies that lead to better outcomes and strengthening the evidence base in policymaking (ACIAR 2014). Projects with policy components seek to understand how policies can influence adoption and further the outcomes of technical research (ACIAR 2015). A review by Pearce (2005) identified that policy environments need to be adequate if research investments are to lead to productivity increases and food security outcomes. An understanding of science–policy approaches is thus important to analyse the extent to which ACIAR investments influence different policy environments.

2.1 The science–policy interface

ACIAR funds scientific knowledge creation that can have long-lasting development impacts in developing countries, and further promote Australia's agricultural research. This task is carried out through a range of investments in research spanning the agricultural value chain. Assessing the impact of ACIAR investments in Australia and partner countries is frequently carried out to identify ACIAR's contribution towards economic development, capacity building and poverty reduction.

ACIAR's guidelines for impact assessment follow an approach that seeks to quantify inputs, outputs, outcomes and impact from a project. As discussed in section 1, the guidelines developed by Davis et al. (2008) seek to identify quantifiable results from ACIAR investments. Although these guidelines have generated a range of useful insights for ACIAR, the nature of international development is changing, in particular with increasing complexity and ambition of projects. This creates a need for more-diverse impact assessment tools that capture different aspects of ACIAR's contribution to development. At present ACIAR does not have a set of impact assessment guidelines that can identify relationships between scientific knowledge and policy change. This report is a contribution in the development of such guidelines.

2.1.1 Literature overview on the science–policy interface

Since World War II science has played a major role in attempting to provide objective knowledge to inform changes in sectors that affect society, such as health, environment and economics (Midgley 2000). Intellectual development has led to interest in how decision-makers identify the type of knowledge required to make decisions (Guston 1997; van den Hove 2007). This has led to critical debates on the iterative relationship between policy and scientific knowledge change, commonly known as the science–policy interface.

Traditionally, the purpose of scientific outputs was to generate the knowledge, and leave societal users such as policymakers to use it as needed. Two generic models aligning with this view have dominated the literature: trickle down and technology transfer.

The trickle down model assumes that practitioners will absorb high-quality research without extra effort needed by the researchers (Latour 1998). The peer-review publishing process established throughout research institutions perpetuates this model. The closed nature of this process and the lack of effort by researchers to make their findings relevant to society have widened the gap between researchers and the social problems they are perceived to serve (Guston 1997). The trickle down approach may be useful when the problem being studied is narrow and technical, or when practitioners actively pursue new information. However, in a more ambiguous, social development context, the uptake of research output is much more complex and unlikely due to technical, social, political and contextual barriers.

The technology transfer model was a response to the trickle down model's inability to influence major social change through using results in a socially relevant context. The model is based around the idea that new scientific knowledge can be used as a lever to change behaviours among practitioners. Since the 1970s this model has been most evident in the agricultural and health sectors. In agriculture, for example, it assumes that improvements in yield and land management can result from the uptake of technical developments coming from research. Agricultural extension programs follow a model in which knowledge is transferred hierarchically to farmers, who either adopt or reject the new technology (Ison and Russell 2000; Scoones and Thompson 1994). The technology transfer model offers the opportunity for research findings to be applied in practice, yet it fails to provide users with the agency to determine the extent to which the technologies are in their long-term interests.

These two models are examples of the common view of science traditionally existing outside policy influence realms. Evaluation tools have largely followed linear thinking in which the sustained uptake of technologies is quantified. A range of authors have contested the linearity of traditional scientific approaches (Bocking 2004; Funtowicz and Ravetz 1993; Kirchhoff, Carmen Lemos and Dessai 2013; Roux et al. 2015), and alternative approaches, strategies and frameworks have been developed (for a review see van Kerkhoff and Lebel (2006)). The broader relevance of research findings are often neglected or minutely addressed in full evaluations.

Understanding some of the critiques of linear models of scientific knowledge transfer offers important insights into developing new approaches to assessing research impact. In their review van Kerkhoff and Lebel (2006) identify how science operates in a broader development context, and they summarise critiques from the literature of the role of scientific knowledge in society. At the core of the critiques is the notion that science does not operate as an independent, value-free system outside social domains. Rather, scientific knowledge is produced in particular social, institutional and cultural contexts that perpetuate specific belief systems and social relationships that affect how end users absorb scientific knowledge.

In a synthesis of the literature van den Hove (2007) argues that science and policy are intrinsically related. The relationship exists through the social expectations of scientific outputs contributing to the greater good, with the natural and political environments guiding how science is funded and carried out, and how science influences public ideas. Policy development is a complex, iterative process through which governments prioritise conflicting pressures to make long-term decisions (Dovers 2005). The use of scientific knowledge in policy development largely depends on the context in which the policy is being developed and applied.

2.1.2 Development relevance

The complex political and dynamic nature of international development indicates that knowledge transfer needs to embrace critiques of the traditional models outlined above. ACIAR embeds this complexity through using diverse, multidisciplinary teams throughout their projects, and is further working on integrating biophysical research with policy relevance (Pearce 2005).

A starting point for developing such an assessment approach is to understand how critiques of traditional approaches to science–policy transfer apply to the development sector. Table 1 synthesises the arguments posed by van Kerkhoff and Lebel (2006), and highlights how critiques of traditional, linear scientific approaches apply to international development.

Table 1: Critiques of traditional science–policy approaches

Critique	Argument	Relevance to development	Example
Science is socially and institutionally embedded.	Scientific outputs are shaped by the social and institutional systems around science. This context means that scientific outputs are the result of interactions between people, political environments, institutions and practical considerations.	Scientific outputs emerging from donors need to be relevant to the political and practical needs of recipient countries. Research outputs can also strategically align with possible future policy directions needed for development.	International multilateral organisations use the best available science from throughout the world to generate guidelines, advice and metrics on best practices across a range of environmental and social issues.
Scientific knowledge is socially constructed.	Scientific outputs do not reveal the truth, but rather offer knowledge of an issue at a particular point in time. Knowledge generated will mean different things to different groups.	Acknowledging scientific outputs as being socially constructed offers the opportunity for other knowledge types, often locally relevant, to contribute to the issues being investigated.	The nature of, and perspective on, soil quality may differ between technical scientific research and a smallholder farmer in an emerging economy, creating possible conflict in how to best manage soils.
The social context bounds the relevance of scientific outputs.	The perceived gap between research outputs and social impact are constructed by the specific context in which the research takes place. Focusing on technical outputs from a project can blind researchers to the root causes of problems, which are often social and political.	The authority of scientific outputs is not in the rigour and quality of the research itself, but on the ability of researchers to negotiate results in the relevant contexts in which they can be applied to create change.	The construction of a dam can be proposed as a source of clean energy that will help reduce poverty, but it can exacerbate conflict over land tenure—which is a greater cause of poverty than lack of access to modern energy.
Power relations can be perpetuated in traditional, linear approaches to knowledge uptake.	Traditional approaches separate produced scientific knowledge from the user. This creates an opportunity for members of a society with easier access to knowledge to use it as they see fit.	The ability of other researchers and institutions to have prior access to knowledge can perpetuate inequitable development pathways in which decisions are centralised and controlled by elites.	The construction of roads into rural areas can be supported by goals of increasing access to markets, but can also facilitate access by ruling elites to control and police previously isolated areas.
Science reflects cultural biases and inequality.	Research agendas, design, approaches and world views perpetuate existing biases to how the world is understood.	Historically, scientific research has been carried out and funded by developed nations. This can continue to perpetuate elitism in institutions and scientific research.	Participation of women and indigenous groups has been historically limited. There is risk that this could continue if traditional science approaches are not critically examined.

Critiques of traditional scientific processes and engagement with policy outline three points of interest for international development. The first is that traditional scientific research methods are often linear in nature, producing technical knowledge to be acquired and applied by end users as they see fit. The second is that scientific research is embedded in the social and political structures in which the research is being carried out. The third is that scientific outputs are not an end point, and the context in which that knowledge exists will continue to shape the social relevance of outputs.

Despite much scholarship establishing the complexities that characterise science–policy–practice linkages (Biermann 2001; Glaser and Bates 2011; Jasanoff 2010; Lahsen 2009), there have been relatively few practical evaluation or assessment methodologies developed that extend beyond linear evaluation models that track return on investment and the technical relevance of research. Examples of non-linear, critical evaluation methodologies are documented by Donaldson et al. (2013), who present a range of tools to understand power dynamics, social systems change, capacity building and innovation in a developing-country context. Williams and Imam (2007) provide an overview of how to conduct evaluation using systems thinking, in which the interactions between organisations, values and knowledge are assessed to understand change. Fujita (2010) follows a similar argument, highlighting the challenges of traditional logical frame models to evaluation and the inability of them to capture longer term, contextual and capacity changes stemming from development investments.

Designing a new framework for ACIAR fills an existing gap for practitioners and agencies interested in understanding and assessing how science is absorbed and used by policy in development contexts. Developing such a tool for impact assessment thus requires a methodological foundation that facilitates the exploration of the science–policy interface in a development context.

To build this tool, we now present two distinct theoretical approaches to understanding knowledge and development, before combining them to propose a new impact assessment framework for research investments.

2.2 Knowledge systems: focusing on actors

Knowledge systems is a concept concerned with knowledge flows that was developed by researchers at the Science, Environment and Development Center, Harvard University, from 2003 (Cash et al. 2003). A knowledge system is defined as '... a network of actors connected by social relationships, formal or informal, that dynamically combined knowing, doing, and learning to bring about specific actions for sustainable development' (van Kerkhoff and Szlezak 2010; p.1). The core elements of a knowledge systems approach include identification of the creation of new knowledge (e.g. through research), knowledge sharing and knowledge application. These are what the knowledge systems literature calls *knowledge-based processes*, and are carried out by actors. Actors are the individuals and groups that develop, transfer and apply the knowledge. As a methodological approach, knowledge systems consider both the processes through which knowledge is created and shared, and the flow of such knowledge through personal, organisational or institutional relationships. The dynamic dimension of knowledge systems emphasises that these systems are not static, but change through time, allowing for analyses that extend over the longer term rather than a project's life span.

The contribution that knowledge systems make towards ACIAR's impact assessment tools is the ability to explore the links between knowledge production and actions. ACIAR produces knowledge outputs from investments. A knowledge systems approach then allows for the exploration of how different actors in a specific system use that knowledge, if at all, to create change.

Through reviewing key knowledge systems literature (Cash et al. 2003; Clark et al. 2011; Manuel-Navarrete and Gallopín 2012; McCullough and Matson 2011; van Kerkhoff and Szlezak 2006, 2010), we identify three main areas of interest for developing an impact assessment framework grounded on knowledge systems concepts—the nature of scientific outputs, the social characteristics of how actors relate to each other, and the limitations of knowledge systems in a development context.

2.2.1 Relevance of scientific outputs

The science–policy interface debate above indicates that scientific outputs are interpreted and used differently depending on contexts. The knowledge systems literature follows this argument and identifies three criteria that allow scientific outputs to be perceived as relevant in specific contexts. Following Cash et al. (2003), credibility, salience and legitimacy of scientific outputs can boost the willingness of actors to apply the produced scientific knowledge.

Credibility relates to the perceived adequacy and quality of the technical outputs produced from scientific research; salience relates to which research outcomes reflect the needs of decision-makers; and legitimacy relates to the perceived inclusiveness of different actors throughout the scientific process, acknowledging divergent values, interests and beliefs. Embedding these three items into the design of scientific research can lead to multiple users having greater confidence in using scientific results to influence a specific issue of interest.

An example of this can be found in Cash and Clark's (2001) review of the Global Biodiversity Assessment (GBA). The authors critique the lack of success that the GBA had on influencing policy change throughout the world. As part of this critique, Cash and Clark (2001) argue that despite rigorous scientific review (credibility), the GBA failed to generate change because it ignored the global political context, did not address the needs of potential users and failed to connect global issues with localised contexts (salience), and did not adequately use the assessment as a cross-sectoral communication tool (legitimacy).

In using these three guiding categories from the knowledge systems literature, initial questions can be developed when designing evaluations geared towards understanding the policy relevance of scientific outputs. These questions are presented in our method in section 3.2.

Creating a framework for assessing research impact that embraces knowledge systems in a development context needs to start with a general understanding by the evaluation team of the relevance of the research investments in the specific context in which the project took place.

2.2.2 Social dynamics in a knowledge system

While the relevance of scientific output focuses on the characteristics of research as a form of knowledge creation, the social dynamics of a knowledge system are concerned with the social and political environment the research is intended to influence. There are three things to look for when trying to identify the knowledge system behind a development issue:

1. the actors responsible for knowledge creation. Actors are the individuals or groups from a particular sector that develop, transfer and apply knowledge over an issue. Actors include research institutions, private sector businesses, public institutions and civil society organisations.
2. the organisations that facilitate knowledge flows between actors. The knowledge systems literature calls these 'boundary organisations' (Cash et al. 2003), and they link different actors in a knowledge system together. An example is The Global Fund to fight AIDS, Tuberculosis and Malaria, which has a focus on reducing specific diseases. The organisation facilitates links between knowledge creation and action (through policy), acting as a highway of knowledge between different actors involved in researching and fighting these diseases (van Kerkhoff and Szlezak 2010).
3. three functions that contribute to the flow of knowledge: communication, translation and mediation. Communication relates to the active, iterative and inclusive dialogue between researchers and policymakers—positive communication can boost the salience, credibility and legitimacy of knowledge flows. Translation relates to the ability of different actors to understand what other actors mean—boundary organisations need to have systems in place that facilitate mutual understanding of the issue across actors. Mediation in a boundary organisation relates to balancing trade-offs between salience, credibility and legitimacy.

Table 2 summarises the key questions based on these elements of a knowledge system as a three-step guide for identifying the state of the system at a point in time during a project.

Knowledge systems in practice

Knowledge systems have been applied to a range of science–policy–development contexts, including analysing agricultural transformations (Manuel-Navarrete and Gallopín 2012; McCullough and Matson 2011), organisations and institutions (Clark et al. 2011; van Kerkhoff and Szlezak 2010), and the impact of scientific products such as climate assessment (Buizer, Jacobs and Cash 2010; Mitchell and Clark 2004).

Table 3 outlines a summary of published material that has taken a knowledge systems approach, showing the sectoral diversity in which such an approach can be applied.

2.2.3 Knowledge systems limitations

A critique of knowledge systems by Leeuwis et al. (1990) argues that knowledge activities are inherently social activities, and are thus dependent on the social dynamics at the particular point in time in which the knowledge is generated and shared. Current versions of knowledge systems attempt to address this through a dual focus on using research as a knowledge production process that needs links with other knowledge-based

Table 2: Three steps for identifying a knowledge system

Step	Task
1. Identify actors	Who are the main individuals or organisations that hold knowledge of the specific issue of interest? Are there actors who are excluded from obtaining and using this knowledge?
2. Identify boundary organisations	Are there any organisations in place that link the actors identified in Task 1? If there are no organisations, can they be developed? Is there a need for such an organisation to exist?
3. Question the knowledge being studied	Are the research outputs salient? Are the research outputs credible? Are the research outputs legitimate?

Table 3: Knowledge systems literature applied to research for development

Summary	Key findings	Reference
Enhancing agricultural productivity in maize and wheat	The International Centre for Maize and Wheat Research (Mexico) developed crop-breeding systems that included farmer and indigenous knowledge. These approaches allowed for different boundary organisations to collaborate towards the common goal of improving maize and wheat.	Cash et al. (2003)
Aquifer depletion in USA	National and state institutions guide the creation and use of science for specific aquifer depletion problems.	Cash et al. (2003)
Using El Niño forecasts	Global institutions and forecasting systems face challenges in making information useful at local scales. The links between institutions across scales are crucial in making scientific findings useful in local contexts.	Buizer et al. (2010); Cash et al. (2003)
Agricultural development in Mexico	The Yaqui Valley in Mexico is home to the Green Revolution of Wheat. The knowledge system created between researchers and farmers was able to adapt to markets and environmental shocks due to strong networks.	McCullough and Matson (2011)
Global Fund to Fight Aids, Tuberculosis and Malaria	The Global Fund has created incentives for knowledge flows at country levels, but the knowledge does not flow back to the Global Fund. International organisations can play a greater role in fostering multiscale learning and knowledge exchange.	van Kerkhoff and Szlezak (2006, 2010)

processes, and seeking to identify and understand the social relationships that shape these interactions.

A more recent critique is that knowledge systems tend to be descriptive rather than analytical (van Kerkhoff 2013), especially when looking beyond the knowledge production factors of salience, credibility and legitimacy. That is, identifying the characteristics and processes of a knowledge system presents a multifaceted picture of the science–policy interface, but not necessarily an explanation of why the decision-making context influenced the application of research in supporting social change. Using knowledge systems in impact assessment and evaluation may be at risk of not being able to identify the underlying reasons why knowledge-based changes occurred.

In order to address this challenge in the knowledge systems literature, we have identified a framework that directs attention to key explanatory factors in the decision-making context (presented in section 2.3). Adding these dimensions of context to knowledge systems can allow evaluators to critically examine both the production and use of knowledge, and contextualise them in the broader conditions in which investments took place.

2.2.4 Links to project design and impact assessment

Understanding a knowledge system is important at any stage of a project, from design to the final impact assessment. The knowledge systems literature provides a set of general themes that can be used to capture knowledge at a particular point in time, and identify how it changes as investments are rolled out.

For assessment and evaluation purposes, a knowledge systems conceptual approach would require identification of how projects contribute to knowledge-based processes across different actors, and whether those processes facilitated change in the relationships and social dynamics of the decision-making context.

Based on the critique of traditional approaches to science–policy interactions and the conceptual value of a knowledge system, we propose three broad areas to consider when attempting to understand the state of knowledge at one point in time:

1. Knowledge is taken to be embodied by actors within the system, rather than independently. Studying knowledge requires an understanding of *who* is using and applying it. Therefore, **a first step is to understand who the actors are and how they engage in knowledge-based processes.** This actor-centred approach directs us to focus on participants' own interpretations of their role in knowledge-based processes rather than attempting to evaluate these activities from an external perspective. It also specifies that research impact can be identified through continuing knowledge-based activities (such as ongoing research), as well as through relationships where people involved in the original project have been able to apply their knowledge and skills in different contexts.
2. Knowledge is regarded as inherently dynamic, where interactions within a knowledge system result in the constant evolution of knowledge-based resources. To study how knowledge is used by actors, it is necessary to understand how it has changed through time and what has influenced this change. Therefore, our analysis does not solely focus on individual ACIAR project outputs, but takes a wider view of where such outputs may have catalysed or facilitated ongoing learning and evolution of knowledge-based processes. As such**, the second step is to pinpoint changes that were supported by knowledge-based processes.**
3. The focus on specific activities and action serves as a reference point, to ensure that we are not simply collecting personal accounts of influence or change. Rather, we seek to document evidence of influence and change that has had a material impact of some form on different end users.

We present how knowledge systems questions can be used for impact assessment design in section 3.

The knowledge systems approach emphasises the role of actors in creating, holding and sharing knowledge. The emphasis on relationships requires evaluators to identify connections among actors, particularly any boundary organisations that facilitate knowledge flows.

Evaluators can use the structure of a knowledge system to guide how questions are asked and problems are analysed. Beginning an impact assessment that is grounded on knowledge systems requires an initial set of broad, analytical and conceptual questions that are able to identify actors, boundary organisations and the components that make research outcomes useful (i.e. salience, credibility and legitimacy); for example:

- What specific people and/or organisations were responsible for knowledge creation and use during this project?
- What was the knowledge baseline like **before** ACIAR investments, and were the investments **salient** for that point in time?
- Where the investment **outputs salient** for the state of the knowledge system?
- How have knowledge processes and associated activities and actions changed since the project finished?
- What evidence is there for these processes of change?
- Did any **boundary organisations** facilitate change, and if so how did they facilitate **communication, translation and mediation?**

These guiding questions can be asked at the **beginning** of a project once evaluators have an initial understanding of the baseline, counterfactual and overview of ACIAR activities. The questions are applicable beyond impact assessments and can help characterise the knowledge in a specific system at one point in time, providing a baseline with which impact assessments can compare results, especially if the focus is on knowledge flows.

To assess how investments and activities changed through time, evaluators need to understand the factors that inhibit or constrain change from the perspective of the decision-making context. The second part of the framework offers these insights by including a **context-centred approach** in the analysis.

2.3 RAPID: focusing on context

As the ODI writes, 'reality tends to be much more dynamic and complex, with two-way processes between research, policy and practice shaped by multiple relations and reservoirs of knowledge' (Overseas Development Institute 2004; p.2). Assessment methodologies seeking to understand the impact of research investments thus require the flexibility of being able to embrace critiques of traditional knowledge-transfer models and integrate broader issues that influence development, such as contextual matters, institutions and the relationships among them, and external forces.

The links between science and policy have been documented in OECD nations across a range of disciplines. Evidence of science and policy linkages in emerging economies, however, were limited until the ODI designed the RAPID approach. Established in the early 2000s, RAPID sought to better understand how research can contribute to poverty-reduction policies and improve the use of research and evidence in development policy and practice.

ACIAR, as a knowledge-facilitating organisation, benefits from understanding how research investments are used by actors in specific contexts. The knowledge systems approach presented above offers questions for evaluators to ask regarding the production, flow and use of knowledge. These activities need to be analysed in the specific context in which they take place. Using the RAPID factors as a general guide to an evaluative approach of issues would contribute to ACIAR's future understanding of research uptake for policy influence in international development.

2.3.1 Overview of the RAPID approach

The RAPID approach to understanding the uptake of research by policymakers stemmed from the critiques of linear science–policy linkages outlined in the previous section. The development of RAPID challenged the assumption of research influencing policy as being a one-way process—that there was a divide between research and policy actors, and that specific research findings provided the ultimate knowledge around an issue. The emergence of RAPID, occurring in parallel with knowledge systems, was another approach to address the critiques of the science–policy interface established in section 2.1.

A review of the literature to determine the foundations of the RAPID approach was conducted by de Vibe, Hovland and Young (2002). The authors identified three major factors to consider when studying the science–policy interface: **political context, the**

relationships among actors, and communication. The political context refers to the dominant ideas that drive development within the context being studied. For example, economic growth through increasing yields may be the driving idea behind agricultural policies. Political context also includes the way decisions are made within and between institutions, and how external elements such as macro-economic development influence decisions. The relationships among actors are important as they allow the flow of knowledge to occur. Relationships are developed through networks, organisations and institutions that are willing to explore new ideas. Positive relationships also create opportunities for the flow of ideas between sectors. The communication of messages relates to the ability of researchers to communicate ideas to those actors that can develop policies to facilitate change. Communication takes place in a range of formats, from scientific reports to face-to-face interaction.

These became the four factors of RAPID: context, evidence, links and external elements. ACIAR actively encourages communication and dialogue of material produced through research projects, and these links form part of identifying impact pathways. Including contextual and external elements adds to ACIAR's concern over the impact of investment in different users.

Relationships among actors (i.e. links) and communication align with the focus of knowledge systems on actor-focused interactions, boundary organisations and mediation. Similarly, some aspects of evidence are addressed in the knowledge systems construct of salience, credibility and legitimacy as characteristics of research-based knowledge that can facilitate its use. RAPID, however, provides a focus on the political and development contexts, which knowledge systems does not. The complementarities and gaps of both approaches form the conceptual basis for linking them into a single impact assessment framework.

2.3.2 The four factors

The arguments from the literature synthesised by de Vibe, Hovland and Young (2002) were used by Crewe and Young (2002) to propose three major factors to consider when looking at the impact of research in policy: context, evidence and links. These three operate within a fourth factor: the external elements that influence change.

1. **Context** refers to the social and institutional structures that shape decision-making, including culture, behaviour, values, power, interests and incentives. Understanding these social and institutional settings is important for determining the long-term impact of knowledge produced from research.

2. **Evidence** is the quality of the original research and the effectiveness of efforts to make research outputs accessible and relevant. A focus on evidence includes understanding the credibility of the research, whether it was perceived as being accurate, and how it was communicated to policymakers.

3. **Links** relate to the ongoing relationships among actors in the problem being studied, focusing on how actors exchange knowledge, the organisations that facilitate the flow of knowledge, and the legitimacy of the knowledge.

4. **External elements** include the macro-economic and development drivers that influence, either positively or negatively, policy change. These include unexpected shocks such as financial crises, environmental disasters and social unrest.

These four factors can inhibit or enable change and the impact of research uptake in policy. For example, an unpredicted political change in a country could rapidly shift the willingness to engage research sectors in policymaking. Or there might be positive links between research organisations and policymakers, but the quality of the evidence might be low, thus making research-informed decisions difficult.

Figure 3 visually presents how these four factors act as inhibitors and enablers of research uptake by policy through time.

A RAPID approach has been applied to over 50 studies since 2002 (Court and Young 2003; Crewe and Young 2002). Crewe and Young (2002) conclude that if research is to be used in policy development, it is critical to understand the interests, assumptions and connections between groups that may use the research. This includes ensuring that the research findings can

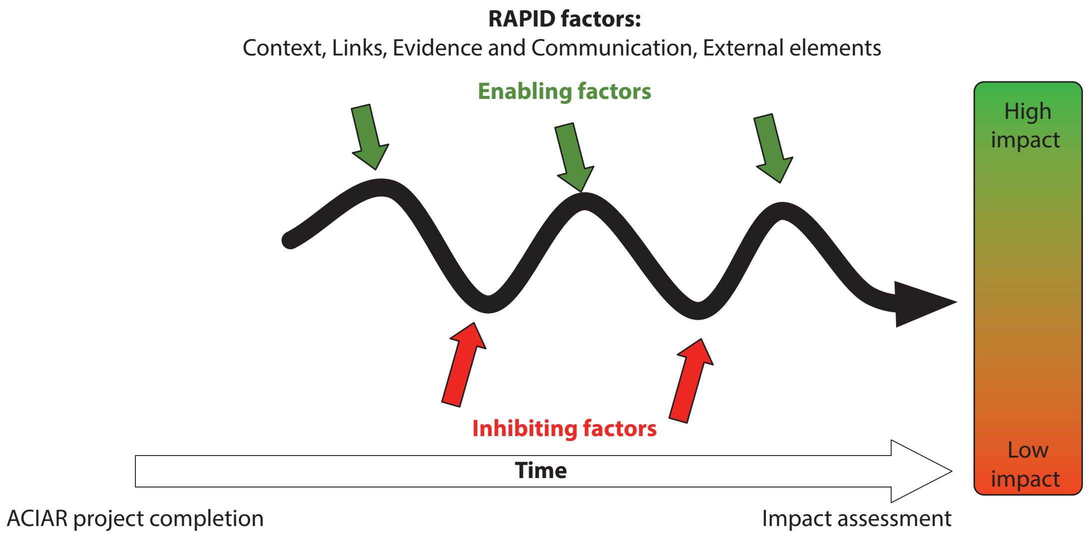

Figure 3: RAPID factors that influence development

be easily translated to different users, and that the research methods are diverse enough so that others can test them. In the review of 50 studies, Court and Young (2003) concluded that **context** plays the most important role in the extent to which research is used in policy. Key factors in the uptake of research are the demand for new ideas by policymakers and political resistance to critique. Their review also found that solutions and **salient** research were most likely to have an impact on policy, and that positive relationships created an adequate environment for research to have impact.

RAPID has been applied as an analytical research tool seeking to draw conclusions about how research and policy influence each other across different contexts. Gathering insights from this tool can be useful for research and can inform new assessment tools that seek to understand research–policy linkages in emerging economies.

2.4 Relevance for impact assessments

In section 2.2 we highlighted initial questions that assessors can ask to identify the knowledge systems and flows facilitated by ACIAR investments. In section 2.3.2 we presented the factors that influence how research activities take place in a development context. These factors are considered when making judgements on findings from qualitative or quantitative data.

Impact assessments can benefit from using RAPID to assess the contributions that research makes in policy within specific contexts. Tsui, Hearn and Young (2014) synthesised a range of monitoring and evaluation theories and tools that can be used to explore the influence of program investments on policy. Within their analysis they identified that the RAPID framework can be a useful evaluation tool to understand the links between activities and policy change. More broadly, they reported on the value of experimenting with different frameworks and finding synergies between multiple ideas to adequately assess the policy impact of development activities. Following this context, we argue that RAPID can add value to existing knowledge systems approaches to build a new evaluation approach.

Questions to consider for analysing research investments in a development policy context are:

- Did the investments create new links between actors, and were these links useful in policy change?
- Did the quality of the evidence influence policy or any other type of behavioural change?
- How did the political context influence the uptake of research-based knowledge?

- Did broader economic, environmental or other external elements influence project impact and behaviour between actors?

Keeping these RAPID-related questions as part of the analysis allows evaluators to make judgements on how the knowledge flows facilitated by ACIAR were relevant in the development and policy contexts of the recipient country. Some clearly overlap with issues raised by the knowledge systems framework, and others are new. In the next section we integrate the two approaches to create a unified impact assessment framework.

3 Impact Assessment Framework for Identifying Science–Policy Linkages

In this section we highlight the importance of developing new frameworks for understanding how to address development challenges. We draw from both the knowledge systems and RAPID ideas presented in the previous section to build a new framework for impact assessment. We then use the diagrams from previous sections and create a step-by-step guide on how to apply the proposed framework to understand research–policy linkages in a development context.

3.1 Advancing knowledge through integrating ideas

As highlighted in section 1 of this report, ACIAR has a strong tradition of developing assessment methodologies that identify economic returns on investment and changes in agricultural productivity in recipient countries. A range of impact assessment publications have demonstrated many possible approaches that can be used to explore non-economic returns on ACIAR investments.

Our review of traditional links between science and policy, knowledge systems, and development factors that influence the science–policy interface allows for a new framework to be developed. The crucial role that policy plays in international development indicates that ACIAR needs tools to understand how research investments contribute to policy change in development contexts.

Blending the actor- and knowledge-centred focuses of knowledge systems and the context-centred focus of RAPID offers opportunities for ACIAR to develop their existing portfolio of impact assessment tools. Our framework balances an overarching conceptualisation of research–policy–practice linkages as complex, evolutionary, human processes with practical experience- and research-based understandings of the importance of social and political contexts. This integrated framework is designed to allow for a wide range of possible pathways to impact (the 'unpredictable' factors), while ensuring that we simultaneously investigate the factors likely to play a role (the 'predictable' factors). This would allow ACIAR to identify the extent to which technical research has contributed to longer term changes more fully than can be done with existing tools.

