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Recognising the Contribution of Capacity Building in ACIAR Bilateral Projects: Case Studies from Three IAS Reports

ACIAR IMPACT ASSESSMENT SERIES 93

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Recognising the Contribution of Capacity Building in ACIAR Bilateral Projects: Case Studies from Three IAS Reports

John Mullen, Julien de Meyer, Doug Gray, Geoff Morris

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Cover: Dr Nghiem Quyen Chi forestry scientist carrying out cutting-edge research on polyploidy in tropical acacias in Vietnam (Photo: Sally Ingleton).

Foreword

ACIAR commissions projects that produce results through the interplay of activities: the partnership role is pivotal and enhances the knowledge discovery gained through trials, experiments and analysis. Moreover, we expect that the training and experience acquired by the scientists, particularly the partner-country scientists, will lift their capacity to contribute more effectively to the project itself and also lead on to significant contributions to later projects.

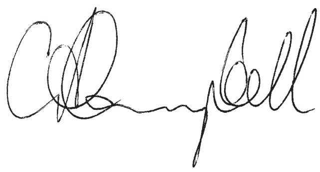
While there is much anecdotal evidence to affirm that this is taking place, no process to date has attempted a quantitative evaluation of these contributions. I welcome this report, which has attempted to rectify the situation by revisiting past projects and through retrospective studies reach some sound conclusions on how capacity building has made a difference.

As the authors say, outcomes of a project are the joint products of all component activities, and they needed to rely on some subjective judgments from Vietnamese scientists, science managers and economists. Their task was to recall many years after project completion their perspectives on the capacities they had directly acquired through participation in an ACIAR project—a challenge in itself! Yet the scientists interviewed had little trouble listing some of the vital skills they acquired: trial management, experimental design, data analysis, scientific writing, English language and presentation skills, and linkage to scientific networks were regularly mentioned.

In all three case studies, the scientists could demonstrate that capacities built in the initial projects were key building blocks for succeeding ACIAR projects. Such skills also inevitably led to institutional strengthening, and the scientists contended that the ACIAR experience spilt over into other areas of work and assisted their own professional development. Specific instances are listed of how scientists receiving either the John Allwright or John Dillon Fellowships have progressed to significant leadership roles and received awards.

The partnership aspect is integral to all ACIAR projects, and it is pleasing to note that both Australian and Vietnamese scientists recognised the benefits of working in multidisciplinary teams—and also resulting in jointly authored scientific papers. The linkages into networks with other countries, from which they can learn and to which they can contribute, provide further evidence of strengthening institutional capacity.

For ACIAR, the work of the authors towards developing a more refined pathway connecting capacity building activities to gains in economic welfare for farmers is useful and timely, and will no doubt lead us to review the way we plan, execute and assess future projects.



Professor Andrew Campbell
Chief Executive Officer, ACIAR

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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
AIDAB	Australian International Development Assistance Bureau
APP	Asia Pulp and Paper
AusAID	Australia Overseas Aid Program and Funding Source (since 1995; formerly AIDAB)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAT	Domestication of Australian Trees
FAO	Food and Agriculture Organization of the United Nations
FSIV	Forest Science Institute of Vietnam
IAS	Impact Assessment Series
JAF	John Allwright Fellowship
MARD	Ministry of Agriculture and Rural Development
NSW DPI	New South Wales Department of Primary Industries
RIA1	Research Institute for Aquaculture No. 1, Vietnam
SAREC	SIDA's Department of Research Cooperation
SAT	Seeds of Australian Trees
SIDA	Swedish International Development Cooperation Agency
UTAS	University of Tasmania
VAFS	Vietnam Academy of Forest Sciences
VND	Vietnamese Dong

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Executive Summary

Bilateral projects sponsored by the Australian Centre for International Agriculture Research (ACIAR) typically fund activities across a spectrum, including human capacity building and the development of farm ready technologies, in pursuit of economic, social and environmental benefits. In the interests of better project design, it is reasonable to enquire about the impact of these alternative investments.