3.2 An integrated knowledge systems and RAPID framework

The previous sections presented knowledge systems and RAPID questions to ask as separate frameworks. Here, we compare the similarities and create an integrated approach. Both approaches emphasise the importance of the qualities of evidence, as well as the role of relationships and networks, in facilitating the application of research-based knowledge in policy. A knowledge systems approach further classifies the qualities of evidence under the categories of salience, credibility and legitimacy; and identifies boundary organisations as a particular supporting component. RAPID also emphasises the role of communication. These overlaps and a synthesised set of questions are presented in Table 4.

The separate contributions of the two approaches are also presented in Table 4. Knowledge systems emphasise dynamics and change, while RAPID presents a snapshot in a particular moment. RAPID points to immediate political contexts, which are implicit in knowledge systems but not overtly addressed. Finally, RAPID highlights the external drivers that will inevitably shape the relationships between research and policymaking, extending the explanatory power of the analysis beyond the immediate actions of the project team and their associates.

Figure 4 is a general guide that assessors can use to investigate how the relationship between knowledge creation and development factors leads to an impact from investments. The left-hand side summarises the initial knowledge systems questions, which include actors, boundary organisations and characteristics that make research useful to policy.

The black curving arrow depicts how project outputs are used through time, and the fluctuating impact that this has on different beneficiaries. The red and green arrows represent the range of inhibiting and enabling factors that will influence the impact of knowledge outputs through time.

Table 4: Integrated knowledge systems and RAPID impact assessment framework

Framework	Issue	Description	Questions
Knowledge systems	Evolving, dynamic systems	Research–policy linkages take place over time, as the interconnected system changes.	What was the knowledge baseline like **before** ACIAR investments? What specific actors and/or organisations were responsible for knowledge creation and use during this project? How have knowledge processes and associated activities and actions changed since the project finished?
	Focus on specific decisions or actions	Analysis needs to identify specific changes or actions that indicate the application of research.	What evidence is there for accounts or claims of change in policy or action? How robust are claims of links to research?
Both knowledge systems and RAPID	Quality / characteristics of evidence	The availability and qualities of research-based evidence affect the usefulness of research-based knowledge.	Were the project outputs accessible and available to decision-makers? Were the project outputs salient, credible and legitimate?
	Relationships and linkages	The pathway from research to impact is formed through interpersonal, organisational and institutional relationships.	Did the investments create new links between actors, and were these links useful in policy change? Did investments facilitate a flow of information between actors? Did any boundary organisations exist or emerge? Did they facilitate change, and if so how?
	Communication	Research needs appropriate communication for different audiences	Were processes in place to facilitate **communication, translation and mediation?**
RAPID	Political context	The political context has an immediate influence on policymaking	How did the political context enable or inhibit the application of research-based knowledge? Did it change over time? How and with what consequences?
	External drivers	External elements can support or inhibit policy change	How did the external context (donors, economic development etc.) influence the environment in which relevant decisions were being made?

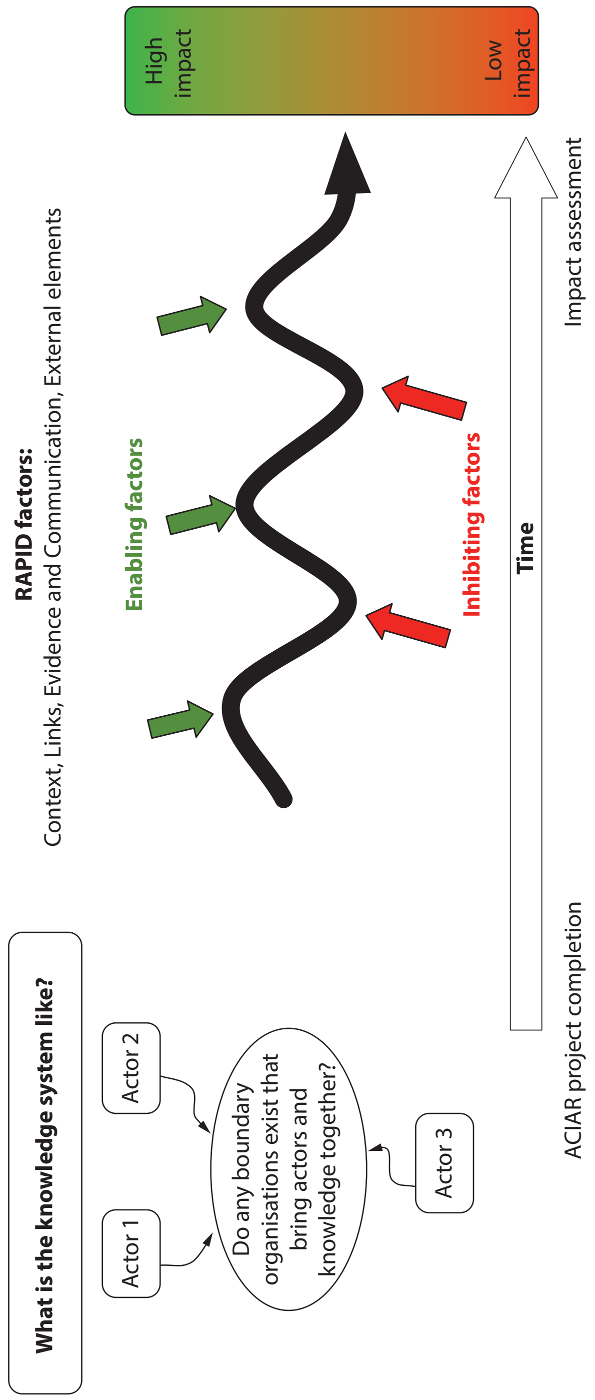

Figure 4: Knowledge systems and RAPID framework

Asking specific questions on how factors influence the application of knowledge allows researchers to determine the varying impact that ACIAR investments have had. The final traffic light box diagrammatically represents the extent to which overall knowledge has impacted different beneficiaries.

3.2.1 Methods: knowledge systems and RAPID

ACIAR has previously documented the contribution that different methods can make towards understanding the complex development context in which investments are made (Carpenter and McGillivray 2012). Quantitative methods can be used to explore the contributions of knowledge outputs to economic growth, increases in yield and productivity, or number of people taking up research outputs. Qualitative methods can explore less-tangible issues such as changes in social structures, relationships, policy environments and behavioural responses to knowledge outputs. Mixed methods would use both qualitative and quantitative approaches, as well as integrative analysis to generate both numerical and non-numerical findings.

In the context of policy uptake of scientific knowledge, quantitative approaches are able to measure trends, economic gains and losses, and general numeric data that can be attributed to scientific outputs. Quantitative data, however, is unable to capture the social, intangible nature of knowledge flows between people and organisations, and the perceived role that this knowledge plays in decision-making.

The traditional guidelines proposed by Davis et al. (2008) provide an excellent framework for using quantitative methods to assess the economic benefits of projects. The guidelines allow for the identification of changes that can be directly attributed to ACIAR investments. The relevance of this information can be augmented through using qualitative methods that explore the more complex context in which the investments took place and that shaped their application in decision-making.

Qualitative methods can identify the human element of knowledge uptake and action. According to Creswell (2007), they can be used to understand the complexity of an issue by looking at peoples' attitudes, knowledge and beliefs, as well as understanding the context in which problems occur. Qualitative methods include, but are not limited to, semi-structured interviews, participatory rural appraisal, open-ended non-numerical surveys, capacity building questionnaires, participant observation, document and policy analysis, and gender analysis.

Our integrated knowledge systems and RAPID framework lends itself to a focus on qualitative approaches to understand complexity. Such methods allow evaluators to understand the extent to which the different actors involved both during and after the ACIAR project created salient, credible and legitimate outputs that were relevant to the dynamic development context at the time.

This can be coupled with quantitative methods to provide data that can show trends through time (e.g. in farm productivity) and the economic impact of, or quantifiable changes in, outputs. Numbers of publications and other metrics of research programs can indicate lasting capacity development. The framework and qualitative methods can be used to understand the role that specific research investments have played in such growth, and the effect of other influences on decision-making and knowledge across actors.

The point in time at which to assess ACIAR's contribution to policy change is also important. Understanding the knowledge system and contextual relevance of impact is most effective when done well after project completion (e.g. the case study example in section 4 was conducted 10 years after project completion). Although ACIAR projects often have immediate impacts on productivity and capacity building, as captured in Adoption Studies, a longer term analysis gives time for the knowledge to become part of the social system, and potentially influence policy and behavioural change at different scales and in wider contexts. These larger scales of change are often flagged in early project documentation (such as Theories of Change), but rarely systematically followed through to see whether the early aspirations were achieved. ACIAR's extensive IAS shows that critical engagement with long-term project impacts, and the increasing number of methods available to assess impact, demonstrate potential for a greater focus on analysing larger scales of change.

This framework offers a tool for comparing initial claims with eventual outcomes, while acknowledging that the processes that link science and policy are often complex with unexpected turns. Building a portfolio of such analyses may help ACIAR extract 'big picture' lessons that can inform their investment decisions.

3.2.2 Using the conceptual framework

This framework was designed to study how investments in knowledge can lead to sustained change and development in Australia and partner countries.

Both of the selected frameworks step beyond assumptions of the linear view to capture different processes and relationships that shape the impact of research on society. The knowledge systems approach offers a conceptual basis for how we think about, identify and analyse such nebulous and contested subject matter as *knowledge*. Its strength and utility lie in formulating how to meaningfully identify, track, trace and examine knowledge-based processes that stem from an identified starting point—the research investment. As a systems-based approach, it allows for non-linearity and a range of possible emergent impact pathways that may not be predicted from the outputs of the project.

This framework is to be used to identify whether research outputs have led to changes that have addressed the broader problem being studied. To understand how knowledge outputs can facilitate change, the framework requires the research team to understand the dynamics of the broader problem being studied and identify where research outputs fit within these dynamics.

The RAPID framework synthesises key issues that are known to be relevant to the science–policy interface in development contexts. It complements the conceptual knowledge systems approach by highlighting political context and external elements that are likely to have played a role in shaping the dynamics of science–policy–practice relationships. Although the knowledge systems literature provides insights into how organisations can facilitate knowledge exchange, the contribution of the RAPID approach is the explicit consideration of the broader context in which research and decisions take place.

To understand these dynamics, the evaluation team should embed questions of history, policy and political realities into interview guides in qualitative methods. The questions in Table 4 provide a broad level of inquiry that will need to be tailored to each research evaluation context; for example, development dynamics can also be captured through providing a macro-economic overview of the country in which ACIAR investments took place. It is up to the evaluation team to determine what data are most valuable to meaningfully attribute change to ACIAR outputs, and thus a range of methods may be needed for a single impact assessment. An understanding of the context and project outputs allows evaluators to choose adequate methods to collect data. The mix of understanding the problem, the nature of the knowledge produced and the factors that facilitate change will determine the types of methods used.

The descriptions in Table 4 also provide an analytical foundation from which evaluators can interpret their data. The categories synthesise both structural and interactional elements of the science–policy interface, allowing evaluators to identify factors that can be shaped by research project teams (e.g. communication, relationships, evidence) as well as those that are beyond their control (e.g. political and external elements).

3.3 Synergies with and difference to existing ACIAR guidelines

Section 1 highlights how a framework that focuses on knowledge flows in a development context would be of value for ACIAR impact assessments. Our framework complements the focus on technology, capacity building and policy provided by Davis et al. (2008) in the sense that it expands beyond concentrating on the inputs, outputs and outcomes, and allows for a broader, non-quantitative analysis of the complex environment in which ACIAR projects have unfolded. The application of our framework allows evaluators to:

- avoid traditional and linear assumptions that science automatically informs policy (see the extensive critiques of linear approaches presented in section 2.1)
- draw from recent, critical and rigorous frameworks that have been used in international development, as presented in sections 2.2 and 2.3
- have a logically structured framework that identifies the knowledge system facilitated by ACIAR, and the external drivers that influence impact (Figure 4)
- choose evaluation methods that can capture both knowledge and contextual matters.

This keeps in mind the focus from ACIAR's traditional guidelines, but adds elements of knowledge systems and RAPID to design qualitative research questions. This addition leads to a deeper understanding of the context and knowledge flows at a point in time of a project, providing a platform through which impact pathways can be studied.

In Table 5 the issues from the knowledge systems and RAPID framework from Table 4 are linked with the overarching impact assessment principles developed by Davis et al. (2008), which constitute ACIAR guidelines.

Table 5: ACIAR guidelines and links to knowledge systems and RAPID framework

ACIAR guidelines (IAS58)	Additional contribution of knowledge systems and RAPID
1. Clearly identify causal links between levels of results.	Original project actors are identified and asked to describe observable changes attributable to project outputs, and to consider the causality of these changes as they relate to both the knowledge systems network **(links and relationships)** and the decision-making processes they influenced **(specific decisions)**. Stories are gathered regarding how positive and negative changes came about **(any factors)**, what deliberate steps were taken to support positive changes **(quality of evidence, communication)** and what inhibiting or enabling environment was in place to facilitate project success **(political context and external elements)**.
2. Identify all outputs, both intended and unintended.	Research extends to actors who may not have been originally involved in the project **(links and relationships)**. Intended and unintended outputs are identified from the research process. The scope of intended and unintended outcomes will expand as a wider range of actors is brought into the evaluation **(evolving, dynamic systems)**. All outputs are considered, regardless of how direct or indirect the linkages to the project may be. The link between these outputs and their contribution to social change is then discussed with immediate and end users **(all issues)**. Any boundary organisations that emerged from the project are identified as knowledge-transferring bodies **(relationships and linkages)**.
3. Identify the preconditions and complementary investments required for the results to be realised.	The historical, political and macro-economic contexts of the partner country are embedded in evaluation questions **(political context and external drivers)**. This allows for an identification of what other factors beyond ACIAR investments have contributed to change.
4. Always measure change from a baseline (counterfactual) and make this counterfactual explicit.	A historical selection of interviews or surveys allows actors to consider the state of the topic and its relationships to policy or action programs at the time ACIAR investments started. A focus on how relationships facilitated change, if any, throughout the project is then possible **(evolving, dynamic systems)**.
5. Make sure that opportunity costs are included in the assessment of impacts.	Where ongoing interventions, changes or activities that involve financial or human resource investments are made, consider the opportunity costs of these interventions.
6. Remember that final users are not always the only beneficiaries.	Encourage participants to consider research impacts broadly and identify a wide range of beneficiaries from the research.
7. Base attribution, in the absence of any information indicating otherwise, on research, development and extension cost shares.	Base attribution on participants' interpretations of connections between project activities and ongoing research, policy development or other associated impacts **(focus on specific actions)**.
8. Validate estimates of results and report on the degree of uncertainty in the assessment of impact and benefits.	Identify tangible examples of claims of influence, impact or change, and document material evidence of these claims **(focus on specific actions)**.

Part 2—Application to a Case Study

4 Aflatoxin Investments

Aflatoxin is a category of mycotoxin that is a carcinogenic, immune-suppressing and anti-nutritional natural contaminant of peanuts, and poses major human health and economic risks throughout the world (Liu et al. 2012; Liu and Wu 2010). There are approximately 20 related fungal strains of aflatoxin, the four major ones being B1, B2, G1 and G2. Aflatoxin B1 is the most potent chemical liver carcinogen known. Early aflatoxin symptoms include anorexia, malaise and low fevers; and advanced symptoms include vomiting, abdominal pains, jaundice and liver failure (Strosnider et al. 2006). Aflatoxins affect both humans and livestock, thus posing serious threats to food chains worldwide. ACIAR has contributed efforts towards understanding the extent to which infected peanuts penetrate the market and the subsequent consequences for health and socioeconomic development in selected regions.

ACIAR's concern for aflatoxin development dates back to the 1980s, when projects in South-East Asia sought to reduce the prevalence of aflatoxin in peanuts (Table 6). Although there has been a region-wide focus on aflatoxin reduction, specific focus has been on Indonesia and Papua New Guinea.

Alongside the focus on developing-country markets, ACIAR's projects have also included studies of and contributions to the Australian peanut industry. For example, initial projects during the late 1980s and early 1990s contributed to a deeper understanding of biocontrol strategies to reduce aflatoxin on-farm, as well

Table 6: Overview of ACIAR aflatoxin-reducing investments in South-East Asia

Country and code	Project title	Dates	Budget (nominal)
Indonesia	CS1/1984/019 Peanut improvement in Indonesia	August 1985 – August 1988	A$651,281
Indonesia	CP/1988/034 Peanut improvement in Indonesia	October 1988 – July 1992	A$819,776
Indonesia, China, Thailand	PHT/1988/006 Fungi and mycotoxins in Asian food and feedstuffs	October 1988 – June 1993	A$1,089,322
Thailand	PHT/1991/004 Occurrence and distribution of *Aspergillus flavus* and aflatoxins in Asian peanuts	July 1991 – June 1994	A$386,129
Vietnam, Australia	PHT/1996/004 Monitoring mycotoxins and pesticides in grain and food production systems for risk management in Vietnam and Australia	July 1999 – June 2004	$1,088,389
Indonesia, Australia	CP/1997/017 Reducing aflatoxin in peanuts using agronomic management and biocontrol strategies in Indonesia and Australia	July 2001 – December 2006	A$953,736
Papua New Guinea and Australia	SMCN/2004/041 Productivity and marketing enhancement for peanut in Papua New Guinea and Australia	September 2006 – November 2009	A$844,422

as to drought tolerance and conditions that led to the prevalence of aflatoxin. This knowledge increased both Indonesia's and Australia's knowledge of the science behind the aflatoxin problem.

ACIAR has contributed approximately A$4 million towards aflatoxin-reducing efforts in South-East Asia (Table 6). These projects included a mix of strategies to minimise the risk of aflatoxin during the production process, as well as surveying its prevalence within South-East Asian markets. Initial projects during the 1980s and 1990s focused on farm management of aflatoxin (see project PHT/1991/004 (ACIAR 1994)). However, it became evident that a broader focus on the peanut supply chain and markets was necessary, to enable efforts to reduce aflatoxin development.

ACIAR has conducted research in diverse food value chains with varying levels of aflatoxin risk reduction policies. For example, the CP/1997/017 project was carried out in both Australia and Indonesia. The two countries have different institutional and production contexts relating to aflatoxin risk, as well as different macro-economic priorities and environmental conditions. The method developed in this paper can be used for such a project, with different contextual and external drivers, as the same analytical questions can be applied in different countries.

Between 1988 and 2001, ACIAR investments provided an economic, social and scientific understanding of the nature of the aflatoxin problem throughout South-East Asia. Lubulwa and Davis (1994) used economic models to identify the social and economic costs of aflatoxin exposure in Indonesia, the Philippines and Thailand. They found that mycotoxins led to economic losses from product spoilage, and that losses extended to the livestock sector. The report found that poverty could increase due to economic losses from mycotoxins and from the risk of liver cancer development through aflatoxin exposure.

In 1999 a workshop facilitated by ACIAR explored a mix of economic, biological and equipment-related solutions, with a specific focus on Indonesia (Dietzgen 1999). The knowledge acquired through these and other projects led to the design of the Indonesia-specific project (CP/1997/017) targeted at understanding and reducing the risk of aflatoxin. This was a collaboration between the Australian Government and Australian and Indonesian research universities and centres. Tools and knowledge for both countries were developed, and new ways of understanding the peanut supply chain in different contexts emerged.

4.1 ACIAR project CP/1997/017

In 2001 ACIAR sought to expand its efforts to reduce aflatoxin in the Indonesian peanut supply chain. The five-and-a-half-year project (CP/1997/017) had a nominal ACIAR investment of $A953,730 and was based on the understanding that aflatoxin contamination was an issue for the Indonesian peanut industry, and had to be addressed and monitored on-farm and post harvest. As detailed knowledge of the prevalence of aflatoxin throughout the supply chain was lacking, the project needed to build this understanding, to inform research outputs that could reduce the risk of aflatoxin development. Table 7 shows the different investments made by relevant agencies involved in the CP/1997/017 project.

The project benefited from the experience of Australian peanut growers, which facilitated an understanding of aflatoxin risk, and from the established food safety and regulatory environments that reduce this risk.

In Australia aflatoxin control is heavily regulated and enforced. Initial work began in the 1980s, with the Queensland Department of Agriculture and Fisheries and the Grain Research and Development Corporation (GRDC) funding research and extension projects that identified on-farm management, harvesting and storage techniques that reduce the likelihood of aflatoxin development. Australian Government regulation and enforcement of the 15 parts per billion (ppb) limit in peanut products ensure that Australian peanuts are aflatoxin free. Heavy fines and legal sanctions are in place for producers and distributors involved in products with higher levels of aflatoxin. Penalties of A$150–450 per tonne apply to delivery loads with aflatoxin levels above 15 ppb, affecting the viability of some producers. Current price incentives encourage producers to mitigate the aflatoxin problem on-farm. Managing on-farm is more cost-effective, as the problem becomes much larger and more costly when processors have to identify and sort aflatoxin-infected products.

The factors that make Australia a leader in aflatoxin mitigation are:

- high industry and government awareness, despite little consumer awareness of the problem
- strong regulation and enforcement
- incentives and penalties for producers
- a small number of centralised shellers/processors, which allows establishment of effective aflatoxin mitigation programs
- advanced monitoring and processing systems that can effectively eliminate aflatoxin from contaminated product.

Australian experience in aflatoxin management and control indicated that solely focusing on on-farm controls was not likely to be sufficient to address the problem. In 2001, when CP/1997/017 began, the Indonesian industry and government required further understanding of aflatoxin risks in supply chains. This need, together with the extensive Australian experience in monitoring, enforcing and reducing risk, led to five project objectives:

1. Survey Indonesian peanuts for incidence of *Aspergillus flavus* and aflatoxin at various stages in the food delivery chain (farm–buyer–retailer) to assess the critical hazard points that result in contamination.
2. Develop and implement integrated packages of agronomic and varietal management options that minimise late-season moisture stress and hence reduce the aflatoxin risk in Indonesian and Australian cropping systems.
3. Develop a detailed understanding of the soil, plant and environmental factors influencing *A. flavus* invasion and aflatoxin production, and incorporate this knowledge into the agricultural production systems simulator (APSIM) peanut model for scenario analysis and development of decision support tools.
4. Further evaluate the biocontrol approach as a means of minimising aflatoxins in peanuts, with emphasis on integrating the technology into crop management systems.
5. Foster the implementation of aflatoxin monitoring and control strategies in Indonesia.

The project's adoption study (Wright and Rachaputi 2011) found that both Indonesia and Australia benefited from the knowledge and relationships built throughout the project. For Australia, the combination of effective regulatory enforcement and pricing incentives and

Table 7: Total investments (in A$) towards the CP/1997/017 project

Source of funding	**Main project PHT/1997/017 (2001–04)**	**Extension project PHT/1997/017 (2004–06)**	**Total—both projects (2001–06)**
Total ACIAR funding	715,741	237,989	953,730
Other support from research agencies directly associated with this project			
Queensland Department of Primary Industries	823,297	335,696	1,158,993
University of Sydney	120,000	48,752	168,752
Research Institute for Legumes and Tuber Crops (RILET)	105,000	65,700	170,700
Southeast Asian Regional Centre for Tropical Biology (BIOTROP)	198,165	88,800	286,965
Gajah Mada University	105,000	–	105,000
Total	2,067,203	776,937	2,844,140

penalties allowed for the safe delivery of peanut products to consumers. These findings continued to facilitate research and investment into postharvest drying and testing techniques that minimise the presence of aflatoxin in the supply chain.

The adoption study found that wet markets in Indonesia are conducive to aflatoxin development in peanuts due to poor storage. Lack of monitoring and fragmentation in these markets leads to major problems in identifying the sources of aflatoxin. Furthermore, survey findings indicated that there is low awareness of the issues associated with aflatoxin development, which leads to non-enforced regulation and poses risks to industries and consumers.

Table 8 summarises the main project objectives and associated outcomes for the CP/1997/017 aflatoxin-reducing project conducted in Indonesia by ACIAR.

The main agencies involved in the research and implementation of the CP/1997/017 project were:

- Indonesian Legumes and Tuber Crops Institute (ILETRI), Indonesia
- South-East Asian Regional Centre for Tropical Biology (SEAMEO BIOTROP), Bogor, Indonesia
- Faculty of Agricultural Technology, Gajah Mada University (GMU), Yogyakarta, Indonesia
- Assessment Institute for Agricultural Technology (AIAT)
- Queensland Department of Primary Industries
- Department of Agricultural Chemistry and Soil Science, University of Sydney.

Overall, the project outputs contributed towards an enhanced understanding of two main aspects of the aflatoxin problem. First was the confirmation that the highest risk of aflatoxin development in Indonesia exists in wet-market settings, where humid environments facilitate the growth of the fungus. A lack of regulatory enforcement and incentives has contributed to this

Table 8: CP/1997/017 project objectives and outputs

Objective	Output
1. To survey Indonesian peanuts for incidence of *A. flavus* and aflatoxin at various stages in the food delivery chain (farm–buyer–retailer) to assess the critical hazard points that result in contamination	Knowledge about the presence of aflatoxin, little awareness, high levels of fungus throughout the food chain
2. To develop and implement integrated packages of agronomic and varietal management options that minimise late-season moisture stress and hence reduce the aflatoxin risk in Indonesian and Australian cropping systems	Experiments that investigated the effect of harvesting time and different seed storage systems—findings that aflatoxin development at the on-farm level is hard to track and reduce AFLOMAN tool developed for Australian growers to assess the risk of aflatoxin development
3. To develop a detailed understanding of the soil, plant and environmental factors influencing *A. flavus* invasion and aflatoxin production, and incorporate this knowledge into the APSIM peanut model for scenario analysis and development of decision support tools	Peanut Whopper Cropper tool that factors in a range of conditions, allowing producers to make decisions on their production practices
4. To further evaluate the biocontrol approach as a means of minimising aflatoxins in peanuts, with emphasis on integrating the technology into crop management systems	Biocontrol management strategies developed in Australia and trialled on selected Indonesian sites—no major uptake as success rate was low
5. To foster the implementation of aflatoxin monitoring and control strategies in Indonesia	Enzyme-linked immunosorbent assay (ELISA) models and processors have the greatest capacity to handle and mitigate aflatoxin development

problem. The second aspect was the ability to monitor the presence of aflatoxin throughout supply chains and provide survey data regarding the potential risks for Indonesian consumers, especially those from lower socioeconomic backgrounds.

4.2 Indonesian case study

Peanuts are commonly eaten in Indonesia. They are a rich and cheap source of vegetable protein, and can also be processed and used for a range of cooking purpose (as well as for cattle feed). Peanut consumption is estimated to average 18 grams per person per day; however, this is a relatively low figure compared with other tropical developing nations, especially in Africa. The interaction between aflatoxin infection and hepatitis B is also important for Indonesia. The chances of developing liver cancer from aflatoxin are 30 times higher for people infected with hepatitis B (Williams, JH et al. 2004)-. In Indonesia the estimated percentage of the population with chronic hepatitis B is 2.5–5.0% (Hong, Zou and Giulivi 2001; Merican et al. 2000; van Hattum et al. 2003).

More than 800,000 tonnes of peanuts are produced annually. However, the demand for peanuts is higher than the domestic agricultural supply, making Indonesia one of the world's largest importers of peanuts. Indonesia's regulatory environment has well-established safeguards to prevent the distribution of aflatoxin-infected goods from imports, but there was little progress in domestic peanut aflatoxin management prior to CP/1997/017.

The chief challenge for Indonesian food safety regulators regarding domestic peanuts is that most are sold in wet markets where producers sell their product to distributors. The low-quality storage situations in these markets can create ideal conditions for the aflatoxin fungus to develop. These wet markets are spread throughout the country to sell products produced by smallholder farmers, who make up the majority of Indonesian farmers. Lubulwa and Davis (1994) attributed major financial risk to peanut producers and processors in aflatoxin-infected products, posing a threat to livelihoods and development.

The Indonesian Government has established regulations and standards regarding maximum acceptable levels of aflatoxin present in a range of products, including peanuts. The Indonesian National Standard for animal feed was established in 1995, where the maximum level of aflatoxin was established at 50 ppb. In 2005 the National Agency for Drug and Food Control (NADFC) established the maximum level of aflatoxin in food products (which covers peanuts) at 15 ppb (Rahayu 2012). Although the presence of such regulatory safeguards indicates that the Indonesian Government is aware of the potential issues associated with aflatoxin exposure, Wright and Rachaputi (2011) argue that there is still little awareness of the problem in producers, distributors and sellers throughout the supply chain.

The Indonesian Government's maximum acceptable limits align with the ones set by the Association of South-East Asian Nations (ASEAN) (ASEAN Taskforce on Codex Alimentarius 2014). The concerns reflected in ASEAN policies are consumer and farmer awareness of the problem, postharvest storage and monitoring strategies.

A summary of Indonesia's aflatoxin-related regulatory policies is presented in Box 1.

Box 1: Indonesian aflatoxin-related regulatory food and feedstuff policies

For feedstuffs:

- SNI (Indonesian National Standard) for feed was established in 1995. Maximum level of total aflatoxins of feed-corn: 50 ppb (final product)

For foods:

- 2004 Indonesian National Agency for Food and Drug Control: Maximum level of aflatoxins in food: 35 ppb and AFB1 20 ppb
  - Limit reduced to 15 ppb in 2005
- 2009 Indonesian National Standardization Agency launched SNI 7385-2009: standard for mycotoxin maximum level of some food products

The Indonesian context thus presents a series of risk factors for aflatoxin prevalence in supply chains:

- very little awareness of aflatoxin throughout the supply chain
- high incidence of hepatitis B
- fragmented production with thousands of producers
- minimal monitoring and enforcement of regulation
- no incentives for growers and processes to learn about and act on aflatoxin reduction
- minimal domestic enforcement, despite ASEAN regulatory limits.

Figure 5 presents the Indonesian peanut supply chain, and ACIAR's contribution to understanding where aflatoxin can be reduced within the supply chain.

4.2.1 International responses to aflatoxin in Indonesia

Parallel to ACIAR's work, other bilateral and multilateral agencies were involved in aflatoxin research at the time of ACIAR's project implementation. Table 9 summarises the different agencies and the extent of their involvement.

4.3 Impact assessment objectives

The main objective for this impact assessment was to determine how the project outputs from CP/1997/017 are being used by regulatory policymakers, research centres and the peanut industry in Indonesia and Australia, and the ultimate impact this has had on aflatoxin risk mitigation.