ACIAR has a strong record in estimating changes in economic welfare from the development of new technologies. However, these estimated changes accrue to all the activities in the project and rarely have analysts attempted to attribute these gains with respect to individual activities. Furthermore, some activities, which build up stocks of human or scientific capital, are expected to contribute to the development of technologies in later projects. While generally the potential of these later contributions is identified, they have not been valued quantitatively.

ACIAR has funded several studies with a view to being able to identify, report and value its capacity building activities in a more systematic and transparent way, notably those by Gordon and Chadwick (2007) and Gray et al. (2015). The research reported here, which follows on from Gray et al. (2015), is one of two components of a larger project identifying and reporting on the outcomes from ACIAR's capacity building activities. This larger project used as case studies two research institutions in Vietnam: the Vietnam Academy of Forest Sciences (VAFS) and the Research Institute for Aquaculture No. 1 (RIA1). The other component of this project examined capacity building in the context of formal training programs funded by ACIAR, specifically the John Allwright and John Dillon Fellowships, and capacity building at an institutional level (Morris et al., forthcoming 2017).

The focus of this second component was on bilateral research projects where capacity building activities usually take the form of mentoring, learning by doing, and short courses. Capacity building is likely to contribute to the successful outcomes of the project in which it was developed, but it can also add to the stock of human capital that potentially yields a flow of services many years into the future in the form of new technologies used by farmers.

We revisited two forestry projects and one fishery project, partly funded by ACIAR, which have been subject to benefit–cost analyses. Our objectives here were, first, to revisit some of the key parameters driving the reported economic gains to confirm that these technologies were still likely to be profitable for farmers and good investments for ACIAR. A second objective was to more carefully describe the specific capacities developed in these projects and to assess the contribution of capacity building to their outcomes relative to the contribution of knowledge discovery processes. A third objective was to search for evidence that the set of capacities developed had in fact been used in later research activities to develop new technologies adopted by farmers. A final objective of this research has been to develop guidelines that will assist ACIAR to more consistently identify and report on capacity building activities in its project development, reporting and impact assessment processes.

Analysing the contribution of capacity building to gains in economic welfare is constrained by the theoretical and empirical impossibility of objectively identifying the separate contributions of capacity building and other research activities such as knowledge discovery activities based on trials and experiments (see below and Mullen et al. 2015). The outcomes of a project are the joint products of all the activities comprising the project. Monitoring and assessing capacity building necessarily requires scientists, science managers and economists to make a set of subjective judgements about the contribution of capacity building, both to the initial projects and to later projects where that capacity has been applied. Our study was based on personal interviews with Vietnamese and Australian scientists who had been involved in the projects using a questionnaire tailored for each project.

The inherent subjectivity of the problem presented several challenges. Eliciting subjective judgements many years after the completion of projects is a source of uncertainty. Another challenge for the scientists in this instance was to associate capacity building and the impact of technology with the specific set of resources invested during the initial projects rather than with the broader research programs within which the projects were situated, especially since it had been many years since the projects were completed.

Perhaps a source of greater uncertainty was a set of what might be termed 'framing' challenges arising from the difficulties of clearly distinguishing between capacity building and knowledge discovery processes, due in part to the preconceptions of scientists as well as the capacity building context of the study and language issues associated with abstract concepts like 'capacity building' and 'knowledge discovery'. These difficulties are discussed in more detail in Section 2.

Revisiting the three case study impact assessment analyses

The three case studies were:

- Acacia Hybrids in Vietnam (FST/1986/030)
- Improved Australian Tree Species in Vietnam (FST/1993/118 and FST/1998/096)
- Building Bivalve Hatchery Production Capacity in Vietnam and Australia (FIS/2005/114).