There were three subobjectives for this evaluation:

1. Assess the extent to which the project outputs have contributed towards greater awareness of the risks of aflatoxin in Australia and Indonesia with reference to CP/1997/017 and the preceding related projects (PHT/1991/004, CP/1988/034, CS1/1984/019 and PHT/1988/006).
2. Examine the impacts that CP/1997/017 has had on relationships among different stakeholders involved in regulating and managing the risks of aflatoxin, which include scientists, regulators, industry and non-government organisations.
3. Determine the extent to which project outputs have led to sustained adoption and changes in institutions and industry to reduce aflatoxin problems in Indonesia.

Table 9: international agencies involved in aflatoxin mitigation

Agency	Involvement in aflatoxin
Food and Agricultural Organization of the United Nations and United Nations Development Programme	Mycotoxin prevention in food grains project, 1991–93, with a focus on understanding the extent to which aflatoxin was prevalent throughout ASEAN markets in various commodities (see Semple et al. (1991))
Department for International Development, UK	Establishment of an ELISA technique for detecting aflatoxin B1 in feedstuffs (2001) The project involved the Indonesian Research Institute for Veterinary Science (Bogor); Centre for Tropical Veterinary Medicine, University of Edinburgh; and Department of Agricultural Chemistry and Soil Science, University of Sydney. The focus was development of ELISA testing kits to monitor the prevalence of aflatoxin in animal feed.
World Health Organization (WHO)	No Indonesia-specific work, but global guidelines, workshops and discussion on the impact of aflatoxin on health; for example, the July 2005 WHO workshop on Public Health Strategies for Preventing Aflatoxin Exposure

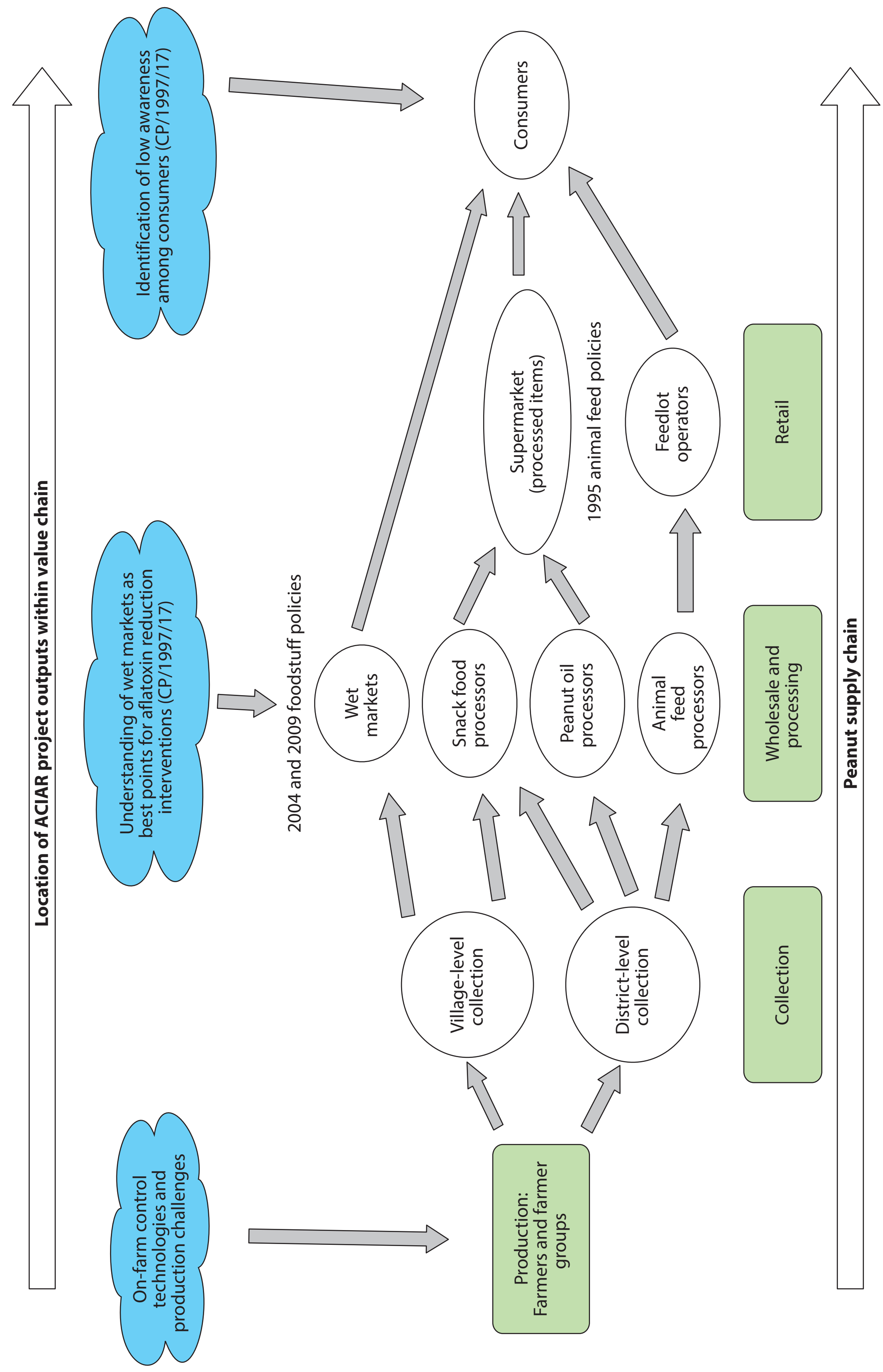

Figure 5: The Indonesian peanut supply chain and location of ACIAR CP/1997/017 outputs

5 Literature Review: Aflatoxin and Development

This section reviews the role of agriculture in international development and the importance of reducing aflatoxin in agricultural systems. We provide insights into management strategies for aflatoxin throughout the supply chain. This broad overview provides the context for the impact assessment, focusing on aflatoxin-reduction strategies.

5.1 Agriculture for development

Agriculture remains a core driver of development, as demonstrated by continued efforts to facilitate access to food by the world's population, up-scale smallholder agricultural systems and adapt to the impacts of agriculture in food production.

Investment in the agricultural sector changed throughout the 1990s. Private agricultural businesses focused their efforts on boosting production and facilitating access to improved agricultural technologies. Public funds from the donor community declined as agriculture lost priority as a main sector in economic growth. In 2008 the World Development Report emphasised the diverse role that research and aid agencies can play in facilitating poverty reduction in the agricultural sector (World Bank 2008). This report set the agenda for how the private and public sectors can use agriculture as an engine of economic growth and poverty reduction in coming decades.

A large quantity of literature exists on the contribution that agriculture can make towards poverty reduction and national economic growth. Van der Ploeg (2010) and McMichael (2014) both present a synthesised historical overview of how agricultural markets have changed through time. Van der Ploeg contends that smallholder agriculture has been left out of development policies both domestically and internationally, with the prioritisation of technological growth and urban expansion. This has contributed to perpetual poverty cycles in rural populations without sufficient support to innovate and transform their practices to more-profitable ones. Along similar lines, McMichael poses that the increasing role of private investment in agriculture has led to diminishing returns to smallholder farmers, and that agricultural policies have shifted to promote large agribusiness and not focus on basic poverty reduction.

Reducing poverty in agriculture is complex and requires a systems understanding and approach to programs. For the developing-country context in which ACIAR contributes research and knowledge, focus across all dimensions of the system is necessary. This is acknowledged through development of a focus on livelihood approaches, which look at the numerous assets that can facilitate a smallholder's reduction in poverty stemming from agricultural activities (Carpenter and McGillivray 2012). Issues of gender equality in developing countries have become more prevalent in agricultural development (Qureshi, Dixon and Wood 2015), and concerns over achieving food security outcomes in a changing global environment will require research that integrates social, economic and environmental concerns (Ingram, Ericksen and Liverman 2010).

To reduce poverty and make agriculture a more profitable and secure livelihood, research and policy interventions across the processing, distribution, consumption and postconsumption management of agricultural produce is also required. The concept of supply chains facilitates this understanding of the links between different parts of the process. Finding places within the supply chain in which targeted research and intervention is most likely to lead to the changes required is necessary for effective and efficient outcomes. To demonstrate this in relation to aflatoxin reduction, we provide an overview of the problem of aflatoxin in supply chains and its relevance for agricultural development.

5.2 The nature of the aflatoxin problem

Aflatoxins are toxic chemicals produced by the food-borne fungi *Aspergillus flavus* and *A. parasiticus* that affect a variety of food items including maize, oilseed, peanuts, tree nuts and groundnuts (Liu et al. 2012; Liu and Wu 2010). Aflatoxins are most common in tropical regions, where postharvest and market conditions are humid and stimulate development of the chemicals in food products (Williams, JH et al. 2004).

Contamination can occur both on-farm and off-farm. During harvesting, fungus growth is promoted by a combination of production and harvesting factors (Williams, JH et al. 2004) such as soil type, lack of water and insect activity (Magnussen and Parsi 2013). Following harvesting, timely and dry storage is essential to prevent the spread of the aflatoxin fungus. Despite knowledge of the conditions in which the fungus develops, aflatoxin remains a major concern for food producers in tropical climates, and poses serious health risks for consumers of aflatoxin-infected products.

Williams, JH et al. (2004) contend that up to 4.5 billion people globally may be exposed to aflatoxin-contaminated products. Aflatoxin infection can occur through direct consumption of the contaminated item, and also by consuming dairy products originating from animals that ate infected animal feed (Dashti et al. 2009; Strosnider et al. 2006).

Aflatoxin infection can have two major human health impacts. Acute aflatoxicosis can lead to the death of the individual; however, records of this are relatively uncommon due to poor documentation of the sudden death of individuals and any association with aflatoxin poisoning (Magnussen and Parsi 2013). Chronic aflatoxicosis results in long-term pathologic changes, including the development of liver cancer. Although estimates are poor, Liu and Wu (2010) suggest that between 25,000 and 155,000 liver cancer prognoses can be attributed to aflatoxin. Since liver cancer is the third most common cause of cancer deaths worldwide (Ferlay et al. 2010), prevention, monitoring and regulation strategies are needed.

There are two major vulnerable groups in a population (Magnussen and Parsi 2013; Williams, JT 2008). Children with less-developed neurologic and immune systems are more prone to developing symptoms associated with aflatoxin exposure (Magnussen and Parsi 2013). People with chronic Hepatitis B virus, as noted earlier, are also particularly vulnerable—those exposed to aflatoxin are up to 309 times more at risk of developing liver cancer than Hepatitis B-negative individuals (Liu and Wu 2010; Magnussen and Parsi 2013).

5.2.1 The response

The global response to the increasing risk of developing liver cancer from aflatoxin exposure has been led by WHO and regulatory bodies in developed countries. In 1998 the global threshold of detectable aflatoxin decreased from 20 mg/g to 10 mg/g and was defined as the maximum limit for maize and peanuts.

If these detectable limits are reduced through the food commodity chain, the incidence of cancer can be reduced (Liu et al. 2012). The potentially severe consequences of exposure to aflatoxin has led WHO to classify it as a Group A carcinogen. WHO continues to prioritise strategies to detect, monitor and reduce exposure to aflatoxin.

5.2.2 Aflatoxin and rural development

The countries at highest risk of their citizens being exposed to aflatoxin and developing liver cancer are the least resourced to monitor and prevent exposure to it (Liu and Wu 2010; Magnussen and Parsi 2013; Williams, JH et al. 2004). Most of Africa and South-East Asia have a climate that favours aflatoxin fungi. Coupled with poor harvesting strategies and humid postharvest storage and distribution environments, it is not surprising that aflatoxin exposure is higher in the developing world. This poses a series of challenges for development, including the profitability of smallholder farmers that have peanuts as their main commodity, the capacity of health sectors to deal with increased liver cancer cases in the future, and the dispersion of infected products to growing affluent urban populations.

Similarly, rural populations have a much higher risk of aflatoxin exposure than urban dwellers, largely due to rural diets being less diverse. Smallholder farmers producing peanuts may be able to discard infected products in a good season but they may be forced to sell or consume infected products during a bad season (Williams, JT 2008).

In the literature, examples from the developing world indicate how widespread aflatoxin is (Alaniz Zanon et al. 2013; Bankole, Ogunsanwo and Eseigbe 2005; Ezekiel et al. 2013; Ezekiel, Kayode et al. 2012; Ezekiel, Sulyok et al. 2012; Kamika and Takoy 2011; Liu et al. 2012; Liu and Wu 2010). Numerous projects from universities, research centres and aid agencies have focused on Africa due to the large presence of aflatoxin, poor awareness of the health ramifications of exposure and low regulatory environments (Bankole, Ogunsanwo and Eseigbe 2005; Ezekiel et al. 2013; Ezekiel, Kayode et al. 2012; Ezekiel, Sulyok et al. 2012).

Animal feed infected with aflatoxin also poses risks to humans. Pei et al. (2009) and Dashti et al. (2009) found that animal feed that is high in aflatoxin levels leads to animal by-products also containing aflatoxin. Work in Indonesia, the Philippines and Thailand has also improved the understanding of links between aflatoxin in animal feed and milk products, posing threats to human populations after consumption (Henry et al. 2001).

Aflatoxin thus poses a number of challenges for rural development, especially in developing countries. Lack of awareness of the problem through all levels of the supply chain poses barriers for change to take place at the farm and market levels, and low incomes may lead to producers or traders selling contaminated products regardless. Furthermore, the lack of tools to monitor the flow of aflatoxin between products makes it difficult for consumers and distributors to understand the extent of the problem. These issues have led to a series of strategies to attempt to reduce the prevalence of aflatoxin.

5.3 Strategies for reducing and monitoring aflatoxin in developing countries

A number of strategies have been proposed to reduce aflatoxin exposure, especially in rural contexts. These include best practice regulation in the European Union and USA, gender and participatory development approaches to community-based risk mitigation, biocontrol and postharvest storage strategies, and use of detection models.

5.3.1 Regulation and policy interventions

Strategies to reduce the risk of aflatoxin infection in products and consumers remain a priority for agricultural, development, health and trade agencies. There is little evidence that aflatoxin is manageable, and the United States Food and Drug Administration considers aflatoxin to be an unavoidable contaminant of food (Williams, JH et al. 2004). Furthermore, global environmental changes such as rising temperatures are expected to increase the presence of aflatoxin (Wu et al. 2011). Despite significant efforts by international health bodies and regulatory institutions to monitor the flow of aflatoxin in formal trade markets, much remains to be done regarding wet markets throughout the developing world, where regulation is hard to enforce.

Policy, regulation and safety standards play a key role in monitoring the presence of infected products and thus reducing the availability of such products to consumers. There are distinct differences in the number of cases of liver cancer attributed to aflatoxin between developed and developing economies, some of which can be attributed to differences in regulatory standards. Although WHO commonly supports the maximum aflatoxin level to be 10 mg/g in peanuts, maximum levels vary throughout jurisdictions, making international monitoring mechanisms difficult to implement.

A major challenge in identifying, monitoring and removing aflatoxin from the food supply chain lies in institutional capacity to develop and enforce regulations. Developed countries have greater capacity to reduce producer and consumer exposure to aflatoxin, as demonstrated by their low estimated number of cases of liver cancer attributable to aflatoxin (Liu and Wu 2010). For example, in USA the national Department of Agriculture regulates the quality of groundnuts through a marketing agreement that stipulates that all groundnuts sold in USA need to be officially inspected by government officials. Any peanut with an aflatoxin level of more than 15 ppb is rejected and disposed of.

The ability to enforce such regulation in developing countries is rarer. Liu and Wu (2010) contend that most countries have established maximum thresholds of aflatoxin standards, yet fail to enforce them, especially in wet markets in rural areas. Similarly, Florkowski and Kolavalli (2014) suggest that there are insufficient resources and knowledge about aflatoxin to develop robust regulatory systems.

5.3.2 Biocontrol and storage systems

Biocontrol of aflatoxin entails the use of chemicals and varieties that attempt to reduce the presence of the fungus during the production process. This has had partial success in both developed and developing countries (Alaniz Zanon et al. 2013). The effectiveness of biocontrol strategies remains contested, and developed countries with strong health and safety standards have made biocontrol a high-risk strategy. For low-income farmers in developing countries, the costs associated with acquiring the knowledge and products to use biocontrol make the mechanism unviable. The CP/1997/017 project identified that, in the Indonesian context, on-farm management is not worth pursuing because the main point for aflatoxin development is in markets rather than on-farm. Furthermore, the high failure rate of biocontrol tests in Australia as well as in Indonesian pilot studies indicates a high uncertainty regarding the likelihood of success of these strategies. These lessons highlight the importance of focusing efforts on building an understanding of the aflatoxin problem and then developing strategies to begin policymaking to monitor the problem.

5.3.3 ELISA models

ELISA tools are used widely to determine the concentration of particular antibodies in a particular solution. There are numerous examples of ELISA models being used to monitor the presence of aflatoxin throughout a supply chain (Chauhan, YS et al. 2010; Lee et al. 2005; Lee and Rachmawati 2006). For example, Lee and Rachmawati (2006) used an ELISA test for screening aflatoxin in animal feed and feed ingredients. The tool allowed for the rapid identification of aflatoxin levels. Mutegi et al. (2013) used the same model in Kenya, where they found that a range of staple commodities were at risk of having high levels of aflatoxin infection. The tool developed by Lee et al. (2005), which was an output of the CP/1997/017 project, provided an ELISA model for identifying the presence of aflatoxin in the Indonesian supply chain.

5.4 Relevance of aflatoxin for development

The literature clearly indicates that there are large uncertainties regarding the extent to which liver cancer can be attributed solely to aflatoxin. The presence of Hepatitis B in a population is argued to be a core contributing factor to the development of liver cancer through aflatoxin exposure. General agreement in the literature also highlights the disadvantage of developing economies, as the coupling of Hepatitis B and poor enforcement of regulation leads to higher risks of aflatoxin exposure and liver cancer. A range of strategies exists to monitor and raise awareness of the risks of aflatoxin; however, the literature commonly agrees that it is enforcement of regulatory measures, coupled with monitoring tools, that can have the most impact in reducing aflatoxin exposure.

6 Applying the Knowledge Systems and RAPID Framework

ACIAR investments have been focused on creating knowledge about the prevalence of aflatoxin throughout the Indonesian supply chain (section 4.1). As indicated in section 5.3.1, enforced policy and regulation is the most useful tool to reduce aflatoxin risk. Awareness and understanding of the prevalence of aflatoxin were also identified earlier as essential for robust regulatory systems; however, the pathways between knowledge creation, awareness and effective action are rarely straightforward.

The outputs of project CP/1997/017 generated knowledge about Indonesian peanut supply chains and aflatoxin, contributing to a diverse understanding of the problem among different actors (this is the knowledge systems dimension of the project, as per the ideas of section 2 and Table 4). Although the project did not intend to influence policy, the broader context of aflatoxin in Indonesia (section 4.2) creates relevance for also incorporating RAPID questions (as per section 2.3).

ACIAR has supported many project outputs towards building knowledge about aflatoxin. As such, the conceptual approach and research tools used for this project explicitly focused on the uptake of knowledge products generated by ACIAR, and the implications of this for current management of the aflatoxin problem in Indonesia.

A framework focusing on knowledge and the factors influencing development allows us to capture a range of intermediate benefits—steps towards the ultimate goal—related to the knowledge creation activity supported by ACIAR. The guidelines by Davis et al. (2008; p. 15) provide an initial step in focusing on inputs, outcomes and impact (as noted in section 3.3). We then expand from this step to include analytical elements of knowledge systems and RAPID (see Table 4).

We use qualitative evidence to document how project outputs led to long-term benefit and change, following our methods discussion in section 3.2.1. Using qualitative research methods that reveal stories, perspectives and values associated with aflatoxin reduction, we are able to discuss the links between knowledge creation and long-lasting change.

We have designed a framework that documents evidence of impacts that are not readily quantifiable (such as economic gain), yet provides critical information on what has been achieved as well as what inhibits and facilitates the application of knowledge generated by ACIAR investments. As such, the analytical questions in Table 4 can be used in parallel with other quantitative methods (such as cost–benefit analysis) to capture a richer picture of ACIAR contributions.

6.1 Analysing aflatoxin with the knowledge systems and RAPID framework

The first step in the method is to understand who the actors are and what decision-making activities exist, as per the knowledge systems literature and Table 4. The second step is applying the analytical questions from the middle section of Table 4, where knowledge system and RAPID items come together. This includes identifying linkages, the quality of evidence that exists and communication channels. Finally, the political context and external drivers that influence policy, such as macro-economic priorities, need to be considered.

In the context of the CP/1997/017 project, the initial knowledge system when ACIAR investments began was as shown in Figure 6.

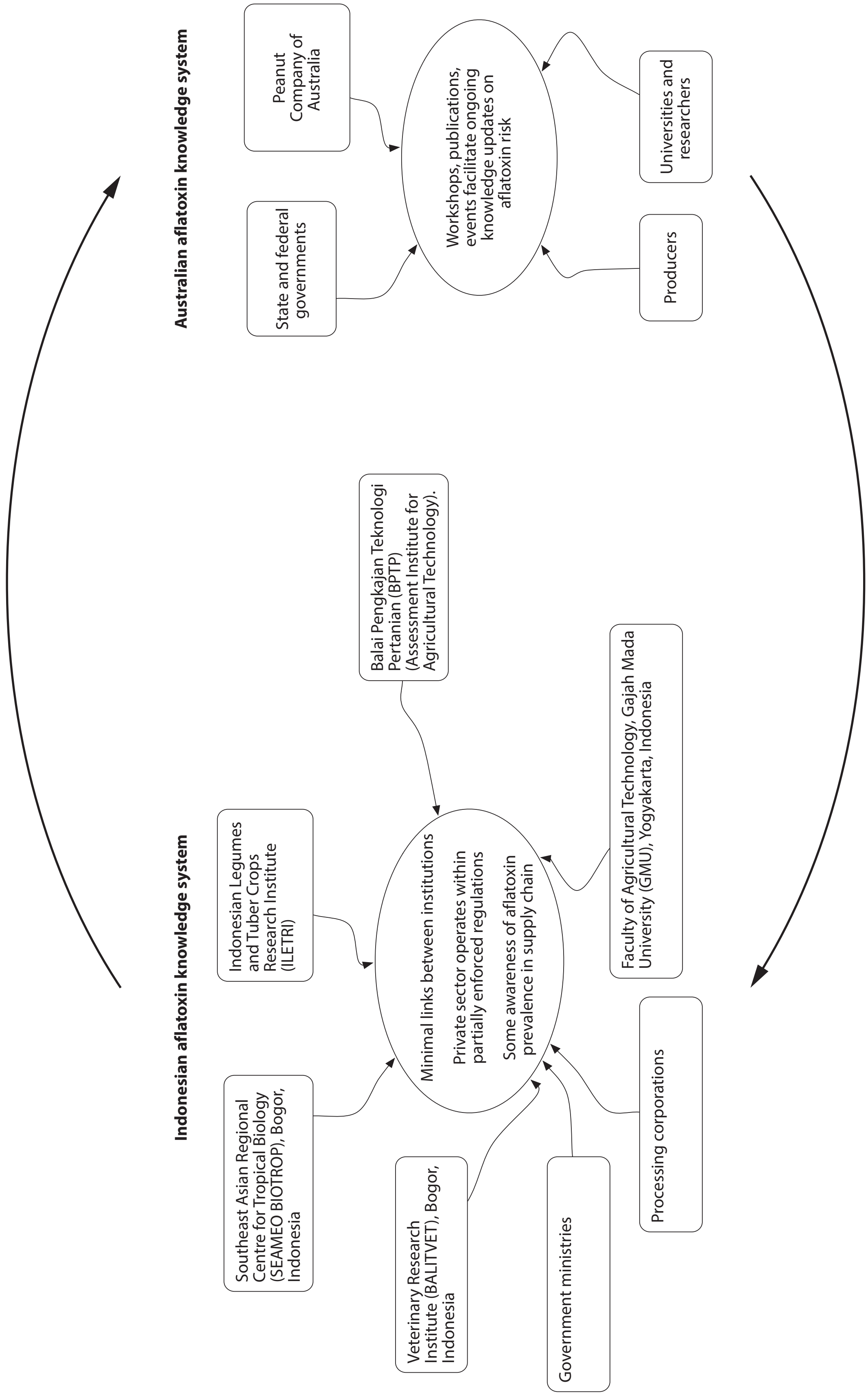

Figure 6: The Indonesian and Australian knowledge systems

6.2 Data collection methods

The data collection methods used were qualitative, primarily semi-structured interviews with participants who had been involved in the original research program (key informants), desk reviews of grey and peer-reviewed literature, and case study analysis. We did not conduct any economic analysis or attempt to quantify the extent of impact or effect, as this inevitably highlights 'measurable' outcomes but may not encompass 'meaningful' outcomes. This is particularly the case where impacts are concerned with public-good outcomes that are difficult to quantify, as in the case of long-term preventive public health measures such as aflatoxin control. Given our conceptual framing of research impact pathways as complex, evolutionary and human processes, qualitative data give us access to a wide range of interpretations and experiences, to capture the breadth of impacts. The concurrent emphasis on identified actions also ensures that we are building an evidence base for any claims of influence or change.

To connect the conceptual framework with the evaluation objectives, we developed an interview protocol and thematic analysis tool around analytical and empirical questions (Table 10).

The semi-structured interview protocols were adapted to suit the context of each participant. They comprised a number of questions that related to the knowledge-based processes and relationships, as well as key events or activities. The participants were not sent the questions beforehand, as the intent was to encourage a more relaxed, conversational style of interaction, rather than a formal question-and-answer session. This allowed participants to think more expansively about the issues raised. Alongside the questions were a number of 'themes' that were not included as questions but prompted the interviewer to explore them more closely if these topics were raised during the conversation. The interview protocol is included in Appendix 1.

The interview protocol had three major categories, with subquestions. These categories— knowledge, relationships, sustained impact—were identified by the impact assessment team as the most salient to assess the policy uptake of research 10 years after project completion.

All interviews were conducted in English. Audio recordings were transcribed as narratives under the three impact assessment objectives. We then used the conceptual framework above to identify the most salient themes around knowledge systems and the factors that enabled or inhibited the framework's application. We have not revealed the names of participants, to maintain confidentiality as much as possible and reduce attribution of quotes to specific people or institutions.

Throughout the interviews we also pursued detailed stories on specific case studies that demonstrated long-term unintended outcomes from ACIAR's investments. The Aflatoxin Forum of Indonesia (AFI) was identified as a case study as it represents knowledge, relationships and the long-term impact of outputs.

Along with interviews, we followed the overview provided by Linder (2011) and tracked publications, conferences, numbers of students and any quantifiable uptake of research results. These data were gathered from ACIAR project documents or through records from relevant organisations involved in the project.

Table 10: Analytical and empirical questions

Analytical questions (from the framework)	Empirical questions (specific to CP/1997/017)
Analytical questions are based on the wider ideas in which studies are carried out. For this project, knowledge systems and RAPID set the analytical questions: Knowledge systems questions: focus on processes, quality, salience and credibility of evidence, communication RAPID questions: focus on links, contextual factors, external drivers.	Empirical questions are ones that can be asked in specific contexts, in this case the CP/1997/017 project. Questions focused on knowledge, relationships, sustained impact. Answers from these questions can be used to link to the impact assessment objectives and, more broadly, the ideas from knowledge systems and RAPID in Table 4.

6.3 Fieldwork

Six Australian and 11 Indonesian stakeholders were interviewed, including 2 government officials, 3 from the private sector, 11 researchers and 1 consultant.

In Indonesia some of the interviews were with researcher groups. Interviews lasted between 40 minutes and 90 minutes, and some people were interviewed multiple times. Informal discussions were held with a range of researchers who were familiar with aflatoxin management. These people were not formally interviewed but contributed towards providing a broader context in which ACIAR investments took place. All Indonesian interviews were conducted in person over 10 days in Jakarta, Bogor and Yogyakarta.

All Australian interviews were conducted by phone. Some participants were interviewed more than once, to further clarify perceived impact and details of the project.

6.4 Data analysis

Data were analysed using a three-pronged strategy:

- identifying and categorising any references to knowledge-based processes, such as ongoing research, publications, meetings and conferences
- capturing issues relating to the relationships among project participants, as well as whether and how participants developed new relationships and roles as a result of their engagement with the ACIAR aflatoxin research projects
- identifying the RAPID factors present in the Indonesian and Australian contexts.

For each of these strategies, we looked for both recurring themes as well as stories that illustrated key relationships or knowledge-based processes. This ensured that we categorised our data systematically and closely examined key events associated with research impact. It also allowed us to identify any evidence of the known factors playing a role, and scope any emergent issues or topics to be identified.

7 Benefits to Australia

This section presents the main findings following the thematic analysis of the interviews with Australian key informants. Table 11 provides a summary of quotes provided by each key informant for each of the three impact assessment objectives. Table 12 presents a thematic count from Australian interviews. We then discuss how CP/1997/017 project outputs contributed to dynamic knowledge systems, enabled communication channels between relevant stakeholders, and influenced the extent to which outputs had broader impacts on aflatoxin management in Australia. We also discuss the extent to which the context of peanut production in Australia, limited to approximately 250 producers and a strong regulatory environment, contributed to the flow of knowledge.

The section conclusion includes Table 13, which connects the findings of the impact assessment with the knowledge systems and RAPID framework developed in section 3.

Table 11: Categorised interview responses from Australian participants

Role in project	Q1: Knowledge and awareness	Q2: Relationships	Q3: Sustained impact
Private sector	■ An understanding among Australian stakeholders of the extent of the problem in Indonesia allowed positive research collaborations. ■ Incentives are needed for the private sector to act on aflatoxin reduction. These incentives worked in Australia and could thus be transferred to Indonesia.	■ Lasting relationships between researchers and industry were established. ■ There were perceived positive relationships between the Indonesian Government and researchers. ■ Whose responsibility is it to learn about the issue?	■ The tools are highly technical and hard to use. ■ QuickTest technologies are better but did not exist at the time. ■ There was huge awareness and capacity building. ■ Australian researchers used knowledge gained in other countries.
Researcher	■ Lots of knowledge was generated in Indonesia on how to do ELISA testing. ■ Research centres in Indonesia are still working on the issue—the networks have been maintained. ■ There is a lot of awareness of the issue, but dealing with aflatoxin is not a priority. ■ Time lag is an issue—no immediate outcomes can be seen. ■ Incentives are needed to penalise those that have poisoned peanuts.	■ Few relationships were built with the Indonesian Government. ■ The Aflatoxin Forum was good at strengthening relationships. ■ Continuing relationships after the project included those with the Aflatoxin Forum. ■ It is unclear what other sectors can do about this—the health sector is heavily affected by the issues but is not doing much.	■ There are policy limitations in what can be done—the scale of the problem is large. ■ The project was very good personally because the knowledge can be used in other projects. ■ Monitoring is very difficult—it is hard to know what to do. ■ The problem has become worse—there are hidden issues and more consumption. ■ But there is enough awareness and knowledge.
Researcher	■ Much knowledge is available, but the scale of the problem is the issue. ■ It is unclear who should be taking the lead in implementing the knowledge—industry or government. ■ It was an excellent context-setting project that identified where the issues are. ■ The knowledge was absorbed but not necessarily acted on.	■ Excellent relationships were built. ■ The Aflatoxin Forum is the only long-lasting outcome of the project that is still visible.	■ Current work on aflatoxin (QuickTest technologies) can be partially attributed to ACIAR investments. ■ There was long-lasting capacity building and training of Australian researchers. ■ Communication between countries and industry and government is much more present as an outcome.

Table 11 (cont'd): Categorised interview responses from Australian participants

Role in project	Q1: Knowledge and awareness	Q2: Relationships	Q3: Sustained impact
Researcher	■ The project helped Indonesian researchers design their own work—they needed a boost. ■ There was lots of awareness, but it is difficult to push agendas to the authorities. ■ Links to the public health system need to be more greatly emphasised.	■ Strong relationships were built between Australian and Indonesian researchers.	■ The problem has become worse—more producers, more consumption and little enforcement despite knowing about it. ■ A major challenge is where the sorted peanuts would go—are they discarded or sold to poorer people or lower buyers? ■ There need to be incentives to apply the knowledge. Industry can take a lead because it is in their interest, but the government needs to support this with carrots or sticks. ■ World trade and ASEAN might play a positive role in this. ■ Capacity in Indonesia was low, but it is much higher now.
Researcher	■ Publishing and disseminating data was a concern for the Indonesian government—they did not want to generate panic. ■ Industry has been a large beneficiary of the knowledge that was generated. ■ The ELISA models produced are very knowledge intensive—not everyone can use them.	■ Excellent relationships and PhD students contributed to the project. ■ Long-term relationships stemmed from the ACIAR project.	■ It is unclear if monitoring has been enforced—it is very hard given the scale of the problem. ■ Huge capacity was built in Indonesia from this project. ■ Middle men were not targeted—they need incentives to reduce the prevalence of aflatoxin. The possibility of black markets exists.
Private sector	■ The technical innovations that ACIAR projects have provided contribute to mitigating aflatoxin risk. There is now an understanding of where and how we need to intervene.	■ Very good institutional relationships and networks were built among researchers. ■ Some networks developed with government, both in Australia and recipient countries. ■ Capacity development was a core outcome from this project. ■ Adequate training for different actors in the value chain has emerged from the networks.	■ In recipient countries it has been hard to influence policy because it can be a political issue; we are tasked with producing knowledge. ■ ASEAN may provide opportunities to harmonise standards across nations in aflatoxin management.

Table 12: Thematic count from Australian Interviews

Theme	Times mentioned	Number of participants	Link to analytical questions from framework
Long-lasting relationships	11	6	Relationships and links
Knowledge	7	6	Evolving, dynamic systems
Capacity built	5	6	Relationships and links, credibility, salience, legitimacy
Aflatoxin Forum of Indonesia	4	3	Boundary organisation, relationships and links
Incentives	3	3	Context, drivers
Links/Networks	2	2	Relationships and links
Acting on knowledge	2	2	Evolving, dynamic systems
Problem is worse	2	2	Context
Difficulty of using tools	1	2	Salience

7.1 Dynamic knowledge systems

This section presents three main themes for the knowledge and awareness objective, and relates to the **knowledge and dynamic systems** analytical section of Table 4:

- the embodied knowledge between different supply-chain actors
- the importance of applying knowledge in an Indonesian context
- the flow of knowledge between Australian and Indonesian stakeholders.

7.1.1 Context-specific knowledge

Throughout the peanut supply chain in Australia, producers, processors and regulatory bodies have advanced knowledge of the threats that aflatoxin poses to Australian peanut industries and consumers. This knowledge is **salient, credible and legitimate**, and has been embedded in institutions since the 1980s. It has become widespread among the stakeholders responsible for monitoring and enforcing aflatoxin limits in Australia.

Australia's understanding of the aflatoxin problem was primarily attributed to previous investments by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and GRDC in aflatoxin research. Throughout the 1980s scientific knowledge on the causes of aflatoxin allowed Australian scientists to contribute towards identification of the problem and possible mitigation strategies. ACIAR's investments in on-farm management of mycotoxins, coupled with knowledge generated from other research centres, contributed to this enhanced understanding of aflatoxin.

During the implementation of CP/1997/017 in the early 2000s, Australian researchers, industry and policymakers already possessed advanced knowledge of the causes and mitigation strategies of aflatoxin. This was noted by key informants, with one from the private sector stating that 'We have cracked it. We understand the problem, and have enforced rewards and punishments for those in the peanut industry'. An Australian researcher noted that 'We have known what to do for a long time. We have a good mix of science and policy enforcement that creates a low-risk environment for producers, consumers and the market'.

The role of ***context*** was present throughout the Australian interviews. Context in Australia referred to two factors that facilitated the reduction of aflatoxin risk: financial incentives and penalties to encourage producers to have aflatoxin-free products in Australia, and a small and readily controlled production environment.

7.1.2 AFLOMAN—a tool that facilitates knowledge flows

One project output for Australia was the AFLOMAN tool, which allows producers to assess the risk of aflatoxin development based on environmental conditions. The AFLOMAN tool is still being used by producers during high-aflatoxin-risk seasons. For example, during the 2012–13 season with high rains, aflatoxin risk increased, leading producers to enquire with the relevant government and research institutions about using the AFLOMAN tool.

AFLOMAN represents a **credible, salient and legitimate** knowledge tool that ACIAR facilitated, which continues to have impact on Australian producers. Through the duration of the CP/1997/017 project, over 100 producers in Australia were kept up to date with aflatoxin risk conditions through the AFLOMAN reports published in the local South Burnett Times newspaper. The use of AFLOMAN was discussed with a key informant as being tested in 'model farms' (Figure 7). Although use of the actual tool was small, the findings from each farm were disseminated through newspapers, text messages and websites. A researcher involved with testing AFLOMAN stated that 'while the use of AFLOMAN was limited to a few growers, other growers benefited from the reports we produced'.

ACIAR's investments in AFLOMAN have led to ongoing new knowledge creation in Australia (demonstrating the **dynamic nature of knowledge)**. An example of this is documented through the development of the AQUAMAN tool (Chauhan, Y et al. 2013). Based on the experiences from AFLOMAN, and the changing environment in Australia leading producers to turn to irrigated peanut production, the AQUAMAN tool was developed to assist with better irrigation schedules. Since its development in 2005, AQUAMAN has been used by approximately 122 producers (Figure 8).

The anecdotal evidence of AFLOMAN provides evidence of how a research output was developed to deal with the **contextual** nature of the problem in a way that was **salient.** AFLOMAN also facilitated new knowledge generation through the development of AQUAMAN. This shows the clear positive impact that ACIAR has on knowledge generation after project investments (Figure 9).

7.1.3 Links and relationships facilitating knowledge flows

The knowledge already exists within state and Australian government institutions tasked with reducing aflatoxin risk to consumers. This availability of knowledge facilitated aflatoxin becoming a priority in

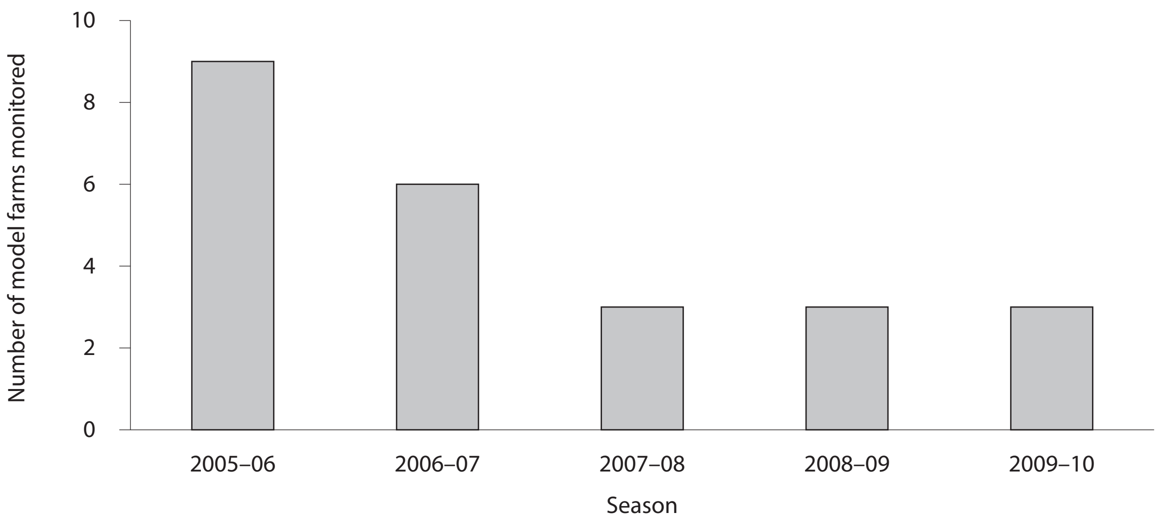

Figure 7: AFLOMAN—number of model farms monitored, 2005–10

Australian public institutions. As one key informant in the private sector stated, 'Rolling out of knowledge has been essential. How else would we get government to prioritise the issue?'

The rollout of this knowledge has been carried out through 18 peer-reviewed publications and over 100 other sources. This knowledge has also been transferred between actors through having 30 years of **linkages** and positive **relationships**, facilitated through ongoing workshops, conferences and other events.

Throughout project CP/1997/017's publications, there was an even balance between Australian and

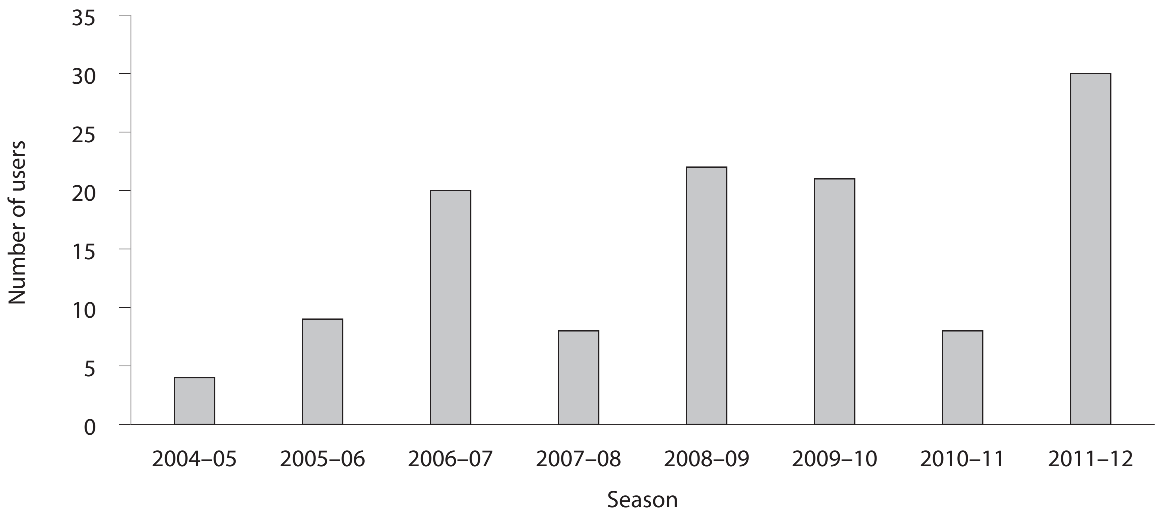

Figure 8: AQUAMAN—number of users, 2005–12

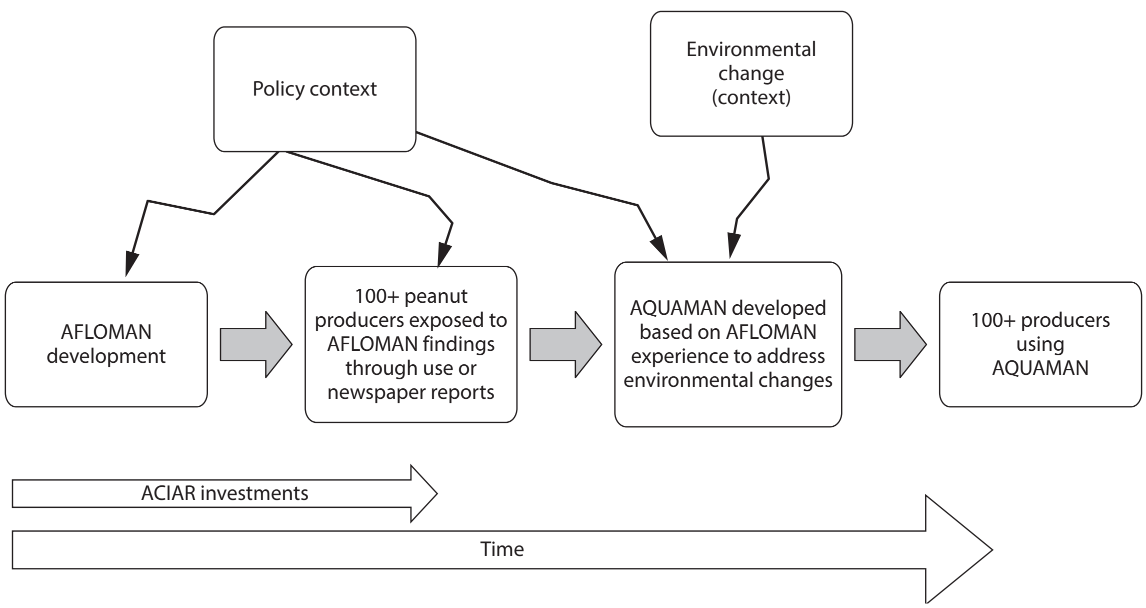

Figure 9: AFLOMAN tool as an example of knowledge flows in Australia

Indonesian authors, demonstrating **legitimacy** in knowledge-building processes. The balance shows that ACIAR facilitated a project in which both countries contributed to the diverse knowledge outputs. Figure 10 shows the number of times that peer-reviewed papers have been cited. Following Linder (2011), the tracking of publications is evidence that there is dissemination of knowledge across actors involved in a particular issue. ACIAR has facilitated this wide knowledge dissemination through the project.

The wealth of knowledge distributed through publication and citation of research funded by ACIAR has led to a detailed understanding of the aflatoxin problem throughout the supply chain, making it manageable. This **dynamic knowledge flow** occurred in a regulatory environment that prioritises food safety, thus making industry and government actors more receptive to the knowledge generated from the research. **External drivers** such as consumer expectations for safe products have created the need for a strong regulatory environment in Australia, and these factors continue to exist in the Australian context.

Figure 11 uses the knowledge system questions from section 3 to illustrate the knowledge system in Australia regarding aflatoxin risk reduction. The different actors come together through a series of **links and communication** channels to continue the focus on reducing risk to consumers and producers.

Regarding the **RAPID factors** highlighted in section 2.3.2, the scale of peanut production provides a **context** that allows Australia to deal with aflatoxin risk. With approximately 250 producers in Australia in 2015, and few distributors and processors, it is a logistically and financially feasible task to monitor the issue. This creates a clear and effective pathway to connect regulation with enforcement of both positive and negative incentives.

The political and institutional **context** of Australia encourages actors to maintain positive relationships to reduce the risk to consumers. For example, CSIRO is able to produce **salient and credible** knowledge about the issue. The **relationships** with actors in other organisations, such as GRDC, allow for knowledge to flow across public institutions and producers. This ongoing **knowledge exchange**, driven by the legal requirements to keep aflatoxin limits at a minimum, makes aflatoxin management in Australia a successful case study.

International **linkages** were also a positive project outcome. The relationships built between Australian and Indonesian researchers and industry were seen as a major benefit from the project. Australian research

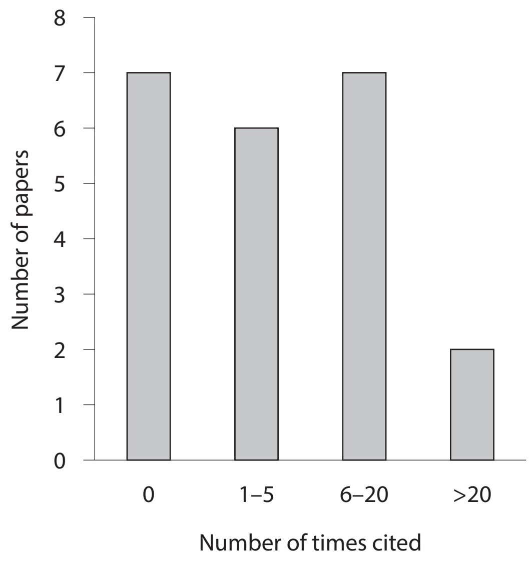

Figure 10: Citation count for CP/1997/017 peer-reviewed publications

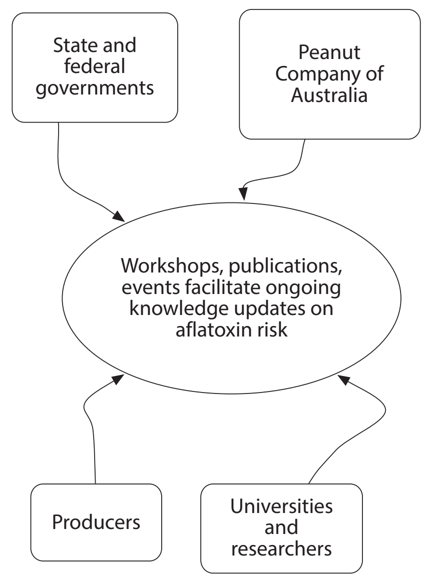

Figure 11: Australian aflatoxin knowledge system

interviewees highlighted that 'We had extremely positive relationships. Some of us met for the first time during the CP/1997/017 project. Evidence of positive relationships is the fact that we remain in touch 10 years after the project. I also believe the Aflatoxin Forum of Indonesia has been beneficial'.

However, the relationships were limited to specific sectors, remaining strongest between the Australian and Indonesian researchers who led the project. There were also positive relationships built between Australian and Indonesian industries, although these have not been actively pursued since the project concluded.

Future risks for the Australian industry include climate change and unexpected outbreaks of aflatoxin due to changing humid environments. Despite these risks, Australian researchers, industry and public institutions are equipped with sufficient understanding of the problem to have the capacity to identify points of intervention to reduce the economic risk to business and consumers. Participants were confident in the collective abilities of producers, regulators and researchers to respond to these changes.

7.1.4 Incentives developed through salient knowledge

Ten years after the project, Australia continues to be a leader in managing aflatoxin. ACIAR has been part of a range of aflatoxin-related research projects, and thus the knowledge created in Australia extends beyond solely ACIAR investments.

The **salient** knowledge generated by ACIAR's research has contributed towards the imperative to act on aflatoxin risks. Australian key informants have commented on the role that prioritisation makes in managing the issue. One private sector interviewee stated that 'In Australia we have prioritised the problem. In Indonesia it is still not in the agenda, but they understand the problem and how to deal with it, but it is not a priority'; and an Australian researcher added that in Indonesia, 'The research findings are there—it is very hard to take action, specially with so many producers'.

Australian key informants also talked about incentives being a good way of managing aflatoxin, and that Indonesia could learn from these in the future. Australia has a well-established system that enforces the maximum aflatoxin levels of 15 ppb, and has adequate market mechanisms and regulations to enforce the limit. However, the limited opportunities for Indonesian producers to be financially rewarded for clean products, or effectively penalised for exceeding the limit, poses challenges for aflatoxin risk reduction.

Part of the challenge of attributing priority and generating incentives is perceived to be time lags and industry fragmentation. As one Australian consultant noted: 'We all know aflatoxin is a slow killer—it might be years until you see symptoms of liver cancer. How can we regulate an issue that does not have immediate visible impacts?'

Another private-sector Australian stakeholder summarised their discussions with 'In Australia, we have few producers and centralised processing. In Indonesia, there are thousands of producers, some smallholders, who process their own products. Coupled with a humid environment, it is no surprise that aflatoxin in peanuts is so hard to manage'.

7.1.5 Communication, translation and mediation between Australian and Indonesian researchers

One major theme present in all Australian interviews was the ongoing **communication** between Australian and Indonesian researchers facilitated by ACIAR projects (see summary Table 11 for an overview of quotes). These knowledge **links** between stakeholders were identified in the adoption study (Wright and Rachaputi 2011), and were present both through implementation and after completion of the project. One Australian researcher noted that 'We are still in touch—we exchange ideas that emerge in our independent research programs'.

Knowledge flow between researchers was high during the project. Extensive **communication and translation** of research through peer-reviewed publications, posters and conference papers emerged as co-produced knowledge between Australian and Indonesian scientists (see Appendix 2), and was actively used to inform Indonesian policy and regulation on aflatoxin (see Indonesian findings in section 8). An Australian researcher noted the value of knowledge exchanges by saying that 'A lead researcher from Indonesia stays in touch, even 10 years after the project! They send me material to revise and provide feedback on. I am also invited on a regular basis to attend the Aflatoxin Forum of Indonesia meetings'.

The project's adoption study (Wright and Rachaputi 2011) indicated that the interaction between Australian researchers and industry throughout the project was high and led to positive knowledge-building outcomes for Australia. They attributed positive project impact to the following activities:

- knowledge gathered through field trials of different varieties that had enhanced aflatoxin tolerance
- development of a decision support tool for producers, which aimed to minimise aflatoxin risk (the Peanut Whopper Cropper)
- development of computer-based aflatoxin monitoring tools for producers and industry (see AFLOMAN impact discussion in section 7.1.2)
- ongoing interaction between producers, industry and researchers, building strong relationships among supply-chain actors.

All these findings were confirmed by our interviews 5 years after the adoption study.

7.2 Sustained impact after project completion

One of the major contributions of ACIAR's research has been the application of Australian-held knowledge throughout the world. ACIAR has supported a diversity of knowledge creation for next-generation researchers throughout the aflatoxin projects. For example, the ACIAR aflatoxin project CS1/1997/114 had synergies with CP/1997/017, as similar stakeholders were involved and similar technical tools were being used. ACIAR supported the training of an Indian PhD student throughout CS1/1997/114, and a young Australian international volunteer throughout the CP/1997/017 project.

A long-term benefit has been the capacity of Australian key informants to use the skills and knowledge they gained from the ACIAR aflatoxin investments in other projects. One interviewee from the private sector stated that 'The learning throughout the project was invaluable. I thoroughly understand the challenges and opportunities for reducing aflatoxin risk in Indonesia. The project identified the key point of intervention in the supply chain. I am going to Timor-Leste next week to look at aflatoxin, and I am sure I will be able to draw common links between Indonesia and Timor-Leste'. A consultant added that 'Aflatoxin investments and research have been extremely valuable for me. I am still involved in aflatoxin monitoring research, and I have worked throughout South-East Asia since the early ACIAR aflatoxin investments finished, using the skills I gained'.

ACIAR project outputs such as AFLOMAN, the Peanut Whopper Cropper, biocontrol strategies and ELISA models have allowed for ongoing activities on the aflatoxin issue:

- development of QuickTest technologies
- workshops, seminars, conferences and training in Timor-Leste, Papua New Guinea, People's Republic of China
- development of AQUAMAN
- ongoing linkages with Indonesian researchers (explored in section 8).

The long-term effects of ACIAR investments are important. Australian researchers obtain knowledge from diverse sources. The discussions with key informants highlight the value of ACIAR's efforts in building **knowledge capacity** in Australia. The ongoing engagement of Australian researchers and industry in aflatoxin-related research throughout Australia and the world is an indicator of the long-term contributions that ACIAR has made to aflatoxin research in Australia.

Australian key informants reported that the sustained adoption of the ELISA modelling tool was low. There was a perception that the limited adoption was attributable to the high level and time requirements of technical training and costs associated with running ELISAs. The tool is also geared towards understanding, rather than reducing, aflatoxin, and thus there is less incentive to utilise it. These factors led Australian key informants to suggest that only a few researchers and their students would be able to continue the work. The **mediation** of these tools in a manner that included end users more thoroughly could have resulted in longer term uptake.

Australian key informants indicated that Indonesian institutions benefited from collaborating with Australian institutions. This was perceived to increase the skills, confidence and overall credibility of future research design from Indonesian institutions. Two researchers noted that 'Working with Indonesian researchers allowed for Indonesia-specific projects to be designed and implemented' and 'There was huge capacity built. There is now a strong network of researchers that know each other and can design technical projects that suit their problems'.

Progress in the science of identifying infected products continued after ACIAR investments ceased. When CP/1997/017 was being implemented, ELISAs were the most up-to-date tools to inform processors of the prevalence of aflatoxin. Since then, QuickTest technologies have been developed as rapid tools by Australian and Indonesian researchers (see Box 2, section 8.1.2 for a discussion on how ACIAR contributed to research capacity to develop new monitoring tools).

Technological innovation depends on a range of **contextual factors and external drivers,** one being previous understanding and knowledge. Researchers involved in the multiple ACIAR aflatoxin research projects have gained rich and deep understanding of why aflatoxin occurs, how it can be mitigated and monitored, and how different supply-chain actors can manage it. This acquired knowledge has led to sustained involvement of researchers in the aflatoxin space.

7.3 Summary of impacts to Australia

Table 13 summarises how the insights provided by Australian project participants and beneficiaries contributed towards the impact assessment objectives. We identify what elements of our integrated framework are present in the table, and diagrammatically apply findings to the conceptual framework presented in section 3 (Table 13 and Figure 12).

Table 13: Summary of findings for Australia

Objective / Framework themes	Knowledge systems			Knowledge systems and RAPID		RAPID	
	Evolving, dynamic systems	Focus on specific decisions or actions	Quality / characteristics of evidence	Relationships and linkages	Communication	Political context	External drivers
Assess the extent to which the project outputs have contributed to greater awareness of the risks of aflatoxin in Australia and Indonesia	■ Project outputs such as AFLOMAN, and subsequent developments like AQUAMAN, allow Australian industry and producers to understand aflatoxin risk. ■ Salient technical tools are developed that are credible and legitimate. Actors who use the tools can use them when required.			N/A		■ The policy context drives the need for adequate tools to reduce aflatoxin risk.	
Examine the impacts that CP/1997/017 has had on relationships among different stakeholders involved in regulating and managing the risks of aflatoxin, including scientists, regulators, industry and non-government organisations	■ Technical tools are developed by researchers with the needs of producers in mind. ■ The tools are geared towards ensuring the high quality of Australian products that meet regulatory standards.			■ Communication is facilitated through publications, workshops and conferences. ■ Actors are freely able to exchange ideas and knowledge.		N/A	
Determine the extent to which project outputs have led to sustained adoption and changes in institutions and industry to reduce aflatoxin problems in Indonesia	■ There is no evidence to suggest regulatory or industry change. ■ Evidence shows positive impact on capacity to design and conduct aflatoxin research by Indonesian researchers.			■ There are ongoing knowledge exchange between Indonesian and Australian researchers. ■ The AFI is identified as a boundary organisation.		■ The changing environmental context has led to more irrigated peanut crops in Australia. As a response, AQUAMAN was developed.	

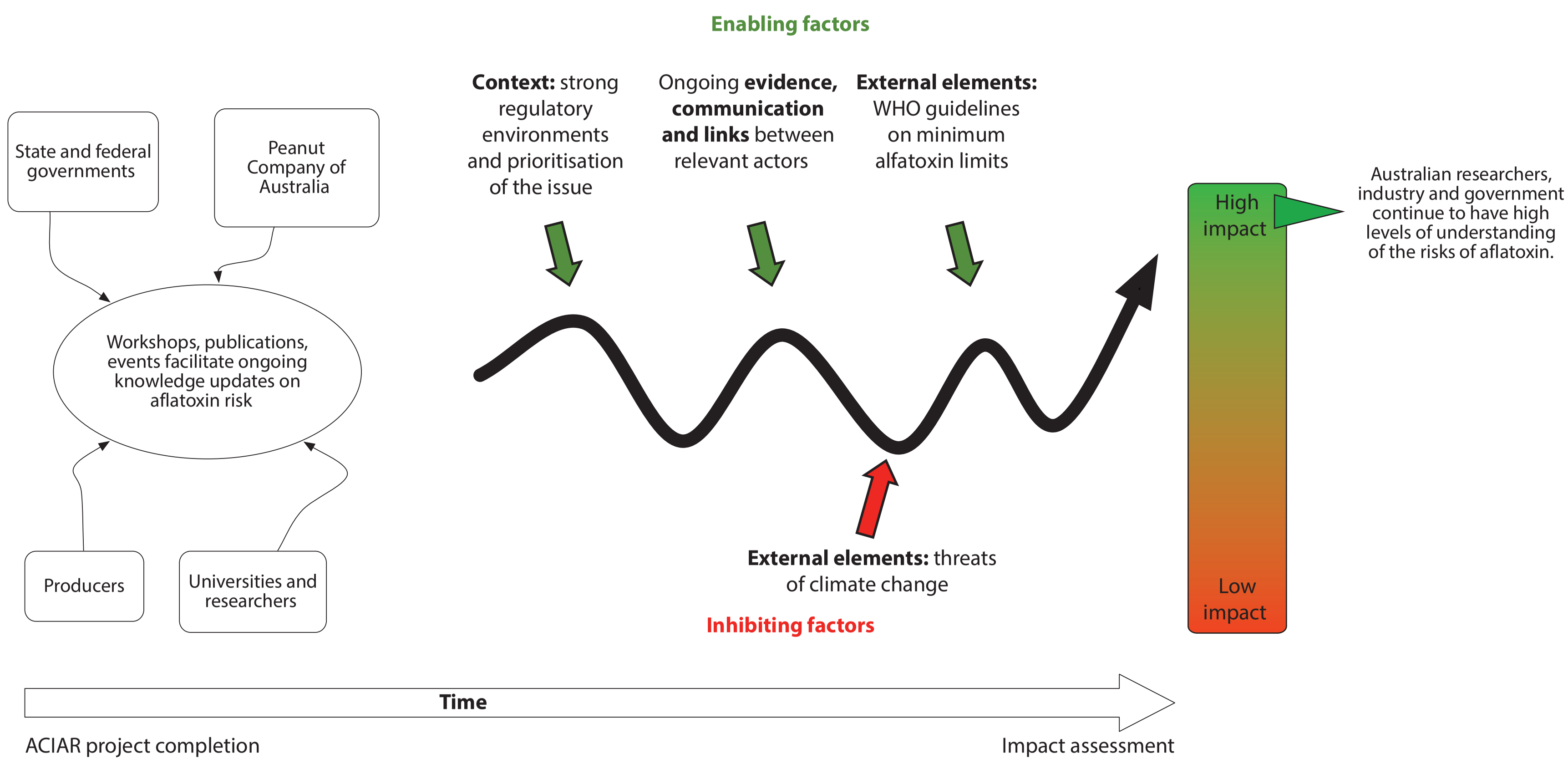

Figure 12: Conceptual framework and impact of project outputs on Australian policy, research and industry

8 Benefits to Indonesia

This section presents the main findings for Indonesia, following the themes from the integrative framework. Table 14 presents a summary of key quotes from each stakeholder in accordance with each of the three evaluation objectives. Table 15 presents a thematic count from Indonesian interviews. The issues of knowledge and awareness are discussed, drawing on data that indicates the high capacity built among Indonesian researchers and the value of technical tool development. Links and communication are discussed through identifying the AFI as a boundary organisation that facilitates knowledge flows. The sustained impact is discussed through highlighting the political and economic context of the peanut industry in Indonesia, identifying some barriers for future enforcement of aflatoxin policies.

Table 14: Categorised responses for Indonesia

Role in project	Q1: Knowledge and awareness	Q2: Relationships	Q3: Sustained Impact
Private sector	■ Awareness of aflatoxin has increased through the trials in specific sites. ■ There is more public awareness about aflatoxin, but more is needed. ■ The Indonesian Government is currently focused on production and productivity.	■ Relationships and networks are essential for dealing with aflatoxin. ■ The ACIAR project built good networks but more is needed to maintain them. ■ Collaboration with business and government is crucial in dealing with aflatoxin. We have good networks but need to maintain them. ■ Mapping interests is crucial—who cares about what in addressing aflatoxin? ■ The AFI has a strong research angle and could open up more room for other stakeholders.	■ For sustained impact, the market needs to value aflatoxin-free goods. ■ Consumer awareness (and purchasing choices through the market) will be important in improving aflatoxin problems. ■ The trials through the private sector were successful but needed more time.
Private sector	■ Awareness is not great, meaning it is unlikely that aflatoxin will become a priority for government.	■ The research–policy gap is a significant issue in Indonesia. Lots of research has been undertaken without policy relevance. ■ A lot of policy was made before research had been conducted. ■ Regulation regarding food safety is good in Indonesia, and is often aligned with EU standards. ■ However, food regulations are often not implemented and not enforced. ■ Different ministries and agencies are responsible for different components of the distribution chain, which can add complexity.	■ The future requires strategic planning, with the different stakeholder groups (and particularly key champions) to set the agenda.

Table 14 (cont'd): Categorised responses for Indonesia

Role in project	Q1: Knowledge and awareness	Q2: Relationships	Q3: Sustained Impact
Policy	■ Research matters, however much action is still geared towards on-farm management. ■ We are not following all the findings from the ACIAR project of intervening at the market level. ■ Regulatory policies are largely focusing on the producer part of the supply chain. ■ Peanuts are of high priority to Indonesia, and there are visions to expand peanut programs, particularly to deal with aflatoxin safety.	■ The importance of the different stakeholders in the supply chain has been noted.	■ Government policy is driven by production, to align with South-East Asian growth trajectories. ■ The current focus reflects a balance among the political economy of Indonesia, the inability of the market to manage poor-quality peanuts, and the pragmatic challenge of regulating and then enforcing regulation at a market supply distribution scale, as found by the ACIAR project.
Policy	■ The AFI raised awareness for this actor group and linked with researchers. ■ Most of the research that influences policy is internal—only minimal external research influences us. ■ Awareness has increased over time but is still a major issue. ■ The Indonesian context—many producers and a humid environment—makes us very worried about aflatoxin. ■ Universities have known about the problem since the 1960s, but it has only been on the government agenda since the 2000s.	■ There are many government agencies involved in the supply chain, depending on the scale of production. ■ There is a disconnect between university researchers and policy. ■ Personal relationships with people within government make influencing policy easier.	■ Continuation of the AFI is an indication of the sustained impact of relationships and influencing the 2009 policy. ■ Other organisations also hold knowledge about aflatoxin—capacity is needed to enforce and monitor regulation.
Policy	■ Not everyone is aware of the key findings of the project. ■ Participant was unaware of the direct link between project outcomes and aflatoxin knowledge.	■ There is a need to further engage the range of actors involved in the aflatoxin problem.	■ Risk assessment tools being developed as the next step are based on the knowledge they hold now.

Table 14 (cont'd): Categorised responses for Indonesia

Role in project	Q1: Knowledge and awareness	Q2: Relationships	Q3: Sustained Impact
Researcher	■ ACIAR contributed to much awareness about the problem. ■ There is a lot of concern for safety in Indonesia, making the ACIAR knowledge relevant.	■ Research institutions were particularly influential in shaping 2009 policy. ■ However, in general there is a challenge relating to the influence of research on policy, and then another large gap reflecting the step from policy existence to implementation. ■ Individually, the researchers noted efforts to engage a broad range of actors; however, this engagement could be done better in the future. ■ Clear coordination exists among research institutions, particularly through the AFI (i.e. international connections are also strong). ■ Some policymakers and business go to the AFI, but are not well represented.	■ The AFI brought together different universities involved in the ACIAR project and contributed the knowledge needed for the 2009 policy.
Researcher	■ The AFI has been the main contributor to linking stakeholders in the project. ■ The AFI has allowed links with regional universities to continue.	■ After influencing the 2009 policy, researchers have not been as successful with influencing government. ■ There are challenges in dealing with different ministries at different parts of the distribution chain, and the responsibility differs depending on the scale of production, the commodity and the sale market.	■ The project connected all the different research institutions interested in aflatoxin for the first time, and they continue to collaborate. ■

Table 15: Thematic count from Indonesian interviews

Theme	Times mentioned	Number of participants
Political economy and context	7	4
Networks and relationships	7	6
Awareness raising	6	3
AFI	4	6
Expanding the AFI	4	2
Policy disconnect	4	3
Lack of awareness	3	2
Acting on knowledge	3	3

8.1 Knowledge and awareness

8.1.1 Embodied knowledge on aflatoxin in Indonesia

The CP/1997/017 project had positive impacts on the generation of knowledge and evidence relating to aflatoxin contamination of peanuts and associated health risks in Indonesia. As a project output, the socioeconomic survey funded by ACIAR provided clear evidence that the retail market sector is a contamination hotspot for aflatoxin development within the peanut supply chain, due to a lack of awareness of how to reduce aflatoxin as well as poor storage techniques.

The project also produced better understanding of the socioeconomic risks associated with aflatoxin in peanuts in Indonesia. People in lower socioeconomic groups were more vulnerable to exposure because spoilt peanut products, likely to be contaminated, were sold at a reduced price within the traditional wet markets.

Researcher participants noted that knowledge of the human health risks associated with aflatoxin was not new. While awareness has been present within research institutions, there was limited government or public awareness prior to the early 2000s. However, while policy frameworks do exist for regulating aflatoxin levels in peanuts, the Indonesian context presents a challenging environment for policy implementation, with interview participants noting that knowledge of the risks was not leading to policy implementation or enforcement.

Interview participants characterised the Indonesian industry as highly dispersed, with a range of different regulatory bodies having responsibility throughout the supply chain. Peanut production is dominated by a large number of smallholder farmers, who often group together in collectives to sell to retailers. While this produces economic benefits for the farmers, it heightens the risk of aflatoxin contamination if appropriate drying and storage techniques are not employed. This issue is particularly acute at a wet market level, where regulation is not easily enforced.

Indonesia has implemented an Integrated Food Safety System as a means of coordinating effort among various areas of government. Throughout the peanut supply chain there are different government agencies who are responsible for regulation of aflatoxin at different phases. At the national level the Ministry of Agriculture is responsible for the commodity while it is still considered a raw material. The National Agency of Drug and Food Control is the responsible agency once the commodity is a processed good. Underpinning this is the Indonesian National Standardization Agency, which sets the maximum tolerable limit for aflatoxin and mycotoxin contamination in food; however, these levels are voluntary and, as a result, not strongly enforced.

Interview participants noted that the district government was responsible for regulating goods sold at the local market level, including wet markets. This means that national agencies have only indirect input into local-scale regulation where the problem is most acute. Challenges in terms of the capacity of district-level officers were also highlighted. As one researcher noted, 'We have too many people in Indonesia and not enough food inspectors or assessors. Beyond the quantity issue, we also need improved quality. We need to improve the capability of our district inspectors and assessors'.

Interview participants contended that the end sale point was important with respect to quality assurance of the product. For peanuts produced for the tourism sector, or for processed supermarket goods, consumer demands and expectations dictated that the product was of a good quality. The industry participant noted that his business was careful to select aflatoxin-free peanuts from trusted producers, 'We select the peanuts from certain producers because we can ensure good quality. This is important for us. However, this quality needs to be reflected in the value price accordingly. Currently, there is not a strong connection in the peanut value chain between the supply of good peanuts at a higher cost and demand for those products'.

An underlying challenge in the Indonesian **context** was positioning of the aflatoxin issue within other social and economic concerns. Interview participants, particularly those from government, cautioned that policy interventions and education campaigns must avoid causing panic in consumers. This echoed the adoption study in that policy interventions need to be sensitive to the potentially adverse impacts they could have on peanut producers (Wright and Rachaputi 2011)

While the CP/1997/017 project generated important new evidence regarding the distribution of aflatoxin risk in the peanut supply chain, the **contextual factors** of the Indonesian peanut industry indicate that aflatoxin management competes with other economic concerns, and regulatory enforcement creates difficulties in reducing aflatoxin risk.

8.1.2 Capacity building and knowledge creation in research institutions

Annual reports of the CP/1997/017 project and the adoption study state that technical tools and collaboration were part of the capacity-building aspects of the project. Indonesian researchers received training in peanut agronomic management, crop modelling and aflatoxin analysis using ELISA systems (Wright and Rachaputi 2011). It was clear that such training was highly effective in ensuring the **credibility of project outputs**, with the adoption study attributing successful training and capacity-building outcomes as underpinning the success of the project (Wright and Rachaputi 2011).

Interview participants from research institutions identified that training and experience gained through the project have resulted in sustained capacity in aflatoxin research within Indonesia. For example, Box 2 presents a vignette narrating that although the use of ELISA systems has not been sustained, the skills gained by the researchers involved have led to the development of context-appropriate QuickTest tools. However, while these tools have benefits for the screening of peanut products at the market level, their use has not been well communicated to other stakeholders. For example, a participant from a different research institution observed that 'I think for screening we need the rapid method. We have rapid screen kits for a range of contaminants, but I don't think we have one for mycotoxins or aflatoxins'.

The capacity of project participants developed through the project area is further evidenced in their positions as trainers and educators. Participants from SEAMEO BIOTROP identified that they now conduct training programs for researchers and government officials (Table 16).

Similarly, participants from GMU noted the diverse **knowledge sharing** activities they undertake, including conducting training workshops and field schools for a range of topics. This includes workshops and training on mycology and mycotoxin analysis with researchers and policymakers, as well as co-running workshops for smallholder farmers with business entities. The activities provide ongoing **salient and credible knowledge** to a range of actors. The individuals responsible for the development of these training programs identified their experience with the ACIAR program as crucial in their ability to undertake these activities.

The capacity of Indonesian researchers is evidenced by the extensive range of research outputs produced during and since the project. Throughout the project Australian and Indonesian researchers collaborated on a range of research publications (e.g. Dharmarmaputra 2005; Lee et al. 2005). Figure 13, Figure 14 and Figure 15 show the number and type of publications produced both throughout the project and after completion.

After the project the Indonesian researchers continued to publish and build knowledge on peanut–aflatoxin issues. Research activities have extended to include other regions and commodities, and an expansion in focus from aflatoxin to mycotoxins (see Appendix 2 for a list of publications and activities stemming from the project).

The research institutions and researchers engaged in the CP/1997/017 project are now considered experts in aflatoxin and mycotoxin studies by their peers in the aflatoxin field. For example, a researcher emphasised that 'We are still in touch and attend events, workshops and conferences on the aflatoxin issue to this day'.

This is evidenced by ongoing publication on the aflatoxin issue in both Australia and Indonesia. Researchers from both countries stated in the interviews that they remain in touch and work together. For example, they jointly presented at the 2015 Tropical Agriculture Conference held in Brisbane on ongoing work on aflatoxin. This shows a long-term **knowledge flow** activity that stemmed from the **links and communication** channels facilitated by ACIAR.

Researchers from ILETRI, SEAMEO BIOTROP and GMU actively participate in national, regional and international events. For example, the 2010 International

Box 2: Capacity building in Indonesian researchers through the development of QuickTest tools

A key output of CP/1997/017 was the ELISA model for testing aflatoxin contamination within peanuts. The model was developed through collaboration between Australian and Indonesian researchers (objective 1; see Table 8). Researchers at three of the collaborating Indonesian research institutions—SEAMEO BIOTROP, BALIVET and GMU—were trained in the ELISA analysis, including the associated quality-assurance tests. During the project the Indonesian researchers were active participants in the development and implementation of the ELISA system.

During the project, and immediately afterwards, the ELISA system had significant adoption within Indonesian research institutions. Wright and Rachaputi (2011) note in the project's adoption study that the method was being used routinely for monitoring aflatoxin in the peanut supply chain. It was also being employed with other commodities. However, participant interviews identified that the use of the ELISA system had not been sustained.

While the adoption study noted that the method was a low-cost technique, Indonesian researchers contended that the ongoing testing costs were too high to be sustainable. The tool was **credible and salient** but did not match the long **context** of costs. The sustained use of the system required antibodies that the Indonesian institutions did not have the capacity to produce. As a result, when the supply of antibodies provided through CP/1997/017 ran out, the ELISA system was discontinued. Testing returned to using high performance liquid chromatography (HLPC), which had previously been used as part of quality-assurance and result-validation testing of the ELISA system, and aligns with the methods used by government assessors.

However, the technical capacity built with the Indonesian researchers through the ELISA models resulted in the development and application of a broader range of context-appropriate QuickTest tools. As one researcher summarised, 'A benefit of the ACIAR project was the knowledge of aflatoxin contamination determination through using the ELISA method. Although the HLCP method remains the conventional testing method, we now have many QuickTests for aflatoxin contamination based on ELISA. The science of these tools is based on the knowledge from using ELISA. We got this knowledge from the ACIAR project'.

The QuickTests fill the role of an effective screening tool, being characterised as non-technical and easy to use, and therefore having useful broader application in allowing assessors to quickly identify aflatoxin at the wet market. One researcher noted the limits to their application: 'QuickTests can be done in the field, but it is just for screening. If we want to know the exact result and type of aflatoxin, we have to continue to use HPLC'.

However, the development of the QuickTests has provided a practical screening tool for researchers, and has further demonstrated the broader application of the capacity developed through the project.

Mycotoxin Conference held in Malaysia had a strong Indonesian representation, with five presentations on aflatoxin reduction, the second-largest ASEAN nation represented after the hosts. A researcher from the ACIAR project was a member of the organising committee for the conference and chaired a session on measurement methods for aflatoxin. Researchers from two research institutions from the project presented papers and posters, and a researcher from Bogor Agricultural University co-authored a paper.

Educating the next generation of aflatoxin researchers is illustrated in Figure 16. Through years of investing in aflatoxin, ACIAR has contributed towards the capacity of Indonesian academics to supervise and produce master's and PhD graduates at a global standard.

Table 16: Training courses run by Indonesian researchers

No.	Name of training course	Venue and date of implementation	Country and number of participants	Institution of participants
1	First Regional Training Course on Prevention and Control of Mycotoxins in Food and Feedstuff	SEAMEO BIOTROP, Bogor, Indonesia, 21–26 June 2004	Brunei Darussalam (2), Thailand (4), Indonesia 7)	Universities, research institutes, Department of Agriculture and food industry
2	National Training Course on Implementation and Documentation of Quality Assurance of Aflatoxin Analyses in Food and Feedstuff	SEAMEO BIOTROP, Bogor, Indonesia, 21–24 July 2009	Indonesia (12)	Research institutes, government and private agencies, Department of Agriculture, and food and feed industries
3	Second Regional Training Course on Prevention and Control of Mycotoxins in Food and Feedstuff	SEAMEO BIOTROP, Bogor, Indonesia, 22–26 November 2011	Philippines (1), Thailand (2), Vietnam (2), Indonesia (17)	Universities, research institutes, Department of Agriculture, government and private agencies, and food and feed industries
4	National Training Course on Prevention and Control of Mycotoxins in Food and Feedstuff	SEAMEO BIOTROP, Bogor, Indonesia, 22–25 May 2012	Indonesia (19)	Universities, research institutions, government and private agencies, and Department of Agriculture
5	Third Regional Training Course on Prevention and Control of Mycotoxins in Food and Feedstuff	SEAMEO BIOTROP, Bogor, Indonesia, 17–22 June 2013	Brunei Darussalam (2), Cambodia (1), Malaysia (1), Singapore (1), Thailand (2), Vietnam (2), Indonesia (17)	Universities, research institutes, government and private agencies, and food industries
6	Fourth Regional Training Course on Prevention and Control of Mycotoxins in Food and Feedstuff	Vietnam National University of Agriculture, Hanoi, Vietnam, 25–30 September 2014	Cambodia (1), Thailand (2), Vietnam (19)	Universities, research institutes, and government and private agencies

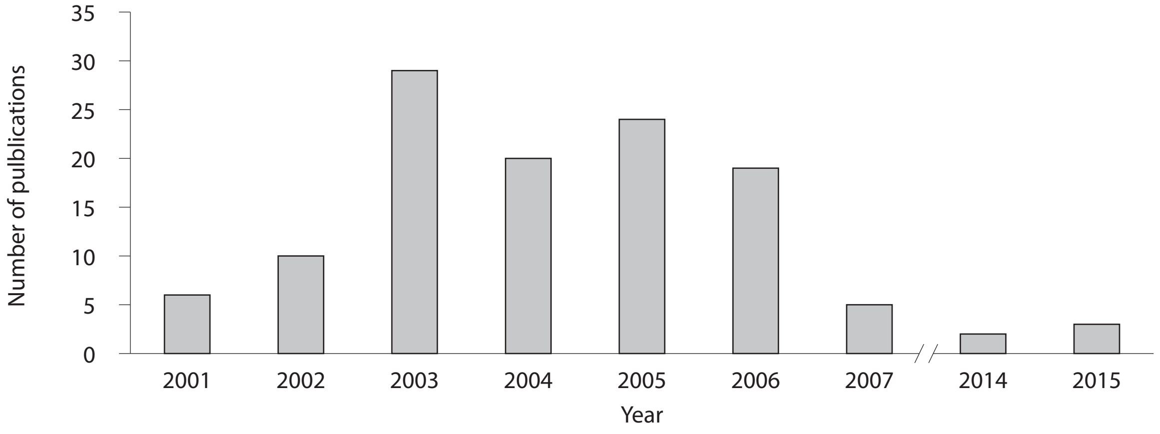

Figure 13: **Number of publications, 2001–15.** Note: The gap during 2008–13 indicates that no publications were found.

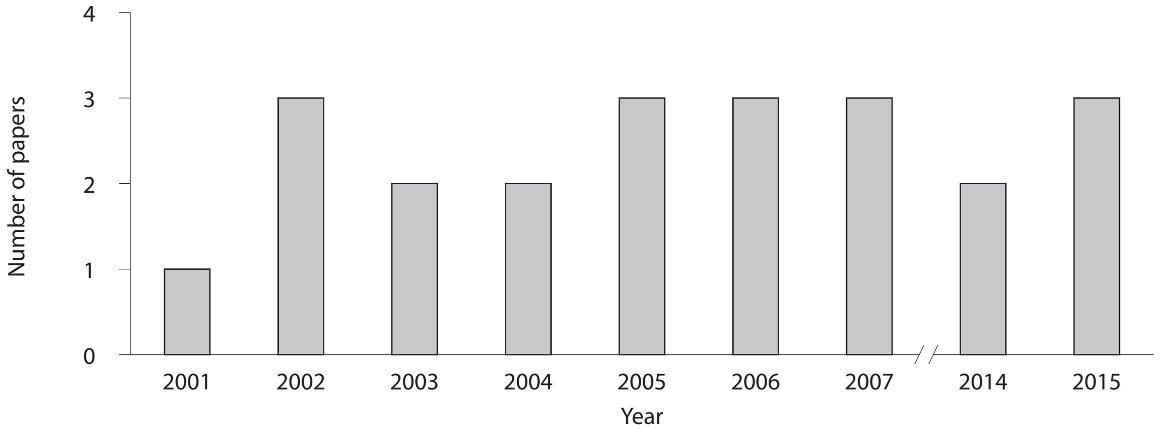

Figure 14: **Number of peer-reviewed papers published, 2001–15.** Note: The gap during 2008–13 indicates that no papers were found.

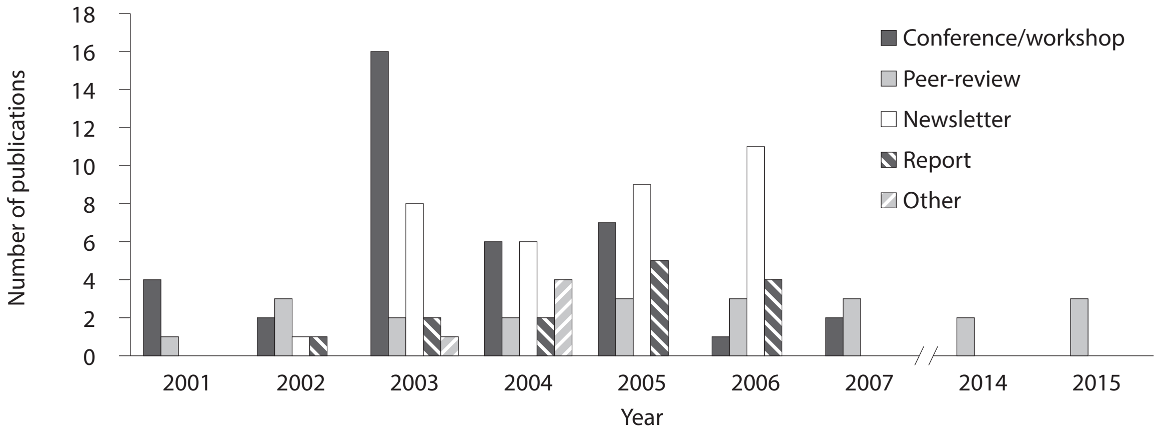

Figure 15: **Publication types per year.** Note: The gap during 2008–13 indicates that no publications were found.

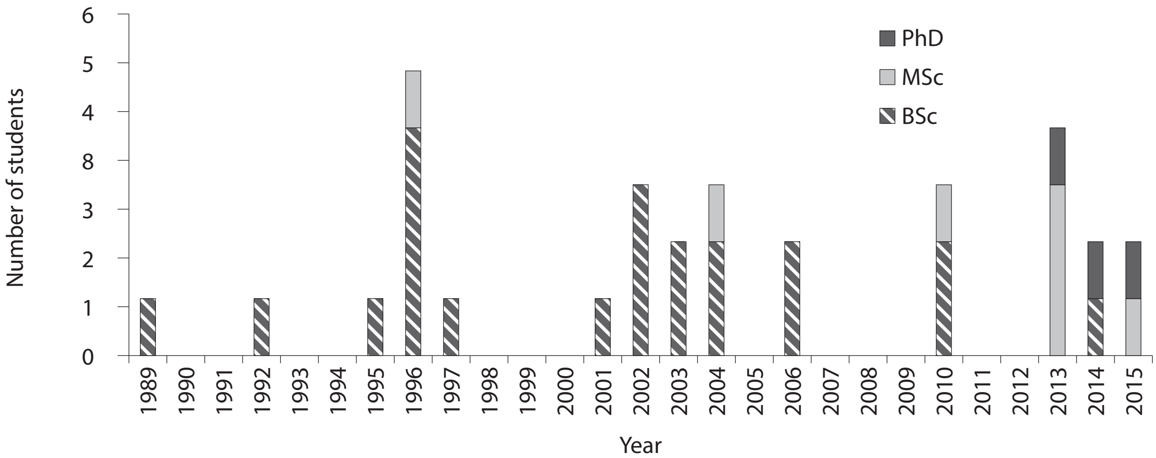

Figure 16: Numbers of students graduated per category, 1989–2015, Indonesia

8.1.3 Communication of evidence

At completion the project was noted as successful in communicating aflatoxin knowledge to a broad range of actors. Following the integrated knowledge systems and RAPID framework presented in section 3, the linkages and knowledge flows between actors are an important component of ongoing knowledge creation of a particular issue. The **linkages** built, as per the RAPID factor, were created through field-day events, public awareness brochures and active participation with government executives (Wright and Rachaputi 2011). ACIAR acted as a catalyst to formalise **networks** between Indonesian researchers and government (as discussed in section 8.2), including the boundary organisation emerging from this project (the AFI).

While insights into contamination throughout the peanut supply chain have influenced a broad range of research activities, there remains a strong research and funding focus on on-farm management strategies rather than intervention at the retail and market level, as recommended by the CP/1997/017 findings.

Industry representatives noted that although they were aware of the knowledge that research institutions held regarding aflatoxin, the ways in which that information was **communicated** was not fully effective. They contended that an underlying reason for this was that the research was not focused on practical, business-oriented solutions to the problems, and as a result was not easily or usefully communicated to industry representatives. This indicates that although the researchers are effectively communicating their findings and producing **credible and salient** outputs, they are not yet effectively tailoring their research programs to meet the needs of different audiences.

Figure 17 shows the diversity of media used to disseminate information from the CP/199717 project. The impact of the peer-reviewed journal articles (see Figure 10) shows that the written outputs reached wider audiences. As only one industry representative was interviewed, we cannot determine why industry did not absorb the knowledge produced.

In the next section we discuss the **boundary organisation** that emerged to facilitate **knowledge flows**.

8.2 Links and boundary organisations

The project had clear benefits in creating linkages between different actors from the peanut supply chain. An enduring impact has been the creation and strengthening of collaborative working relationships among Indonesian research institutions. As separate entities, institutions such as ILETRI, SEAMEO BIOTROP, BALITVET (Balai Besar Penelitian Veteriner), GMU and BPTP (Balai Pengkajian Teknologi Pertanian) were noted for their institutional knowledge on aflatoxin prior to the project. Although the institutions involved in CP/1997/017 had met in the

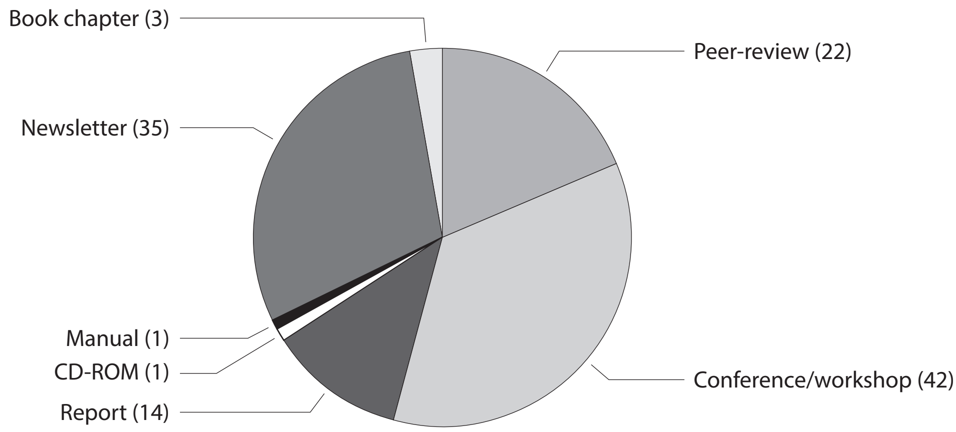

Figure 17: Types of publication from CP/1997/017

past, this was the first time that many of the key research individuals within them had met. Interview participants noted that this was a catalyst for ongoing research collaboration and greater coordination of research effort on aflatoxin and mycotoxins in Indonesia. ACIAR facilitated and cemented these linkages through the creation of awareness programs. One researcher commented that 'That is the story! ACIAR invited me, SEAMEO BIOTROP and someone from BALIVET, to go to Australia to discuss the ACIAR project. I first met them at the airport—I didn't know them before!'

The highest impact of ACIAR investments on **knowledge flows** was the creation of a **boundary organisation**. This was an output from objective 5 (see Table 8) and took shape in the form of the AFI. This has been an important forum through which relationships have been maintained and knowledge continues to flow.

8.2.1 Boundary organisation: the Aflatoxin Forum of Indonesia

Objective 5 (A) of the CP/1997/017 project sought to **foster an aflatoxin information and awareness program in Indonesia and Australia.**

This objective was successful through the creation of the AFI. Following the boundary organisation component of a knowledge system, our framework can be used to analyse the AFI as a boundary organisation linking actors and facilitating mediation, communication and translation (section 2.2).

The AFI was first convened in February 2006 at GMU. It was stimulated by the individual and institutional relationships developed through CP/1997/017, and enabled through a Ministry of Education grant to support public awareness of food safety issues.

Although the objective of establishing an awareness centre was achieved, knowledge was not fully absorbed by all actors. Some key government agencies were not aware of the results from CP/1997/017. For example, the National Agency of Drug and Food Control set aflatoxin contamination in corn and peanut commodities as a priority area for 2015. The agency is undertaking a risk assessment of aflatoxin contamination, including identifying points of contamination risk in the peanut supply chain, but it is not aware of the relevant CP/1997/017 findings. This highlights that although communication avenues exist between researchers and government agencies, they are not currently sufficient for **translating** evidence into policy.

The original scope of the AFI was to build awareness of the aflatoxin issue and associated health risks in Indonesia. It sought to do this through engaging a broad range of stakeholders, including from government, research institutions, industry, community and farmer groups. This engagement has been facilitated through annual meetings conducted largely at GMU.

Since it was established, the AFI has successfully maintained a dialogue regarding aflatoxin issues in Indonesia. As one interviewed researcher noted, 'We are inviting experts every year, we can update our knowledge well in the aflatoxin area from many sides—from the research and analysis, from the policy, from the regulation and control. It is good!'

It has played an important role in the coordination and maintenance of relationships and collaborations built during CP/1997/017. These relationships were noted by interview participants as having a direct influence on policy development. Specifically, this was in the development of the Indonesian National Standardization Agency's maximum tolerable limits for aflatoxin and mycotoxins permitted in food products (SNI 7385:2009). During the policy design phase, core members of the AFI were engaged as consultants to advise on appropriate standards. Researchers from CP/1997/017 played an important role in this consultation process, with the research conducted informing the final standards. A comment from one research participant was that 'Our role in policy discussions and our influence was all based on our research through the ACIAR project'.

Influencing the new food safety standards remains the milestone achievement for researchers engaged in aflatoxin and mycotoxin forums. However, since 2009 the forum has had limited impact on implementation of the policy. One issue that interview participants noted was that while there was a broad range of stakeholders from across policy development, regulation and industry that attended, the core focus of the AFI has been research dissemination. As a result, it has not been the most effective forum for transitioning research into practice, either for policy or industry.

The challenges with research influencing policy and industry are not isolated to AFI, or to this project more broadly. The forum has continued to respond to the **changing policy context** in Indonesia, expanding its focus to mycotoxins in 2012 as the Mycotoxin Forum Indonesia (MFI) and engaging regionally with researchers and industry, including from Malaysia, Singapore and Japan. Similarly, the Centre of Excellence on Mycotoxin Studies, established in 2010, emerged through a collaboration with three Indonesian research institutions engaged in CP/1997/017 (GMU, SEAMEO BIOTROP, BALITVET), along with the National Agency of Drug and Food Control and Romer Labs (Singapore). The Centre aims to be 'a melting pot of activities engaged in education, research, and public services concerning the prevention and reduction of fungal infestation and mycotoxin contamination' (researchers, Indonesia).

The collaborating research partners, including SEAMEO BIOTROP, a linkage that emerged through the AFI, have actively participated in international conferences.

One researcher noted that the forum is still important in driving their research agenda— 'From AFI, I develop my research on mycotoxin and aflatoxin. As you know the area of food safety is broad and this annual meeting reminds me to keep attention on this issue'.

Since 2015 the AFI has not had the sustained and ongoing influence upon policy decision-making that may have been expected. It has acted as a good **communication and mediation tool,** but the **translation** of knowledge to policy actions remains vague. However, the rapidly expanding institutions and shifting priorities in Indonesian policies may allow it to influence aflatoxin policy in the future if it sustains the **linkages** built throughout, and aligns communication with the specific context of Indonesian policies.

The AFI has extended the relationships among other actors. For example, although Bogor Agricultural University was not part of the CP/1997/017 project, the forum has actively included them in **knowledge exchanges.** Research participants noted that partnerships with other domestic research institutions were most important, being more significant for them than the range of partnerships with international universities that have developed since the project.

Although the **knowledge system and relationships** have been facilitated by outcomes from ACIAR investments, other **development contexts** also create opportunities for **knowledge exchanges**. These relationships are further maintained through research partnerships, co-supervision of postdoctoral students and use of the technical capability of different institutions (see Figure 16).

The ACIAR project generated a range of collaborations between the Indonesian and overseas research institutions. While the linkages between Australian and Indonesian research institutions have not been sustained on an institutional level, they still exist between key individuals from the project. More broadly, the Indonesian research institutions have engaged in ongoing collaborations with universities, for example, from Austria, Germany, Japan, Italy and Thailand. Interview participants identified that the catalysts for these collaborations grew out of research conducted throughout the ACIAR project, and the collaborations have been facilitated through international attention generated by the AFI and participation in other regional and international conferences.

8.2.2 Links between research institutions and business and government

Relationships and links of research institutions with government and business stakeholders have not been sustained over time.

For government, the research institutions that were part of CP/1997/017, and continue to be participants in AFI/MFI, are a source of expertise. However, their contribution to policy has not been sustained. As one research participant noted, 'In influencing the formulation of the Indonesian National Standardization Agency standards for maximum tolerable, it only happened in 2009. In influencing this policy we were only getting busy since 2000, and it took more than 10 years to inform the decision makers to come up with a decision! After that decision, in 2009, everyone went quiet again. The standard needs to be enforced. We need to strengthen our capacity in terms of influencing the standards and implementation of the standards'.

For business, during the project a business entity was engaged in partnership with ILETRI in trialling an aflatoxin-tolerant peanut variety for commercial viability. While the adoption study noted that the variety was in the final stages of testing prior to commercial production (Wright and Rachaputi 2011), fieldwork identified that it had not been successfully released for commercial production, although the reasons for this were unclear.

Business engagement in knowledge flows is affected by the dispersed nature of peanut production in Indonesia, with hundreds of thousands of farmers, multiple tiers of production, and distribution focused on different markets. While AFI/MFI engage business stakeholders and grower groups, a private-sector participant noted that the forum was not well suited to the type of knowledge that could be usefully employed in a business context. Business stakeholders noted the importance of building **relationships** between research and industry, with a particular focus on better on-farm management through technological innovation, but also noted that these relationships did not currently exist.

8.2.3 The importance of individual and institutional relationships

Institutional relationships exist to different extents between government, business and research institutions. However, the organisational linkages have not been sufficient to ensure communication of evidence to all relevant actors. For example, the identification of acute contamination points in the peanut supply chain has not been incorporated into current government risk assessments for aflatoxin in corn and peanuts. This was despite key researchers from CP/1997/017 having been in regular communication with relevant government agencies since the early 2000s.

Project participants noted that the identification of key individuals, and building links between them, was critical for **ongoing knowledge flows.** For example, between 2002 and 2004 GMU collaborated very successfully with the Food Security Agency in East Java, focused on mapping and reducing aflatoxin in maize. The project occurred simultaneously with CP/1997/017, and was noted by researchers as drawing explicitly on capabilities developed through the ACIAR investments. A key enabler of the project was that senior members of the Food Security Agency had a strong interest in food safety and were keen to draw on GMU's expertise to enhance public awareness.

Although developing **links** between government, business and research institutions is important, in practice the capacity to **communicate salient evidence and knowledge** to specific individuals within those institutions was emphasised by participants as being crucial.

8.3 Sustained impact

8.3.1 Contribution to a broader public awareness of the problem

An indirect impact of the project has been the contribution to broader wider awareness of aflatoxin among the public. As part of a wider trend, participants noted that food safety had become a more significant issue for the public in the past 10 years. This had been enhanced by new informal accountability mechanisms such as social media. Even so, some participants noted that awareness of aflatoxin risks among retailers remained low. For example, recent fieldwork at the wet market retailer level identified that there was still low awareness of the problem, and there existed a perception that heat treatment (e.g. boiling the peanuts) would be sufficient to kill the aflatoxin.

However, interview participants noted that the regulation contributed to a broader impact on awareness. One researcher stated that 'Since we have the regulation, we have much better awareness. That a broad range of agencies are working individually on this is good, however it remains fragmented'.

Although business engagement in the aflatoxin problem has not been as strong, evidence suggests that it is emerging as a more significant issue in public discourse. For example, one research participant noted that 'Now on the television in Indonesia we have a herbal medicine company that states in their commercials that there is 'no aflatoxin' in their product! They are advertising the health benefits on the television. I think the awareness of aflatoxin is definitely increasing in Indonesia'.

While this is not a direct output of the ACIAR project, the researchers attributed their work to developing research, business and government awareness of the aflatoxin problem, and contributing to public awareness on the issue.

8.3.2 Sustained knowledge creation

The capacity built through this project has led to sustained generation of new knowledge through training and further research. The expertise and collaborative relationships built through this process have established these institutions as regional experts, capable of influencing policy. As recorded by a researcher—'The establishment of the SNI, the maximum tolerable limit, was a milestone for us. It signals we have influential data and valuable contributions to make. From that point, now we are one of the key players in terms of regional expertise on mycotoxins. We have the data, we have national support, even if it is still limited, and no one objects to our expertise and national leader in aflatoxin and mycotoxins'.

Indonesian researchers have demonstrated their capacity to generate research outputs for international audiences. However, the research institutions are aware of the need for further assistance, particularly from international partners, in transitioning their research into more practical outputs. One stated that 'International collaborations, particularly with developed countries, will continue to be important for us. This is particularly in helping us go beyond the publication phase. For publications, we are strong enough, but we need cooperation with colleagues from abroad for more practical implementation beyond publication'. This quote summarises the desire among researchers to expand their scope of influence, and continue to have an evolving role in influencing public awareness as well as policy decisions on aflatoxin and mycotoxins.

8.3.3 Policy impact and relevance to the Indonesian context

While a milestone achievement of the researchers engaged in CP/1997/017 was influencing SNI 7385:2009, this impact on policy implementation has not been sustained. However, this should not be taken as a significant shortcoming of research institutions. Policy decisions are situated in a broad **social, economic and political context**. In assessing the impact that research institutions have had, the Indonesian context is important to consider. As one government researcher noted, 'In terms of next steps, I think we need to look at the national capacity for food safety control. We have done the research and have data about the problem. The bigger challenge is why the improvement isn't happening? At the farmer level, with the traders and retailers, it involves a much bigger range of stakeholders and higher authorities to intervene in the problem'.

There are a number of core contextual challenges to consider in Indonesia—one relates to a broader concern with not causing financial stress for peanut producers and traders. Policymakers also want to avoid spreading a fear of peanuts within the community; and policy decisions regarding aflatoxin exist within the broader political economy of Indonesian agriculture.

A second challenge is the fragmented system of regulation. As previously noted, there are three different government agencies with direct regulatory responsibility for aflatoxin. In addition, interview participants noted that the Ministries of Trade, Industry, Health and Education are also involved, depending on the type of commodity and the end consumer. As one research participant observed, the broad range of institutions engaged in enforcement of regulations had resulted in a fragmented approach to managing it, and a relative lack of leadership—'There is no national leadership to address the problem. Different stakeholders may already perform some work according to their official obligations, but they are only focused on their own. What I mean by a lack of leadership is how to connect the work being undertaken by many different institutions into a coordinated strategy'.

In this process there are clear limitations for the influence of research institutions in addressing the peanut aflatoxin problem, or mycotoxin issues in other commodities. As one researcher noted, government needs to go beyond expecting research to be able to solve the problem. In making further progress on aflatoxin and mycotoxins, all stakeholders identified the collaboration and coordination of different stakeholder groups as being crucial. For some participants, the issue concerned government coordination and taking responsibility to lead. One researcher stated that 'The next project should be around connecting fragmentation at a national level. For the university, this is very hard to do and can't be sustained. We need sustained national commitment'.

For others, it was coordinating effort among the different stakeholders engaged in the problem. A private-sector participant commented that 'We need to coordinate funding and effort across government, industry and research. There needs to be a roadmap where all stakeholders have the same objective that they work towards, the matches their own objectives'.

While the research, sustained production of knowledge and facilitation of collaboration between research institutions generated through the ACIAR project has been significant, it has not been, and will not be, sufficient to address the aflatoxin problem. As summarised by one researcher, 'Addressing the aflatoxin problem in the last 10 years has had limited success. Not limited success in terms of our collaboration with ACIAR or other research partners, but limited success due to lack of readiness at the national level to action'.

8.4 Summary

Table 17 summarises the discussion from this section according to the three impact assessment objectives and the analytical themes from the integrated knowledge systems and RAPID framework. Figure 18, Figure 19 and Figure 20 diagrammatically represent our findings in the conceptual framework presented in section 3, and the nature of the sustained project impact on policymakers, researchers and industry.

Table 17: Summary of findings for Indonesia

Objective / Framework themes	Knowledge systems			Knowledge systems and RAPID		RAPID	
	Evolving, dynamic systems	Focus on specific decisions or actions	Quality / character-istics of evidence	Relationships and linkages	Communi-cation	Political context	External drivers
Assess the extent to which the project outputs have contributed towards greater awareness of the risks of aflatoxin in Australia and Indonesia	■ A range of publications emerged from the project. ■ Multiple conferences and workshops throughout South-East Asia and Australia were held. ■ Government key informants discussed changes in policy due to knowledge increase.			N/A		■ Not all businesses are fully aware of the AFI or research findings due to time and lack of networks.	
Examine the impacts that CP/1997/017 has had on relationships among different stakeholders involved in regulating and managing the risks of aflatoxin, including scientists, regulators, industry and non-government organisations	■ Informal markets were identified as the main supply-chain areas where aflatoxin develops. ■ Some producers and government were aware of the ACIAR findings.			■ The AFI has been the primary boundary organisation facilitating knowledge exchanges and bringing different actors together. ■ Ongoing relationships mean that researchers continue to exchange knowledge in Indonesia and Australia. ■ There has been some private- and government-sector engagement, but it has been limited.		■ Strong relationships between government and policymakers can lead to policy change. The changes in the 2009 aflatoxin limits are partially attributed to the work of the AFI.	
Determine the extent to which project outputs have led to sustained adoption and changes in institutions and industry to reduce aflatoxin problems in Indonesia	■ The supervision of master's and PhD students throughout and after the project shows ongoing engagement with the aflatoxin research. ■ Capacity was built in Indonesian research institutes as regional leaders in aflatoxin research.			■ Strong capacity was built, with researchers are still participating in knowledge exchanges with each other and Australian researchers.		■ Indonesia is focusing on core commodities in agricultural growth, and peanuts are one of them. Distributors need greater ability to monitor and reduce aflatoxin risk at the informal market level, as identified by the ACIAR project. ■ Monitoring and enforcement of regulation is limited, creating risks to consumers. ■ Consumer awareness is increasing, facilitated by the rapidly growing economy and consumer trends. ■ The private sector needs to adapt to increased consumer awareness.	

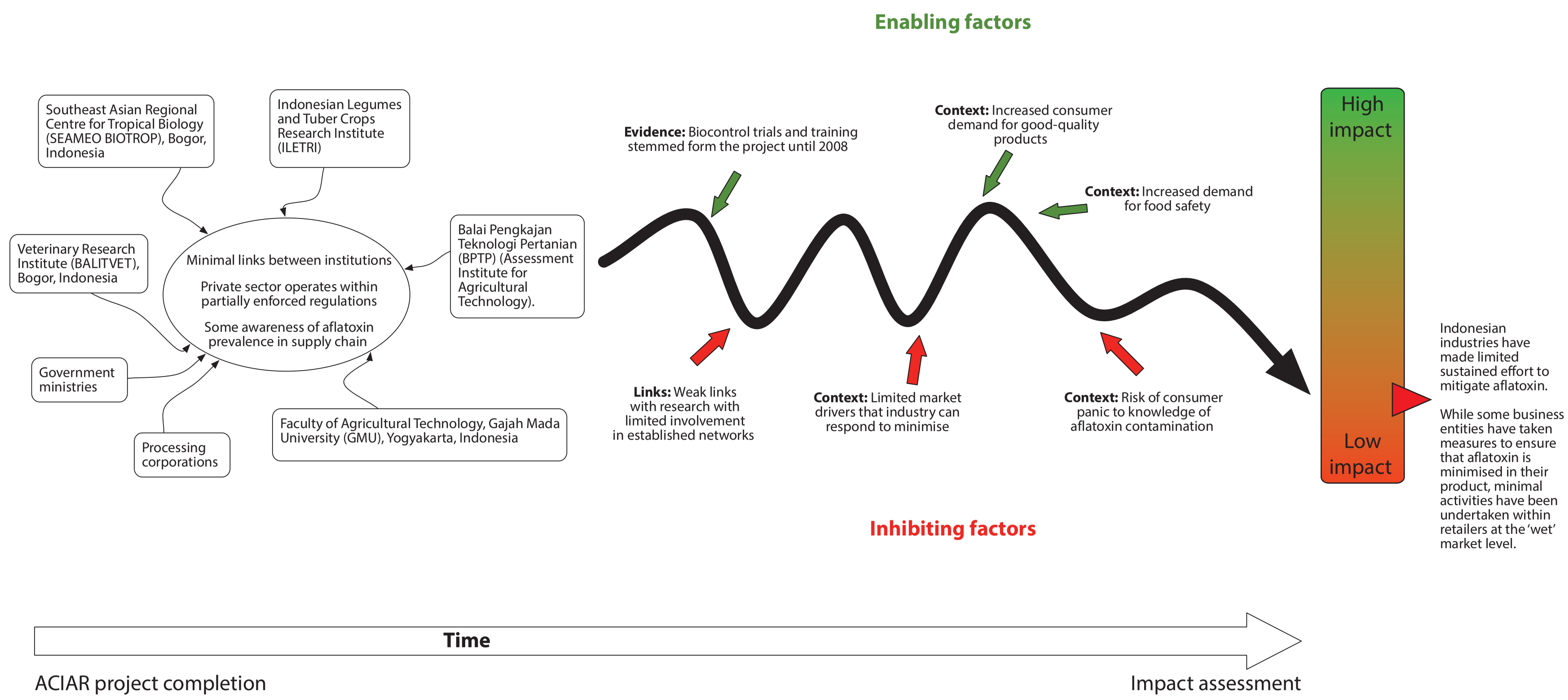

Figure 18: Knowledge systems and RAPID framework with industry impact

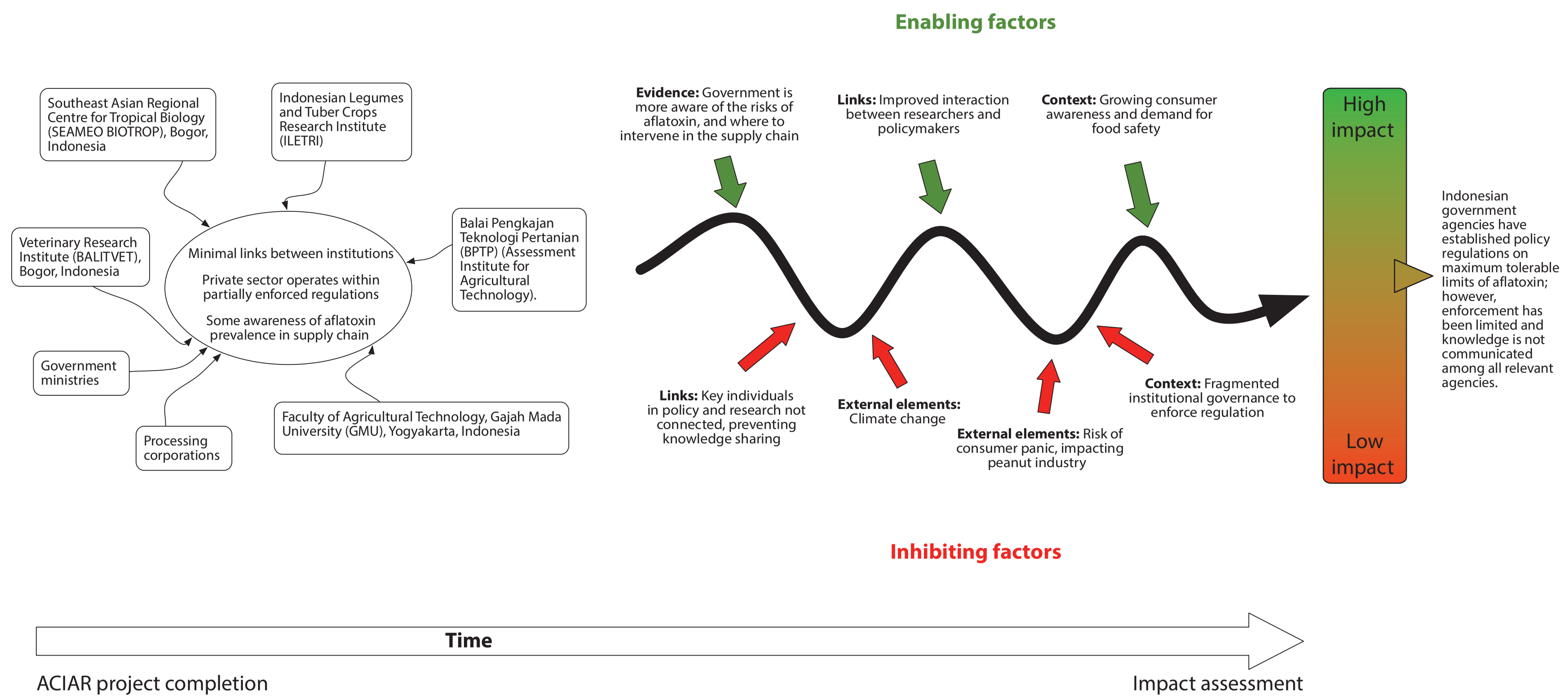

Figure 19: Knowledge systems and RAPID framework with policy impacts

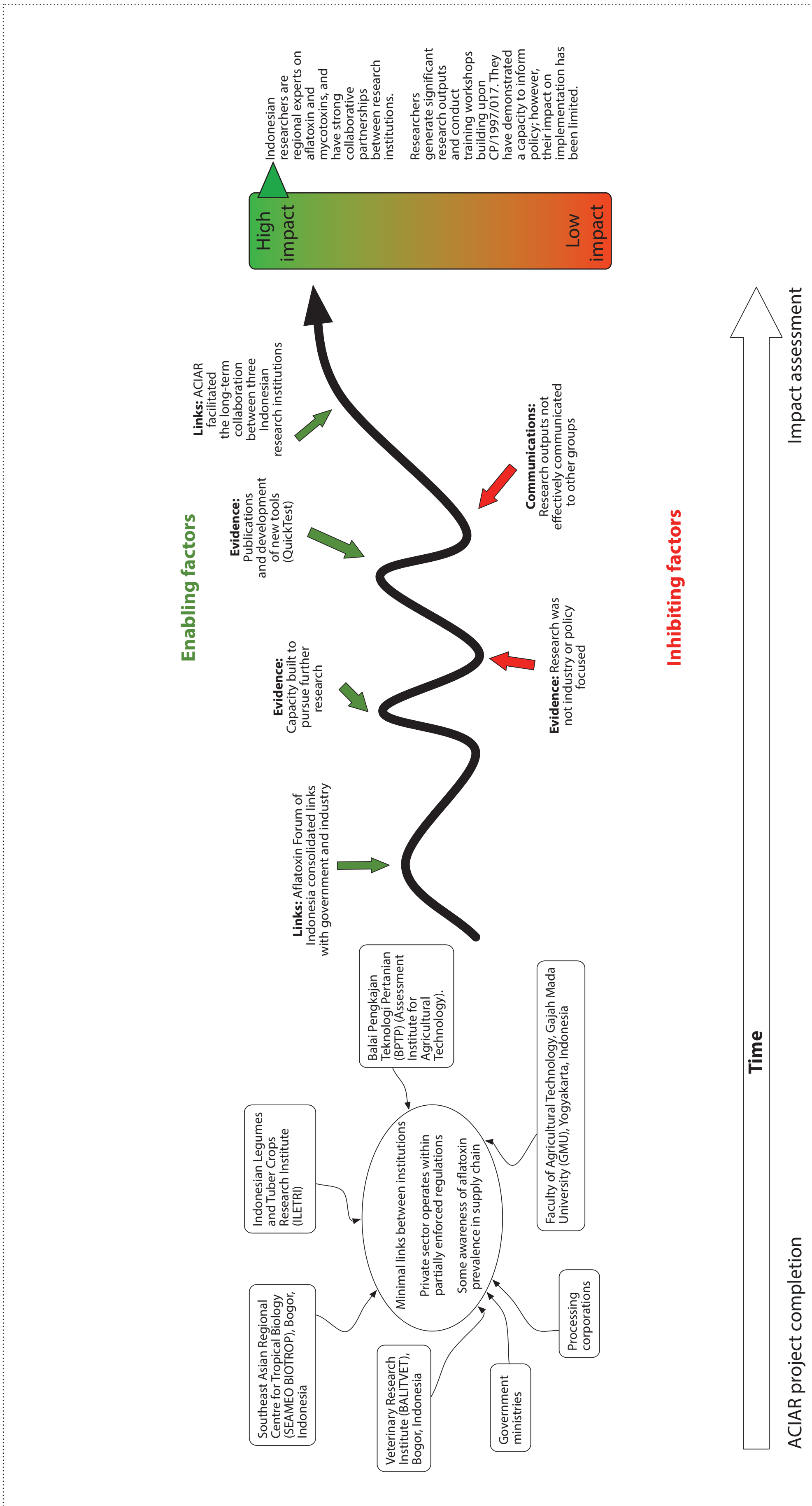

Figure 20: Knowledge systems and RAPID framework with research impact

9 Knowledge Systems and RAPID Assessment of Aflatoxin

The interaction of science and policy is crucial for reducing aflatoxin in the Indonesian peanut supply chain. Technologies such as ELISAs and QuickTest tools that can identify the prevalence of aflatoxin resulted from scientific investment. Scientific research has also resulted in farmer decision support tools that estimate changes in aflatoxin development depending on a range of environmental conditions. Biocontrol continues to offer opportunities to fight the growth of aflatoxin on-farm, using non-toxic strains of the *Aspergillus flavus* virus.

ACIAR project CP/1997/017 made significant contributions to knowledge development and flows. This project followed from a legacy of other aflatoxin- and mycotoxin-related projects in the South-East Asian region, all of which enhanced technical understanding.

Yet, despite highly advanced understanding in the scientific community on the need for reducing and monitoring aflatoxin in the supply chain, challenges remain. The creation of suitable tools to mitigate aflatoxin, as well as external environmental factors such as humidity, continue to pose challenges for effective aflatoxin control in tropical countries. In addition, the large number of producers responsible for aflatoxin-prone commodities and highly dispersed markets create challenges for implementing large-scale changes.

In this final discussion we identify core take-home messages from studying the impact of the technical knowledge generated by ACIAR on aflatoxin reduction. The lessons learned range from the immediate benefits of the project outputs to the broader, non-quantifiable benefits, and offer insights into the future of aflatoxin research and investment by donors.

9.1 Evolving and dynamic systems

When is enough technical knowledge enough? ACIAR investments between 1980 and 2006 generated a range of technical understandings of the factors that led to aflatoxin development throughout South-East Asian countries, including Indonesia. This scientific knowledge included the genetic and management solutions required to reduce aflatoxin in peanuts and other commodities. Broader studies on mycotoxins in other commodities and feedstuffs provided similar technical knowledge, highlighting the conditions in which aflatoxin develops and possible mitigation strategies.

What our impact assessment indicates is that both Indonesian and Australian researchers and authorities are highly aware of aflatoxin. Both countries understand what causes it and where it occurs in the supply chain. Scientific research will typically seek to pursue an even deeper understanding of the technical problems, yet our findings indicate that this is no longer necessary for aflatoxin. QuickTest technologies are the most up-to-date technical tool for monitoring aflatoxin, and ongoing scientific research continues to focus on on-farm management. All this is occurring despite ACIAR's CP/1997/017 project indicating that intervening in wet markets and designing adequate economic market mechanisms to mitigate aflatoxin are the next steps.

The implication of this finding is that aflatoxin risk reduction is most likely to occur in the social and institutional contexts of market regulation and enforcement. Social and institutional systems need awareness and knowledge to take action, and ACIAR's investments since the 1980s have provided this. To transform this awareness into implementation and effective action for aflatoxin risk reduction, the research agenda should address these contexts to identify strategies for regulating or enforcing regulations in the identified wet-market settings. This shift in research agenda has not yet occurred.

9.2 Australian findings: context facilitating stronger links and evidence

The Australian example indicates a successful story of how scientific technical knowledge created high levels of awareness among the range of institutions tasked with reducing aflatoxin. The prioritisation of aflatoxin reduction in the Australian supply chain by regulators allowed for both knowledge to inform the maximum limits, as well as financial incentives for producers and distributors of commodities with aflatoxin risk. The ultimate goal of public health was achieved through high awareness among producers, regulatory bodies and distributors. The Australian case shows that consumers do not require knowledge and understanding of aflatoxin if other supply-chain actors reduce the risk to consumers by acting upon available knowledge.

This success was facilitated by an industry structure that enabled the research to be acted upon. However, the lessons to be gained from Australian policy experiences have limited relevance for Indonesia due to their structural and institutional differences, and cannot be readily transferred.

9.3 Indonesian findings: contextual factors, external drivers and boundary organisations

Indonesia is faced with a much more widespread and complex task. The **external elements** in Indonesia include the political economy of peanuts, the fragmented nature of production and trade, and a humid environment.

Our impact assessment sought to identify the extent to which these immediate benefits permeated to other longer term beneficiaries. Our study indicates that technical knowledge has advanced in Indonesian research institutions, and issues of regulation, policy enforcement and monitoring are now a major area of interest.

Since project completion in 2005, **relationships** and **research capacity** have been strengthened, and this can be directly attributed to ACIAR's investments. The AFI and MFI demonstrate how **boundary organisations** generate knowledge flows. As technical understanding of aflatoxin has been acquired, the nature of the challenge has now moved on and become focused on policy, market mechanisms and enforcement.

However, institutional capacity to monitor and enforce regulation is limited. As capacity to intervene in the countless wet markets is likely to take time, new opportunities may emerge as the **political context** evolves. Having a well-established research sector means that they will be in a good position to respond to any policy windows that open, as demonstrated by their engagement in setting standards. It is critical that both researchers and key policy groups remain open to the ongoing knowledge exchanges facilitated by the AFI.

Future research into aflatoxin should focus on risk minimisation technologies suitable for wet markets (e.g. storage), and enforceable policy design and incentives that are relevant to the political context in Indonesia.

9.4 The value of networks

The stories from Australian and Indonesian key informants identified the significant contribution that ACIAR made towards establishing long-term links. The most tangible evidence of the ongoing impact of investments is the AFI. This network of researchers was established as a by-product of the positive relationships established among Indonesian research centres. Members of the forum include researchers involved in the CP/1997/017 project, but also the next generation of Indonesian researchers being trained by those involved in the ACIAR project.

The long-term capacity being built in Indonesia due to ACIAR's investments was documented through key informant narratives. Australian stakeholders identified the learning value that was directly attributed to ACIAR's project outputs. The capacity of Australian stakeholders to critically analyse aflatoxin problems from a supply-chain perspective is actively used by those still working in the field. The examples indicated that the flow of knowledge is being transferred to other development contexts, such as Timor-Leste and China. The long-lasting value of ACIAR's investment on individual capacity provides positive avenues to continue to study and address crucial development challenges throughout emerging economies.

The capacity of Indonesian researchers was also built through the development and application of project outputs. For example, the ELISA models provided the technical capacity to monitor aflatoxin throughout a supply chain. This highly technical exercise contributed towards Indonesian researchers' understanding of how to design and apply an ELISA, and this has led to longer term research in aflatoxin monitoring without Australian support. The new generation of PhD students being trained in aflatoxin reduction is an unintended, long-lasting benefit of ACIAR's investments. Through providing new knowledge to senior Indonesian researchers, ACIAR has played a role in establishing a knowledge base for ongoing aflatoxin work in Indonesia.

As noted in the case studies, policy in Indonesia in 2004 was only influenced in a minor way by the knowledge and networks produced by ACIAR. This policy was developed in parallel with the ACIAR project and there was minimal crossover. However, in 2009 the long-term impact of the project was directly documented in policy changes in that year. Five years after project completion, the knowledge provided by ACIAR facilitated standard regulatory changes in Indonesian policy. Although other factors and political contexts would have played a role, ACIAR was directly responsible for providing the knowledge and insights needed to design this policy.

Regulations, however, have not led to a concrete reduction in aflatoxin in the Indonesian supply chain. There remains a lack of enforcement, despite the high knowledge and understanding of aflatoxin. Prioritising the issue is key, and this has been difficult due to the slow-impact nature of aflatoxin poisoning in humans. Insufficient synergies have been drawn between the agricultural and health sectors, both of which are affected by aflatoxin. Understanding the long-term implications for the health sector of aflatoxin poisoning may provide the incentive required to enforce policy.

9.5 Limitations to the impact of CP/1997/017 outputs

There have been two limitations to the sustained impact of CP/1997/017—the complex nature of the technical outputs; and the broader context of Indonesia, where there is still fragmented governance of aflatoxin regulation.

The technical outputs produced were highly scientific tools, and their complexity has made sustained adoption of them very difficult. For example, rigorous training is needed in analysing data from ELISAs. The project indicated little uptake of these technologies, partly because of the availability of QuickTests, which is a more accessible technology.

The project outputs did not contribute to the end beneficiaries within the aflatoxin problem—consumers, smallholders and the health sector. This is because ACIAR's investments were geared towards building knowledge and understanding about aflatoxin, rather than the knowledge being acted upon.

The adoption of technical outputs was high among researchers, and continued to be used after project completion in training and education. The project outputs that built an understanding of aflatoxin prevalence in the Indonesian supply chain provided good knowledge but limited action in policy.

9.6 Future investments in aflatoxin

ACIAR's investments in aflatoxin reduction in Indonesia between the 1980s and 2005 have provided valuable knowledge on identifying aflatoxin, managing on-farm occurrence and assessing how to best intervene in a supply chain. Future investments should minimise concern over further technical understanding of the problem, and focus more on using existing scientific knowledge throughout the supply chain to reduce aflatoxin. There are a number of suggested avenues for future aflatoxin risk-reduction investments:

- a study into possible market incentives and penalties available for Indonesian policymakers to enforce regulation on peanut supply-chain actors, particularly at the high-risk points of wet markets
- low-cost storage systems that can be used in wet markets, to keep peanuts dry and minimise aflatoxin risk
- capacity-building programs to integrate the three regulatory bodies involved in aflatoxin reduction; and workshops, conferences and capacity-building exercises that draw together the agriculture and health sectors, to discuss aflatoxin challenges
- research on fragmented governance and associated institutional challenges to identify whether a single body would have greater capacity to enforce aflatoxin regulations
- a trial of the extent to which QuickTest technologies can be easily used by wet-market peanut sellers to identify aflatoxin; this should be coupled with market incentives research
- a study into peanut waste products—mouldy and infected peanuts still pose a risk to development as poorer consumers may still buy them; and infected peanuts, if fed to livestock, can still cause liver cancer in humans
- detailed risk assessments for the different actors within the supply chain.

9.7 Future use of the integrated knowledge systems and RAPID framework

The framework applied in this impact assessment was designed to capture and document both tangible and intangible benefits arising from ACIAR's investments in aflatoxin research. The qualitative rigorous approach allows for a wide range of both predicted and unpredicted impacts to be identified and explored in depth from different stakeholders. Drawing on both knowledge-based activities and relationships allows for a thorough understanding of the ongoing social and political contributions of ACIAR's projects to date. This was a suitable approach for projects such as these with largely public-good outcomes.

This theoretical approach and the qualitative research methods were useful for the nature of ACIAR's aflatoxin investments. The framework captures the non-quantifiable, social outcomes that the project generated. Through collection of perspectives and narratives, we identified the largely positive impacts that this project had on building knowledge and strengthening networks.

The framework developed is a suitable template to apply to projects to capture the state of knowledge of a particular agricultural problem at a point in time. This is useful for impact assessments, as it can capture how ACIAR investments have contributed to knowledge flows over time. Importantly, undertaking an integrated knowledge systems and RAPID analysis can be extended to any particular stage of project development— during project design, implementation, evaluation and impact assessment.

Future applications of the framework would benefit from adding a quantitative approach towards understanding a project's impact on key beneficiaries. This framework also has some limitations in comparison with other impact assessment methods. As an interpretive method, it is highly related to the specific context and processes of the project being examined, and the findings presented here are not intended to be compared with other research programs or projects. What 'worked' or 'did not work' in this assessment cannot be regarded as indicating success of failure in other settings.

This method may well be applicable alongside more-conventional approaches in future research impact assessments where a combination of economic outcomes (i.e. amenable to cost–benefit analysis) and social–political outcomes arise. Using this approach in conjunction with other methods such as cost–benefit analysis may effectively capture the full impact of research investments in complex projects or programs with both public and private benefits.

The use of integrative, mixed methods has been suggested previously by ACIAR (Carpenter and McGillivray 2012). The use of qualitative and quantitative methods allows for integration of findings to generate new knowledge. The value of such analysis for ACIAR is the fact that integrative research is centred on a problem rather than a particular disciplinary framework (van Kerkhoff 2005). Bringing together multiple analytical perspectives, values and concerns for a problem that spans across scales makes integrative methods a unique, dynamic and innovative tool for analysing the impact of investments. ACIAR, by pursuing future integrative impact assessments, can contribute to the growing body of knowledge on how food security is understood and achieved across cultures, institutions and environments.

This method has contributed to the literature and understanding of impact assessments in two ways. First, we have explored how ACIAR, as a knowledge investor, has contributed towards awareness and understanding of the critical challenge of aflatoxin poisoning in supply chains. Second, we have built on ACIAR's approaches to impact assessment and provided additional conceptual tools to integrate with traditional approaches. The use of knowledge systems and development factors was relevant to the nature of ACIAR's aflatoxin investments, which were geared towards understanding the problem.

Finally, capturing how knowledge created is used to improve food systems and bring people out of poverty is crucial for ACIAR's ongoing institutional learning. Using mixed-method tools that both quantify change and grasp non-tangible outcomes is essential for ACIAR to understand how investments are contributing to development.

Pursuing purposeful change towards sustainable development will require ACIAR to critically assess the impact of its investments on how knowledge is produced, its associated economic benefits, and how it is sustained and absorbed by relevant institutions.

Appendix 1: Aflatoxin Impact Assessment: Interview Guide

IAS objectives

The main objective for the impact assessment will be to determine how the project outputs from CP/1997/017 are being used by regulatory policymakers, research centres and the peanut industry in Indonesia and Australia, and the ultimate impact this has had on aflatoxin risk mitigation.

The impact assessment will:

1. Assess the extent to which the project outputs have contributed towards greater **awareness of the risks** of aflatoxin in Australia and Indonesia with reference to CP/1997/017 and the preceding related projects (PHT/1991/004, CP/1988/034, CS1/1984/019 and PHT/1988/006)
   - **Knowledge of the problem questions**
2. Examine the impacts that CP/1997/017 has had on relationships between different stakeholders involved in regulating and managing the risks of aflatoxin, including scientists, regulators, industry and non-government organisations
   - **Role of networks and relationships in knowledge and risk mitigation**
3. Determine the extent to which project outputs have led to sustained adoption and changes in institutions and industry to reduce aflatoxin problems in Indonesia
4. Identify key 'sticking points' (challenges) and opportunities that may usefully inform future investment in aflatoxin risk mitigation, policy-oriented research in Indonesia, and ACIAR project design / management for better policy engagement and outcomes.

Themes to be alert for

These are themes that we are not directly asking about but should be probing/investigating further if they arise:

A. **Politics**, as in party politics, government dynamics. Keys may be reference to change of government, comparisons between previous and current Indonesian government emphases, and the role of elected Ministers in supporting / not supporting aflatoxin-reduction efforts.

B. **Politics**, as in departmental politics. These exist regardless of who is in power at the time. Key may be reference to interdepartmental tensions, or differentiated influence or power relations, e.g. Health may more powerful / better resourced than Agriculture or Food and Drug regulation.

C. **Gender**, especially references to the vulnerability of women farmers or market buyers/sellers if aflatoxin regulation is enforced; and any other general references to the role or presence/absence of women in research, policy or regulation.

D. **Barriers** to impact/implementation/enforcement—trying to differentiate between whether the lack of action is due to ignorance of the problem (i.e. knowledge exists but has not been shared), insufficient understanding of the problem (i.e. knowledge does not exist), lack of resources (i.e. the problem is known but not sufficiently resourced), structural barriers (i.e. the problem is known and resourced but it is just really hard to reach the markets where the toxin develops).

E. **Opportunities** for change and improvement, especially where research could make a difference (allowing for different models of engagement).

Indonesian stakeholder questions

Objective 1: Knowledge and awareness questions

- How do you understand the nature of the aflatoxin problem in Indonesia? What has contributed to this understanding?
  - **Prompts:** other agencies, ACIAR work, past and present Indonesian aflatoxin-reducing efforts. Has there been further aflatoxin research since the ACIAR project?
- What is the most up-to-date Indonesian aflatoxin policy? When did it become official? What are the enforcement mechanisms?
  - **Prompts:** emphasise policy name/number and the regulatory enforcement body associated with it.
  - What is the current political context in which these decisions get made?
  - What evidence is used to make decisions, if any?
- In general, is there greater awareness now about the aflatoxin problem in Indonesia than 10 years ago?
  - [If yes] How has that come about? Have there been any particular turning points in generating that awareness? Did the ACIAR project play a role?
  - [if no] What are the challenges for building that awareness? Is there a role for research projects in this? What would such projects need to look like or do?
  - **Prompts:** reference ACIAR CP/1997/017 project outputs, and previous ACIAR efforts in Indonesia. Who should be engaged?
- What has happened since the completion of the ACIAR project in 2005?
  - **Prompts:** more research? [by whom?], lobbying?, partnering? [historical overview of the development].
- What understanding of aflatoxin existed before the ACIAR project ?
  - **Prompts:** emphasise Indonesian history in dealing with aflatoxin.
- Who else in terms of donors have been involved in aflatoxin-reducing efforts in collaboration with Indonesian institutions? How would you describe the quality or effectiveness of those projects in dealing with aflatoxin risk reduction?
  - **Prompts**: getting towards an understanding of whether other projects had greater impacts and, if so, why. Unlikely to be determined through direct questioning.
- To what extent do you think ACIAR project outputs built the capacity in Indonesian universities and government on how to reduce aflatoxin risk, and enforce any policies?
  - **Prompts:** do current Indonesian staff know about the ACIAR project? Do they use the project outputs?
- What do you feel are the strengths and weaknesses of research-based projects like ACIAR's in supporting decision-making? (How does knowledge get used in decision-making?) Were there any specific elements of the project that were more important or relevant than others?
  - **Prompts:** Discuss the ELISA model as one of the key outputs. Is this a useful tool to **create** policy as opposed to **monitoring**
- Are there any other groups who have used or referred to the project outputs? Who? In what context? Examples?
- Is there a wider network of people involved in aflatoxin policy and regulation? How do they access information?
- What are the steps needed to improve enforcement of aflatoxin regulation?

Objective 2: Relationships, links and politics questions

- Who are the main bodies/institutions involved in developing aflatoxin policy? Who are the most influential? Who is the most active?
  - **Prompts:** try to get specific examples.
  - Were they new or independent organisations, e.g. Aflatoxin Forum of Indonesia? How did that institution come about? Were the ACIAR project or ACIAR project staff involved at all?

- Did the ACIAR project contribute to any new relationships between different individuals or groups?
- Who is responsible for monitoring and enforcing aflatoxin limits? Are any people who were involved in or connected with the ACIAR project now in positions where they are responsible for aflatoxin policy or enforcement?
  - **Prompts:** try to identify specific people who were involved in the project, even peripherally, and whether they are now working in policy or related areas.
- To what extent do you think relationships contribute to knowledge creation, sharing and aflatoxin risk reduction?
- Do existing relationships facilitate the flow of knowledge on aflatoxin?
- What **supports/inhibits** knowledge generation and action on aflatoxin-reduction strategies?
- What were the biggest challenges in working across institutions during the project?
  - Was there any conflict between individuals or groups? How was that dealt with or overcome?
- Do these challenges persist today?
  - Is there any conflict between institutions at present that might prevent aflatoxin standards being enforced?
- Are there different networks that deal with aflatoxin? Have they used the project outputs, if at all? [Note that it may be unlikely that participants will know.]
  - **Prompts:** [if they don't know] Are there any key policies, papers or documents from those groups regarding aflatoxin [that we can look up to see if there is any reference to ACIAR outputs]?
- Staff turnover is often cited as a key challenge in maintaining and growing knowledge on specialised topics. How successful have key groups [name them if you can] been in maintaining or building institutional knowledge in the 10 years since the project finished?
  - **Prompts:** is staff turnover a relevant challenge in aflatoxin programs in Indonesian agencies?
- Is there concern about the impact of aflatoxin on other stakeholders who aren't or haven't been involved or represented in the policy and regulatory processes to date?
  - For example, impact on smallholder farmers or market buyers/sellers? Others?

Objective 3: Adoption and sustained impact questions

- Has the aflatoxin situation improved or progressed over the past 10 years? Why? [Why not?] Can you identify any specific points where the ACIAR research has contributed to this?
- What would be the next steps in improving aflatoxin risk reduction?
- Project CP/1997/017 identified lack of enforcement as the key issue now confronting aflatoxin risk reduction. Is this still the case? Who is the most affected by the lack of enforcement [think of the broader stakeholders that are affected by aflatoxin prevalence]?
  - **Prompts:** The ASEAN target of 15 ppm—what are the next steps in enforcing this? Is enforcement common/uncommon throughout SE Asia?
- Do you have any other general comments or observations on the role that ACIAR research has played in aflatoxin risk reduction?
- If ACIAR or other research agencies were to continue to support research in this area, what would you recommend to them as the most productive area to invest in? Why?
  - [Need to ensure there is no implied promise here.]
- For ACIAR: what is the current policy landscape like in Indonesia now, and how might it influence a future project? Is there any need/value/interest in doing a project from the Indonesian end?
- What are the broader dynamics and interactions with other agencies?

Australia-only questions, to complement questions above

- Do relationships between industry and government play a role in improving awareness and action on aflatoxin?
- What were the relationships like between Australian and Indonesian researchers and government? What was most challenging/rewarding?
- Did Australia have any influence on policy decisions?
- To what extent was the project concerned with targeting policy as opposed to generating knowledge?
- Has there been any sustained institutional memory since the project finished?

Case study: Aflatoxin Forum of Indonesia (AFI)

The purpose of using the AFI as the vignette/case study for the IAS will be to explore how the ACIAR project outputs have facilitated a platform for knowledge and relationships to be sustained after completion of the project.

- What is the purpose of the forum and their annual meetings?
- Ask questions on their history: what stimulated the development, did the CP/1997/017 project contribute to it in any way, and what is their primary agenda?
- How do they understand and deal with the science–policy-implementation interface?
- What are the main barriers in implementing change regarding aflatoxin regulation and enforcement?
- Are there any windows of opportunity?
- Have there been new relationships and changes that can be attributed to the forum?
- What would they like to happen next?
- What contribution did ACIAR make towards building or supporting the rationale for the AFI?

Appendix 2: Project Communication (in chronological order)

Scientific publications—published

Dharmaputra O.S., Putri A.S.R., Retnowati I. and Ambarwati S. 2001. Soil mycobiota of peanut fields in Wonogiri regency, Central Java: their effect on the growth and aflatoxin production of *Aspergillus flavus* in vitro. Biotropia 17, 30–59.

Rachaputi Rao C.N., Wright G.C. and Krosch S. 2002. Management practices to minimise pre-harvest aflatoxin contamination in Australian peanuts. Australian Journal of Experimental Agriculture 42, 595–605.

Bulaong S.S.P. and Dharmaputra O.S. 2002. Fungal population, aflatoxin and free fatty acid contents of peanuts packed in different bag types. Biotropia 19, 1–25.

Dharmaputra O.S. 2002. Review on aflatoxin in Indonesian food- and feedstuffs, and their products. Biotropia 19, 26–46.

Dharmaputra O.S., Putri A.S.R., Retnowati I. and Ambarwati S. 2003. Antagonistic effect of three fungal isolates to aflatoxin-producing *Aspergillus flavus*. Biotropia 21, 19–31.

Dharmaputra O.S., Putri A.S.R., Retnowati I. and Ambarwati S. 2003. Control of aflatoxigenic *Aspergillus flavus* in peanuts using nonaflatoxigenic *A. flavus*, *A. niger* and *Trichoderma harzianum*. Biotropia 21, 32–44.

Lee N.A., Wang S., Allan R.D. and Kennedy I.R. 2004. Simple and rapid aflatoxin B1 ELISA: development and validation of quantitation for various food matrices. Journal of Agricultural and Food Chemistry, Journal of Agricultural and Food Chemistry 52(10), 2746–2755.

Robson A., Phinn S. and Wright G.C. 2004. Assessment of peanut crop maturity, aflatoxin risk and yield forecasting with QuickBird satellite imagery and field spectroscopy. Spatial Science (Queensland) August 2004, 35–37.

Lee N.A., Rachaputi Rao C.N., Wright G.C., Krosch S., Norman K., Anderson J., Ambarwati S., Retnowati I., Dharmaputra O.S. and Kennedy I.R. 2005. Validation of analytical parameters of a competitive direct ELISA for aflatoxin B1 in peanuts. Food and Agricultural Immunology 16(2), 149–163.

Dharmaputra O.S., Retnowati I., Ambarwati S. and Maysra E. 2005. *Aspergillus flavus* infection and aflatoxin contamination in peanuts at various stages of the delivery chain in Cianjur regency, West Java, Indonesia. Biotropia 24, 1–19.

Ginting E. 2006. Mutu dan kandungan aflatoksin biji kacang tanah varietas Kancil dan Mahesa yang disimpan dalam beberapa jenis bahan pengemas. [Quality and aflatoxin content of Kancil and Mahesa variety peanut kernels after storage in several types of packaging.] Jurnal Agrikultura 17(3),165–172.

Lee N.A. and Rachmawati S. 2006. A rapid ELISA for monitoring aflatoxin B1 in animal feed and feed ingredients in Indonesia. Food and Agricultural Immunology 17(2), 91–104.

Thomasson J.A., Sui R., Wright G.C. and Robson A.J. 2006. Optical peanut yield monitor: development and testing. Applied Engineering in Agriculture 22(6), 809–818.

Robson A., Phinn S. and Wright G.C. 2006. Using field spectroscopy for the assessment of peanut crop maturity and aflatoxin risk. Spatial Science 52,151–162.

Chauhan Y., Wright G.C., Rachaputi Rao C.N., Krosch S., Robertson M., Hargreaves J. and Broome A. 2007. Using APSIM-soiltemp to simulate soil temperature in the podding zone of peanut. Australian Journal of Experimental Agriculture 47(8), 992–999.

Lee N.A. and Kennedy I.R. 2007. Immunoassays, pp. 91–145 in: 'Food toxicants analysis: techniques, strategies and developments', ed. by Pico Y., <http://dx.doi.org/10.1016/B978-044452843-8/50006-7>.

Dharmaputra O.S., Retnowati I. and Ambarwati S. 2007. *Aspergillus flavus* infection and aflatoxin contamination in peanuts at various stages of the delivery chain in Wonogiri regency, Central Java, Indonesia. Biotropia 14(2), 9–21.

Simatupang S., Rahayu W.P., Lioe H.N., Herawati D., Broto W. and Ambarwati S. 2014. Pola pertumbuhan *Aspergillus ochracheus* BIO 220 dan produksi okratoksin pada jagung dan kedelai in vitro. [Growth pattern of *Aspergillus ochracheus* BIO 22 and ochratoxin A production in maize and soybeans in vitro]. (ID) Jurnal Penelitian Pascapanen Pertanian 11(1), 48–56.

Lisangan M.M., Syarief R., Rahayu W.P. and Dharmaputra O.S. 2014. Antifungal activity of kebar grass leaf extracts on the growth of aflatoxigenic *Aspergillus flavus* in food model media. International Journal of Sciences: Basic and Applied Research 17(2), 116–128.

Pratiwi C., Rahayu W.P., Lioe H.N., Herawati D., Broto W. and Ambarwati S. 2015. The effect of temperature and relative humidity for *Aspergillus flavus* BIO 2237 growth and aflatoxin production on soybeans. International Food Research Journal 22(1), 82–87.

Lisangan M.M., Syarief R., Rahayu W.P. and Dharmaputra O.S. 2015. Aktivitas antiaflatoksin B1 ekstrak daun rumput kebar (*Biophytum petersianum*) terhadap *Aspergillus flavus*. [Antiaflatoxin B1 activity of Kebar grass (*Biophytum petersianum*) leaf extract on *Aspergillus flavus*]. (ID) Jurnal Agritech 35(1), 9–17.

Rahayu D., Rahayu W.P., Lioe H.N., Herawati D., Broto W. and Ambarwati S. 2015. Pengaruh suhu dan kelembaban terhadap pertumbuhan *Fusarium verticillioides* Bio 957 dan produksi fumonisin B1 [The effect of temperature and humidity on growth of *Fusarium verticillioides* Bio 957 and fumonisin B1 productions]. (ID) Jurnal Agritech (in progress).

Conference and newsletter publications

Rachaputi Rao C.N., Wright G.C., Krosch S., Tatnell J. and Mackson J.V. 2001. Management practices to reduce aflatoxin contamination in peanut. Proceedings 10th Australian Agronomy Conference, Hobart.

Rachaputi Rao C.N., Wright G.C., Krosch S., Tatnell J. and Cruickshank A.W. 2001. Management practices to reduce aflatoxin contamination in peanut. Poster, Proceedings 2nd Australasian Soilborne Diseases Symposium, Victoria.

Putri A.S.R., Retnowati I., Dharmaputra O.S. and Ambarwati S. 2001. *Aspergillus flavus* population and aflatoxin content of stored peanuts. Paper presented at 16th National Congress and Scientific Seminar, Indonesian Society for Phytopathology, Bogor, Indonesia, 22–24 August 2001 (*in Indonesian*).

Wright G.C., Rachaputi Rao C.N., Krosch S. and Broome A. 2001. Research improves peanut safety and quality. Nomination for Innovation and Productivity Award, 2001 Premier's Awards for Excellence in Public Sector Management.

Mills G., Wright G.C., Rachaputi Rao C.N., Mackson J., Broome A., Jeff T. and Krosch 2001. Hip pockets and aflatoxin: a positive model for change in the peanut industry. [Rec-News] Australasia Pacific Extension Network (APEN) 2001 Conference, 3–5 October 2001, Toowoomba.

Lee N.A. and Kennedy I.R. 2002. Elisa workshop: analysis of aflatoxin B1 in peanuts, University of Sydney, Bogor, E. Java, Indonesia, February 2002 (CD-ROM).

Wright G.C., Lamb D.W. and Medway J. 2002. Application of aerial remote sensing technology for the identification of aflatoxin affected areas in peanut fields. Proceedings of 11th Australasian Remote Sensing Conference, Brisbane, Queensland, September 2002.

Dharmaputra O.S., Putri A.S.R., Retnowati I. and Ambarwati S. 2002. Antagonistic effect of soil mycobiota on aflatoxin-forming *Aspergillus flavus* in vitro. Pp. 188–207 in 'Quality management and market access' ed. by Sukprakarn C., Ruay-Aree S., Srzednicki G., Longstaff B., McGlasson B., Hocking A.D., Van S., Graver J., Wongkobart A. and Visarathanonth P. Proceedings of 20th ASEAN / 2nd APEC Seminar on Postharvest Technology, Chiang Mai, Thailand, 11–14 September 2001.

Lee N. and Kennedy I.R. 2002. Immuno-analytical techniques in the monitoring of contaminants in food and the environment. Pp. 37–44 in Proceedings of Seminar Nasional Teknologi Peternakan dan Veteriner, Bogor, Indonesia, 30 September – 1 October 2002.

Lee N. A. and Kennedy I.R. 2002. Monitoring mycotoxins in grain and food production systems for risk management: collaborative development of an ELISA test kit for aflatoxin B1. International Atomic Energy Agency (IAEA) Coordinated Research Program on Mycotoxins Workshop, Cape Town, August 2002

Kennedy I.R. 2003. An overview of aflatoxin contamination in food and feed: risk assessment and management. Pp. 1–17 in Pelatihan Metode ELISA Untuk Mendeteksi Aflatoksin Pada Pakan, Balai Penetian Veteriner, Bogor, Indonesia, 25–26 June 2003.

Lee N.A. 2003. An overview of aflatoxin analysis. Pp. 18–28 in Pelatihan Metode ELISA Untuk Mendeteksi Aflatoksin Pada Pakan, Balai Penetian Veteriner, Bogor, Indonesia, 25–26 June 2003.

Kennedy I.R. 2003. An overview of aflatoxin contamination in food and feed—quality assurance for feeds analysis of aflatoxin contamination: analytical validation with particular reference to HPLC and ELISA tests. Pp. 59–73 in Pelatihan Metode ELISA Untuk Mendeteksi Aflatoksin Pada Pakan, Balai Penetian Veteriner, Bogor, Indonesia, 25–26 June 2003.

Lee N.A. 2003. Sampling strategies for aflatoxin analysis. Pp. 74–83 in Pelatihan Metode ELISA Untuk Mendeteksi Aflatoksin Pada Pakan, Balai Penetian Veteriner, Bogor, Indonesia, 25–26 June 2003.

Lee N.A., Wang S., Allen R.D., Vo Thanh Hau, Nguyen Thu Trang, Bui Van Thin, Tran Van An, Le Van To, Ambarwati S., Rachaputi Rao C.N., Wright G.C. and Kennedy I.R. 2003. Monitoring aflatoxin in food: development and validation of immunochemical methods. ASEAN/APEC Postharvest Technology Seminars, 2003.

Kennedy I.R. and Le Van To 2003. Quality assurance using ELISA tests for rapid monitoring of contaminants in agricultural produce. Pp. 203–210 in 'Strengthening cooperation in post-harvest technology transfer within APEC economies', ed. by Nguyen Manh Dung and Bach Quoc Khang, Department of Agro-forestry Product Processing and Rural Industries, MARD, Hanoi, Vietnam.

Rahmianna A.A., Dharmaputra O.S., Rahayu E.S., Wright G.C. and Rachaputi Rao C.N. 2003. Reducing aflatoxin in peanuts using agronomic management and biocontrol strategies in Indonesia and Australia. International Seminar on Investment Opportunity on Agribusiness in Perspective of Food Safety and Bioterrorism Act. Organised by West Java Assessment Institute for Agricultural Technology and Faculty of Animal Husbandry and held at Padjadjaran University in Horison Hotel, Bandung, Indonesia, 9 September 2003.

Rahmianna A.A., Taufiq A., Wright G.C. and Rachaputi Rao C.N. 2003. Preharvest management practices to minimize aflatoxin contamination in peanut (*Arachis hypogaea* L.) in Indonesia. 21st ASEAN / 3rd APEC Seminar on Postharvest Technology, Putri Bali Hotel, Nusa Dua, Bali, Indonesia, 23–26 August 2003.

Fachrur Rozy, Heriyanto and Rahmianna A.A. 2003. Socio-economic study of peanut entrepreneur to aflatoxin comprehension. Annual Seminar on Food Security and Agribusiness. Organised by Central Research Institute for Food Crops and held in Research Institute for Legume and Tuber Crops, Malang, Indonesia, 16–17 September 2003 (*in Indonesian*).

Rachaputi Rao C.N., Wright G.C., Krosch S. and Tatnell J. 2003. Management of pre- and postharvest aflatoxin contamination in Australian peanuts. Abstract, 21st ASEAN / 3rd APEC Seminar on Postharvest Technology, Putri Bali Hotel, Nusa Dua, Bali, Indonesia, 23–26 August 2003.

Wright G.C., Rachaputi Rao C.N., Rahmianna A., Dharmaputra O.S., Rahayu E.S. and Mills G. 2003. Reducing aflatoxin in peanuts using an integrated approach of agronomic management, bio-control and genetic enhancement. Abstract, 21st ASEAN / 3rd APEC Seminar on Postharvest Technology, Putri Bali Hotel, Nusa Dua, Bali, Indonesia, 23–26 August 2003.

Dharmaputra O.S., Retnowati I., Setianingsih A., Putri A.S.R. and Ambarwati S. 2003. *Aspergillus flavus* and aflatoxin in peanuts at various stages of delivery chain in Pati Regency, Central Java. 21st ASEAN / 3rd APEC Seminar on Postharvest Technology, Putri Bali Hotel, Nusa Dua, Bali, Indonesia, 23–26 August 2003.

Dharmaputra O.S., Rahmianna A, Rachaputi Rao C.N., Wright G.C. and Mills G. 2003. Aflatoxin in Indonesian peanuts: how to manage the contamination within the food chain. Workshop on Agri-Product Supply Chain Management, 21st ASEAN / 3rd APEC Seminar on Postharvest Technology, Putri Bali Hotel, Nusa Dua, Bali, Indonesia, 19–22 August 2003.

Wright G.C., Rachaputi N.C. and Broome A. 2003. Reducing aflatoxin in the Australian peanut crop using an integrated harvesting management system. In Proc. American Peanut Research and Education Society (APRES), Clearwater Beach, Florida.

Rachaputi Rao C.N., Wright G., Krosch S. and Tatnell J. 2003. Aflatoxin monitoring and management decision support system. CD-Rom on 'National Peanut Update Ready Reference', 2003 edition, ed. by Toni Grundy and Greg Mills.

Wright G.C. 2003. The peanut problem in S.E. Asia. Pp. 4–5 in ACIAR Indonesia Newsletter, May 2003.

Rahmianna A.A. and Taufiq A. 2003. Aflatoxin: toxic metabolite in peanut kernels. In Buletin Tani, Tanaman Pangan dan Hortikultura, No. 004 Edisi (*in Indonesian*).

Rahmianna A.A. and Ginting E. 2003. The agronomic factors practised for growing peanut in Indonesia cropping systems in relation to aflatoxin contamination. Seminar on The Role of Agricultural Machinery to Increase Food Safety for Peanut Commodity, Center for Agricultural Machinery Development, Serpong, West Java, 17 December 2003.

Wright G.C. and Rachaputi Rao C.N. 2004. Drought and drought resistance. Pp. 386–390 in 'Encyclopedia of plant and crop science 1', Marcel Dekker Inc.: New York, doi: 10.1081/E-EPCS 120010407.

Rachaputi Rao C.N. and Wright G.C. 2004. 'Future technologies and approaches for the development of drought resistant ideotypes', Pp. 391–394 in 'Encyclopedia of Plant and Crop Science 1', Marcel Dekker Inc.: New York, doi: 10.1081/E-EPCS 120010407.

Wright G.C. 2004. Peanuts. In 'Encyclopedia of grain science', ed. by Wrigley C., Corke H. and Walker, C, Elsevier: United Kingdom.

Robson A., Phinn S., Wright G.C. and Fox G. 2004. Combining near infrared spectroscopy and infrared aerial imagery for assessment of peanut crop maturity and aflatoxin risk. Proceedings of 4th International Crop Science Congress, Brisbane, Queensland, 26 September – 1 October 2004. <www.regional.org.au/au/cs>.

Rachaputi Rao C.N., Wright G.C., Krosch S. and Tatnell J. 2004. On-farm monitoring and management of aflatoxin contamination in Australian peanuts. Proceedings of 4th International Crop Science Congress, Brisbane, Queensland, 26 September – 1 October 2004. <www.regional.org.au/au/cs>.

Dharmaputra O.S., Rahmianna A.A., Rachaputi Rao C.N., Wright G.C. and Mills G. 2004. Aflatoxin in Indonesian peanuts: how can the contamination within the food chain be managed? Pp. 88–97 in 'Agriproduct supply chain management in developing countries', ed. by Johnson G.I and Hofman P.J. Proceedings of a workshop held in Nusa Dua, Bali, Indonesia, 19–22 August 2003.

Dharmaputra O.S., Retnowati I., Ambarwati S. and Maysra E. 2004. *Aspergillus flavus* infection and aflatoxin contamination in imported peanuts at various stages of the delivery chain in West Java. Research Report. ACIAR project PHT/1997/017.

Rahmianna A.A., Yusnawan E. and Taufiq A. 2004. Effect of harvest timing and post-farm storage conditions on on-farm aflatoxin contamination. Seminar Nasional Peningkatan Daya Saing Pangan Tradisional, Balai Besar Pascapanen Pertanian [National Seminar on Improving the Competitiveness of Traditional Foodstuffs, Agricultural Postharvest Institute], Bogor, Indonesia, 6 August 2004.

Lee N.A. 2004. Mycotoxins and their analyses, In the 'BIOTROP Regional Training in Mycotoxins' 2005 manual, BIOTROP, Bogor, Indonesia, 21–26 June 2004.

Ginting E., Rahmianna, A.A. and Yusnawan E. 2004. Pengendalian kontaminasi aflatoksin pada produk olahan kacang tanah melalui penanganan pra dan pasca panen [Control of aflatoxin contamination in peanut processed products through pre and postharvest handling]. Pp. 123–136 in Syukur M., Kartono G. and Widajati E. (eds), 'Petunjuk teknis rakitan teknologi pertanian'. Puslitbang Sosial Ekonomi Pertanian, BPTP: Malang, Jawa Timur ['Technical manual of agricultural technology packages'. Centre of Agricultural Social and Economic Research and Development, Institute for Agricultural Technology Studies: Malang, East Java].

Yusnawan E. and Rahmianna A.A. 2004. Ekstrak kelapa komersial sebagai media untuk deteksi cepat *Aspergillus flavus* penghasil aflatoksin. Seminar Hasil Penelitian Tanaman Kacang-Kacangan dan Umbi-Umbian, Puslitbangtan, Malang [Commercial coconut extract as a media for rapid detection of aflatoxin-producing *Aspergillus flavus*. Seminar on Results of Legumes and Tuber Crop Research, Centre of Agricultural Research and Development], 5 October 2004.

Wright G., Rachaputi Rao C.N., Chauhan Y. and Robson A. 2005. Increasing productivity and quality of peanuts using novel crop modeling and remote sensing technologies. Pp. 14–17 in 'Prospects and emerging opportunities for peanut quality and utilisation technology', International Peanut Conference, Kasetsart University, Bangkok, Thailand, 9–12 January 2005.

Lilieanny, Dharmaputra O.S. and Putri A.S.R. 2005. Population of storage moulds and aflatoxin content of processed peanut products. Jurnal Mikrobiologi Indonesia 10(1), 17–20 (*in Indonesian with abstract in English*).

Dharmaputra O.S., Retnowati I., Ambarwati S. and Maysra E. 2005. *Aspergillus flavus* infection and aflatoxin contamination in peanuts at various stages of the delivery chain in Wonogiri regency, Central Java, Indonesia. Summary, 'Proceedings of International Peanut Conference', Bangkok, Thailand, 9–12 January 2005.

Lee N.A. 2005. Immunodiagnostic tests for detecting food contaminants. Abstract, 38th Annual AIFST Convention 2005, Sydney Convention Centre, Darling Harbour, 10–13 July 2005.

Ginting E. 2005. The effects of preparation methods on the aflatoxin content of selected peanut food products. ILETRI report.

Ginting E., Tastra I.K., Fatah G.S.A. and Ratnaningsih. 2005. Teknologi pasca panen dan pengolahan kacang tanah untuk mendukung agroindustri. [Postharvest technology and peanut processing in support of agro-industry]. Temu Koordinasi Instansi Terkait Dalam Rangka Pengembangan Kacang Tanah Menuju Swasembada, Direktorat Jenderal Bina Produksi Tanaman Pangan, Yogyakarta [Coordination Meeting of Stakeholders in the Development of Peanut Enterprise, Directorate General for Development of Food Crop Production, Yogyakarta], 28–30 September 2005.

Ginting E., Tastra I.K. and Rahmianna A.A. 2005. Teknologi pasca panen kacang tanah untuk mendukung peningkatan mutu dan keamanan pangan [Postharvest technology for peanuts to support improvement of quality and food safety], Temu Usaha Pemasaran Kacang Tanah di Wilayah Regional Timur, Direktorat Jenderal Bina Pengolahan dan Pemasaran Hasil Pertanian, Denpasar [Meeting on Peanut Marketing Enterprise in the Eastern Regions, Directorate General for Development of Agricultural Product Processing and Marketing, Denpasar], 13–15 September 2005.

Rahmianna A.A. 2005. Pengelolaan lengas tanah dan umur panen pada infeksi *Aspergillus flavus* dan kontaminasi aflatoksin pada kacang tanah [Management of soil moisture and harvest time and effect on *Aspergillus flavus* infection and aflatoxin contamination in peanuts], Seminar Rutin Puslitbang Tanaman Pangan [Routine Seminar of the Agency for Agricultural Research and Development], Bogor, Indonesia, 28 July 2005.

Rahmianna A.A., Taufiq A. and Yusnawan E. 2005. Effect of end of season drought on pod yield and seed quality of Indonesian peanut genotypes. Seminar Hasil Penelitian Tanaman Kacang-Kacangan dan Umbi-Umbian, Puslitbangtan [Seminar on Results of Legumes and Tuber Crop Research, Centre of Agricultural Research and Development, Malang], 5 October 2004.

Lee N.A. 2005. Immunodiagnostic tests: rapid and cost-effective analytical technique for mycotoxin detection in stored grains, Conference Proceedings, 1st International Conference of Crop Security 2005, Brawijaya University, Malang, 20–22 September 2005.

Dharmaputra O.S., Retnowati I., Ambarwati S. and Maysra E. 2005. *Aspergillus flavus* infection and aflatoxin contamination in imported peanuts at various stages of the delivery chain in West Java, Indonesia. 1st International Conference of Crop Security, Malang, Indonesia, 20–22 September 2005.

Dharmaputra O.S. 2006. Aflatoxin on foodstuff and their processed products. 1st Aflatoxin Forum Indonesia, Yogyakarta, Indonesia, 4 February 2006.

Ginting E., Rahmianna A.A., Yusnawan E., Suprapto, Indrasari M., Kusumawati L. and Sutrisno L. 2006. The effects of preparation methods on the aflatoxin content of selected peanut food products, ACIAR project review, 27 July 2006.

Rahmianna A.A., Taufiq A. and Yusnawan E. 2006. Hasil polong dan kualitas biji kacang tanah varietas Kancil pada lengas tanah dan umur panen berbeda. [Pod yield and kernel quality of Kancil variety peanuts grown under different soil moisture with different harvest timings], Seminar Hasil Penelitian Tanaman Kacang-Kacangan dan Umbi-Umbian, Puslitbangtan [Seminar on Results of Legumes and Tuber Crop Research, Centre of Agricultural Research and Development], Malang, Indonesia 2006.

Wright G.C., Robson A. and Rachaputi Rao C.N. 2006. Remote sensing applications for peanuts in Australia and Papua New Guinea, in 'Improving yield and economic viability of peanut production in Papua New Guinea and Australia', ed. by Rachaputi Rao C.N., Wright G.C. Kuniata L. and Ramakrishna, A. ACIAR Proceedings No. 122, 106–111. Australian Centre for International Agricultural Research: Canberra.

Dharmaputra O.S., Retnowati I. and Ambarwati S. 2007. Physical quality and relative humidity affecting *Aspergillus flavus* infection and aflatoxin contamination in peanut kernels. Pp. 306–308 in 'Proceedings of 3rd Asian Conference on Plant Pathology', ed. by Sumardiyono Y.B. et al., Yogyakarta, Indonesia, 20–23 August 2007.

Dharmaputra O.S., Retnowati I. and Ambarwati S. 2007. *Aspergillus flavus* infection and aflatoxin contamination in peanuts stored at wholesale and retail in Bundang, Bogor and Jakarta (West Java, Indonesia). Pp. 510–517 in 'Proceedings of 10th International Working Conference on Stored Production protection', ed. by Carvalho MO et al., Estoril, Portugal, 27 June – 2 July 2010.

Setyabudi S., Sardjono, Raharjo S., Hidayat C., Rahayu E. and Suparmo 2014. CEMycoS: Currents, Future Research, and Community Outreach, IUMS Outreach Program on Food Safety and International Conference on Mycotoxin, 14–15 November 2014, Yogyakarta, Indonesia.

References

ACIAR 1994. Factors affecting invasion by *Aspergillus flavus* and aflatoxin formation in Asian peanuts. <http://aciar.gov.au/project/cp/1997/017>.

ACIAR 2014. ACIAR Strategic Plan 2014–18. <http://aciar.gov.au/files/strategic_plan_2014-18_accesspdf.pdf>.

ACIAR 2015. Agricultural Development Policy Research Program Strategy. <http://aciar.gov.au/files/adp_factsheet_update_2015.pdf>.

Alaniz Zanon M.S., Chiotta M.L., Giaj-Merlera G., Barros G. and Chulze S. 2013. Evaluation of potential biocontrol agent for aflatoxin in Argentinean peanuts. International Journal of Food Microbiology 162(3), 220–225.

ASEAN Taskforce on Codex Alimentarius. 2014. Regulatory limits of mycotoxins in ASEAN countries. <http://www.hsa.gov.sg/content/dam/HSA/ASG/Food_Safety/ASEANRefLab/Aflatoxins_2015.pdf>.

Bankole S.A., Ogunsanwo B.M. and Eseigbe D.A. 2005. Aflatoxins in Nigerian dry-roasted groundnuts. Food Chemistry 89(4), 503–506.

Biermann F. 2001. Big science, small impacts–in the South? The influence of global environmental assessments on expert communities in India. Global Environmental Change 11(4), 297–309.

Bocking S. 2004. Nature's experts: science, politics and the environment. Rutgers University Press: New Brunswick, NJ, USA.

Buizer J., Jacobs K., and Cash D. 2010. Making short-term climate forecasts useful: Linking science and action. Proceedings of the National Academy of Sciences of the United States of America, doi:10.1073/pnas.0900518107.

Carpenter D. and McGillivray M. 2012. A methodology for assessing the poverty-reducing impacts of Australia's international agricultural research. ACIAR Impact Assessment Series Report no. 78. Australian Centre for International Agricultural Research: Canberra.

Cash D. and Clark W.C. 2001. From science to policy: assessing the assessment process, Faculty Research Working Paper RWP01-045, John F Kennedy School of Government Harvard University: Cambridge, MA, USA.

Cash D.W., Clark W.C., Alcock F., Dickson N.M., Eckley N., Guston D.H. and Mitchell, R.B. 2003. Knowledge systems for sustainable development. Proceedings of the National Academy of Sciences of the United States of America 100(14), 8086–8091.

Chauhan Y., Wright G., Holzworth D., Rachaputi R.N. and Payero J. 2013. AQUAMAN: a web-based decision support system for irrigation scheduling in peanuts. Irrigation Science 31(3), 271–283.

Chauhan Y.S., Wright G.C., Rachaputi R.C.N., Holzworth D., Broome A., Krosch S. and Robertson M.J. 2010. Application of a model to assess aflatoxin risk in peanuts. The Journal of Agricultural Science 148(3), 341–351.

Clark WC., Tomich T.P., van Noordwijk M., Guston D., Catacutan D., Dickson N.M. and McNie E. 2011. Boundary work for sustainable development: natural resource management at the Consultative Group on International Agricultural Research (CGIAR). Proceedings of the National Academy of Sciences of the United States of America, doi:10.1073/pnas.0900231108.

Court J. and Young J. 2003. Bridging research and policy: insights from 50 case studies. Retrieved from Working Paper 213, Overseas Development Institute: London, UK.

Creswell J.W. 2007. Designing and conducting mixed methods research. Thousand Oaks: California Sage Publications: California, USA.

Crewe E. and Young J. 2002. Bridging research and policy: context, evidence and links. Retrieved from Working Paper 173, Overseas Development Institute: London, UK.

Dashti B., Al-Hamli S., Alomirah, H., Al-Zenki S., Abbas A.B. and Sawaya W. 2009. Levels of aflatoxin M1 in milk, cheese consumed in Kuwait and occurrence of total aflatoxin in local and imported animal feed. Food Control 20(7), 686–690.

Davis J., Gordon J., Pearce D. and Templeton D. 2008. Guidelines for assessing the impacts of ACIAR's research activities. ACIAR Impact Assessment Series Report no. 58. Australian Centre for International Agricultural Research: Canberra.

de Vibe M., Hovland I. and Young J. 2002. Bridging research and policy: an annotated bibliography. ODI Working Paper 174, Overseas Development Institute: London, UK.

Dharmaputra O. 2005. *Aspergillus flavus* infection and aflatoxin contamination in peanuts at various stages of the delivery chain in Cianjur regency, West Java, Indonesia. Biotropia 24, 1–19.

Dietzgen R.G. (ed.) 1999. Elimination of aflatoxin contamination in peanut: workshop report. Australian Centre for International Agricultural Research: Canberra.

Donaldson S., Azzam T. and Conner R. (eds.) 2013. Emerging practices in international development evaluation. Information Age Publishing Inc.: Charlotte, NC, USA.

Dovers S. 2005. Environment and sustainability policy: creation, implementation and evaluation. The Federation Press: Sydney.

Dugdale A., Sadleir C., Tennant-Wood R. and Turner M. 2012. Developing and testing tool for measuring capacity building. ACIAR Impact Assessment Series no. 79, Australian Centre for International Agricultural Research: Canberra.

Ezekiel C.N., Kayode F.O., Fapohunda S.O., Olorunfemi M.F. and Kponi B.T. 2012. Aflatoxigenic moulds and aflatoxins in street-vended snacks in Lagos, Nigeria. International Journal of Food Safety 14, 83–88.

Ezekiel C.N., Sulyok M., Babalola D.A., Warth B., Ezekiel V.C. and Krska R. 2013. Incidence and consumer awareness of toxigenic *Aspergillus* section *Flavi* and aflatoxin B1 in peanut cake from Nigeria. Food Control 30(2), 596–601.

Ezekiel C.N., Sulyok M., Warth B., Odebode A.C. and Krska R. 2012. Natural occurrence of mycotoxins in peanut cake from Nigeria. Food Control 27(2), 338–342.

Ferlay J., Shin H.-R., Bray F., Forman D., Mathers C. and Parkin D.M. 2010. Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. International Journal of Cancer 127(12), 2893–2917.

Florkowski W. and Kolavalli S. 2014. Strategies to control aflatoxin in groundnut value chains. IFPRI Discussion Paper 01369, International Food Policy Research Institute, Washington DC, USA.

Fujita, N. 2010. Beyond Logframe; Using Systems Concepts in Evaluation. Foundation for Advanced Studies on International Development: Tokyo, Japan.

Funtowicz S.O. and Ravetz J.R. 1993. Science for the post-normal age. Futures 25(7), 739–755.

Gardner T.A. 2008. Methods of assessing policy-oriented research: a review. In: 'Impact assessment of policy-oriented research in the CGIAR: evidence and insights from case studies'. Study commissioned by the Science Council Standing Panel on Impact Assessment, Rome, Italy.

Glaser G. and Bates P. 2011. Enhancing science-policy links for global sustainability. <http://www.stakeholderforum.org/fileadmin/files/ICSU%20Science%20Policy%20Final.pdf>.

Guston D. 1997. Critical appraisal in science and technology policy analysis: the example of science, the endless frontier. Policy Sciences 30(4), 233–255.

Henry S.H., Whitaket T.B., Rabbani I., Bowers J., Park D. and Price W. 2001. Aflatoxin M1: chemical safety information from intergovernment organizations. <www.inchem.org/documents/jecfa/jecmono/v47je02.htm>.

Hong Z., Zou S. and Giulivi A. 2001. Hepatitis B and its control in Southeast Asia and China. Canada Communicable Disease Report 27(supplement 3), 31–33.

Ingram J., Ericksen P. and Liverman D. 2010. Food security and global environmental change. Earthscan: London, UK.

Ison R. and Russell D. 2000. Agricultural extension and rural development: breaking out of traditions. Cambridge University Press: Cambridge, UK.

Jasanoff S. 2010. A new climate for society. Theory, Culture & Society 27(2–3), 233–253.

Kamika I. and Takoy L.L. 2011. Natural occurrence of Aflatoxin B1 in peanut collected from Kinshasa, Democratic Republic of Congo. Food Control 22(11), 1760–1764.

Kirchhoff C.J., Carmen Lemos M. and Dessai S. 2013. Actionable knowledge for environmental decision making: broadening the usability of climate science. Annual Review of Environment and Resources 38(1), 393–414.

Lahsen M. 2009. A science-policy interface in the global south: the politics of carbon sinks and science in Brazil. Climatic Change 97(3–4), 339–372.

Latour B. 1998. From the world of science to the world of research? Science 280, 208–209.

Lee N.A., Rachaputi N.C., Wright G.C., Krosch S., Norman K., Anderson J. and Kennedy I.R. 2005. Validation of analytical parameters of a competitive direct ELISA for aflatoxin B1 in peanuts. Food and Agricultural Immunology 16(2), 149–163.

Lee N.A. and Rachmawati S. 2006. A rapid ELISA for screening aflatoxin B1 in animal feed and feed ingredients in Indonesia. Food and Agricultural Immunology 17(2), 91–104.

Leeuwis C., Long N. and Villarreal M. 1990. Equivocations on knowledge systems theory: an actor-oriented critique. Knowledge, Technology and Policy 3(3), 19–27.

Linder B. 2011. Frameworks for assessing policy research and ACIAR's investment in policy-oriented projects in Indonesia. ACIAR Impact Assessment Series no. 72, Australian Centre for International Agricultural Research: Canberra.

Liu Y., Chang C.-C.H., Marsh G.M. and Wu F. 2012. Population attributable risk of aflatoxin-related liver cancer: systematic review and meta-analysis. European Journal of Cancer 48(14), 2125–2136.

Liu Y., and Wu F. 2010. Global burden of aflatoxin-induced hepatocellular carcinoma: a risk assessment. Environmental Health Perspectives 118(6), 818–824.

Lubulwa G. and Davis J. 1994. Estimating the social costs of the impacts of fungi and aflatoxins. In: Highley E., Wright E.J., Banks H.J. and Champ B.R. (eds), Proceedings of the 6th International Conference in Stored-Product Protection, Canberra,17–23 April 1994. 1017–1042. CAB International: Wallingford, UK.

Magnussen A. and Parsi M.A. 2013. Aflatoxins, hepatocellular carcinoma and public health. World Journal of Gastroenterology 19(10), 1508–1512.

Manuel-Navarrete D. and Gallopín G.C. 2012. Feeding the world sustainably: knowledge governance and sustainable agriculture in the Argentine Pampas. Environment, Development and Sustainability 14(3), 321–333.

McCullough E.B. and Matson P.A. 2011. Evolution of the knowledge system for agricultural development in the Yaqui Valley, Sonora, Mexico. Proceedings of the National Academy of Sciences of the United States, doi:10.1073/pnas.1011602108.

McMichael P. 2014. Historicizing food sovereignty. The Journal of Peasant Studies 41(6), 933–957.

Merican I., Guan R., Amarapuka D., Alexander M.J., Chutaputti A., Chien R.N. and Xu D.Z. 2000. Chronic hepatitis B virus infection in Asian countries. Journal of Gastroenterology and Hepatology 15(12), 1356–1361.

Midgley G. 2000. Systemic intervention: philosophy, methodology and practice. Kluwer Academic/Plenum Publishers: New York.

Mitchell R.B. and Clark W.C. 2004. Science, scientists and the policy process: lessons from global environmental assessments for the Northwest Forest Plan. In: Arabas K. and Bowersox J. (eds.), 'Forest futures: science, politics and policy for the next century'. Rowman & Littlefield Publishers: Maryland, USA.

Mutegi C., Wagacha M., Kimani J., Otieno G., Wanyama R., Hell K. and Christie M.E. 2013. Incidence of aflatoxin in peanuts (*Arachis hypogaea* Linnaeus) from markets in Western, Nyanza and Nairobi Provinces of Kenya and related market traits. Journal of Stored Products Research 52(0), 118–127.

Overseas Development Institute. 2004. Bridging research and policy in international development. <http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/198.pdf>.

Palis F., Sumalde Z., Torres C., Contreras A. and Datar F. 2013. Impact pathway analysis of ACIAR's investment in rodent control in Vietnam, Lao PDR and Cambodia. ACIAR Impact Assessment Series Report no. 83. Australian Centre for International Agricultural Research: Canberra.

Pearce D. 2002. Measuring the poverty impact of ACIAR projects: a broad framework. ACIAR Impact Assessment Series Report no. 19. Australian Centre for International Agricultural Research: Canberra.

Pearce, D. 2005. Review of ACIAR's research on agricultural policy. ACIAR Impact Assessment Series Report no. 31. Australian Centre for International Agricultural Research: Canberra.

Pearce D. and White L. 2012. Including natural resource management and environmental impact within impact assessment studies: methodological issues. ACIAR Impact Assessment Series no. 81. Australian Centre for International Agricultural Research: Canberra.

Pei S.C., Zhan, Y.Y., Eremin S.A. and Lee W.J. 2009. Detection of aflatoxin M1 in milk products from China by ELISA using monoclonal antibodies. Food Control 20(12), 1080–1085.

Qureshi M.E., Dixon J. and Wood M. 2015. Public policies for improving food and nutrition security at different scales. Food Security 7(2), 393–403.

Rahayu E. 2012. Controlling aflatoxin in the food chain: the Indonesian experience. Sixth Asian Conference on Food and Nutrition Safety, Singapore, 26–28 November 2012.

Roux D., Kingsford R., McCool S., McGeoch M. and Foxcroft L. 2015. The role and value of conservation agency research. Environmental Management 55(6), 1232–1245.

Scoones I. and Thompson J. (eds) 1994. Beyond farmer first: rural people's knowledge, agricultural research and extension practice. Intermediate Technology Publications: London, UK.

Semple R., Frio A., Hicks P. and Lozare J. (eds.) 1991. Mycotoxin prevention and control in foodgrains. ASEAN Grain Postharvest Programme: Bangkok, Thailand.

Strosnider H., Azziz-Baumgartner E., Banziger M., Bhat R.V., Breiman R., Brune MN. and Wilson D. 2006. Workgroup report: public health strategies for reducing aflatoxin exposure in developing countries. Environmental Health Perspectives 114(12), 1898–1903.

Tsui J., Hearn S. and Young J. 2014. Monitoring and evaluation of policy influence and advocacy. Working Paper 395, Overseas Development Institute: London, UK.

van den Hove S. 2007. A rationale for science–policy interfaces. Futures 39(7), 807–826.

Van der Ploeg J.D. 2010. The food crisis, industrialized farming and the imperial regime. Journal of Agrarian Change 10(1), 98–106.

van Hattum J., Boland G.J., Jansen K.G., Kleinpenning A.S., van Bommel T., van Loon A.M. and van den Berg J. 2003. Transmission profile of hepatitis B virus infection in the Batam region, Indonesia: evidence for a predominantly horizontal transmission profile. Advances in Experimental Medicine and Biology 531, 177–183.

van Kerkhoff L. 2005. Integrated research: concepts of connection in environmental science and policy. Environmental Science and Policy 8, 452–463.

Van Kerkhoff L. 2013. Knowledge governance for sustainable development: a review. Challenges in Sustainability 1(2), 82–93.

van Kerkhoff L. and Lebel L. 2006. Linking knowledge and action for sustainable development. Annual Review of Environment and Resources 31(1), 445–477.

van Kerkhoff L. and Szlezak N.A. 2006. Linking local knowledge with global action: examining the Global Fund to Fight AIDS, Tuberculosis and Malaria through a knowledge systems lens. Bulletin of the World Health Organization 84(8), 629–635.

van Kerkhoff L. and Szlezak N.A. 2010. The role of innovative global institutions in linking knowledge and action. Proceedings of the National Academy of Sciences of the United States, doi:10.1073/pnas.0900541107.

Williams B. and Imam I. (eds.) 2007. Systems concepts in evaluation: an expert anthology. EdgePress / American Evaluation Association: Point Reyes, CA, USA.

Williams J.H., Phillips T.D., Jolly P.E., Stiles J.K., Jolly C.M. and Aggarwal D. 2004. Human aflatoxicosis in developing countries: a review of toxicology, exposure, potential health consequences, and interventions. The American Journal of Clinical Nutrition, 80(5) 1106–1122.

Williams J.T. 2008. Institutional stakeholders in mycotoxin issues—past, present and future. In Leslie J.F., Bandyopadhyay R. and Visconti A. (eds.), 'Mycotoxins: detection methods, management, public health and agricultural trade'. CAB International: Oxfordshire, UK.

World Bank 2008. Global Development Report: agriculture for development. The World Bank: Washington DC, USA.

Wright G.C. and Rachaputi N.C. 2011. Adoption study report: reducing aflatoxin in peanuts using agronomic management and bio-control strategies in Indonesia and Australia. <http://aciar.gov.au/files/node/14130/reducing_aflatoxin_in_peanuts_using_agronomic_mana_12046.pdf>.

Wu F., Bhatnagar D., Bui-Klimke T., Carbone I., Hellmich R., Munkvold G. and Takle E. 2011. Climate change impacts on mycotoxin risks in US maize. World Mycotoxin Journal 4(1), 79–93.

IMPACT ASSESSMENT SERIES

No.	Author(s) and year of publication	Title	ACIAR project numbers
1	Centre for International Economics 1998.	Control of Newcastle disease in village chickens	AS1/1983/034, AS1/1987/017 and AS1/1993/222
2	George P.S. 1998.	Increased efficiency of straw utilisation by cattle and buffalo	AS1/1982/003, AS2/1986/001 and 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 and CS2/1989/019
6	Ryan J.G. 1998.	Pigeonpea improvement	CS1/1982/001 and 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 and FST/1988/048
9	ACIL Consulting 1998.	Sulfur test KCL–40 and growth of the Australian canola industry	PN/1983/028 and 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 and 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 and CS1/1988/039
14	McLeod R., Isvilanonda S. and Wattanutchariya S. 1999.	Improved drying of high moisture grains	PHT/1983/008, PHT/1986/008 and 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 and 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 Southeast Asia	AS1/1983/067, AS1/1988/035, AS1/1992/004 and AS1/1994/038
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 and AS2/1993/001

No.	Author(s) and year of publication	Title	ACIAR project numbers
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 and CS1/1988/014
26	Mullen J.D. 2004.	Impact assessment of ACIAR-funded projects on grain-market reform in China	ADP/1997/021 and 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 and 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 and 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 and FIS/1999/076
37	McLeod R. 2005.	Management of fruit flies in the Pacific	CS2/1989/020, CS2/1994/003, CS2/1994/115 and CS2/1996/225
38	ACIAR 2006.	Future directions for ACIAR's animal health research	
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 and 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 and 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 and LWR2/1998/034

No.	Author(s) and year of publication	Title	ACIAR project numbers
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 and AS2/1999/060
47	Fisher H. and Gordon J. 2007.	Improved Australian tree species for Vietnam	FST/1993/118 and 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 and 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
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 and FIS/2006/144
56	Lindner B. and McLeod P. 2008.	A review and impact assessment of ACIAR's fruit-fly 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 and 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 and 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

IMPACT ASSESSMENT SERIES <CONTINUED>

No.	Author(s) and year of publication	Title	ACIAR project numbers
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 and 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 and 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 and 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
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 and 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 and 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 and 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 and PLIA/2000/165
76	Grewal B., Grunfeld H. and Sheehan P. 2011.	The contribution of agricultural growth to poverty reduction	

No.	Author(s) and year of publication	Title	ACIAR project numbers
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 and CSE/2006/124
78	Carpenter D. and McGillivray M. 2012	A methodology for assessing the poverty-reducing impacts of Australia's international agricultural research	
79	Dugdale A., Sadleir C., Tennant-Wood R. and Turner M. 2012	Developing and testing a tool for measuring capacity building	
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
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 and 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

IMPACT ASSESSMENT SERIES <CONTINUED>

No.	Author(s) and year of publication	Title	ACIAR project numbers
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
90	Pearce D. 2016	Impact of private sector involvement in ACIAR projects: a framework and cocoa case studies	PC/2006/114, ASEM/2006/127, SMAR/2005/074, HORT/2010/011
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

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