The two forestry projects had previously been subject to the ACIAR impact assessment process (Fisher and Gordon 2007; van Bueren 2004). The economic impact of the bivalve project was also subject to a benefit–cost analysis but commissioned by the project team towards the end of the project (Johnston 2012). In all cases there was evidence of adoption of the technology by farmers, and the actual and projected gains in economic welfare exceeded the investment by ACIAR and partners—by a wide margin in the case of the forestry projects.

We did not attempt to update all parameters and re-estimate the welfare gains arising from each of the projects. Rather we focussed on trends in the key parameters that influence the extent of welfare gains—the extent of adoption of the technology reflected in the size of the industry, and the cost saving or change in profit associated with the technology. There have been other changes in economic conditions since the technologies were developed, such as changes in the regulatory environments, other R&D-induced changes in technology, and more general changes in demand and supply conditions. We have not attempted to address the severe attribution issues in accounting for the separate contributions of these industry-wide changes. Rather, we have settled for making a judgement about whether the technology developed has remained attractive to farmers and hence that the original assessments that the projects earned good rates of return to the investments by ACIAR and its partners still hold.

Plantings of parent acacia and hybrid acacias now far exceed projections made by van Bueren (2004) and Fisher and Gordon (2007), and the yields of timber they used are now regarded as being too conservative. There is uncertainty about the trend in real timber prices; perhaps they have fallen a little. However, the high rates of return estimated in these impact assessments (Fisher and Gordon 2007; van Bueren 2004), which were partly based on future projections about the adoption of technologies developed during the project, seem most likely to have held up in the years since these analyses.

Trends in the oyster industry in Vietnam have not been so rosy. Production is perhaps 25% less than projected by Johnston (2012), and a significant proportion of the industry uses cheap spat from China that have high mortality and slow growth rates. More positively, oyster growing has spread more widely in Vietnam and private hatcheries have emerged using skills developed in the initial project at Cat Ba. While the rate of return estimated by Johnston (2012) may not yet have been achieved, a strong breeding project being developed in an ongoing ACIAR project at Cat Ba may lead to the sustainable growth of a profitable oyster industry in Vietnam.

Capacities built during the three case studies

The scientists we interviewed had little trouble in listing sets of skills developed during the projects. The Vietnamese scientists identified a set of generic research tools common to the projects covered by the three benefit–cost analyses, including:

- trial management
- experimental design
- data analysis
- scientific writing
- English language and presentation skills
- scientific networks.

These skills were developed to a greater or lesser degree across all projects as the needs of the project demanded and the existing capacities of team members allowed. So, for example, there was little emphasis on experimental design and data analysis in the bivalve project because at that stage a breeding program had not yet been initiated.

These generic skills were not sufficient to achieve the project objectives, and it is likely they were less necessary to achieve project outcomes than some of the technical skills required to undertake the trials that were integral to the project's success. The Vietnamese scientists were quick to identify the contribution of ACIAR projects to the development of 'softer' skills such as scientific writing and English language and presentation skills. The pathway to changes in farm practice is more indirect for such capacities. Nevertheless, these skills likely increase the access of Vietnamese scientists to the international scientific community and make new knowledge more accessible sooner. The opportunity to maintain and incrementally increase capacity was an important benefit of a succession of ACIAR-funded projects. This is an appealing argument but nevertheless must be supported by evidence that there is a plausible pathway to productivity gains by farmers and/or environmental or human health gains to the people of Vietnam.

Some skills acquired during capacity building were technical in nature and closely related to the projects' research processes and the technology being developed. The potential future uses of these skills in developing technologies were relatively easy to conjecture. The specific skills developed in each project are enumerated later in this report.

The project-specific skills developed in the Seeds of Australian Trees (SAT) and Domestication of Australian Trees (DAT) projects included:

- hybridisation
- cutting propagation
- seed technology skills (including seed extraction and storage)
- managing a seed database (documentation and characterisation of seed).

The three projects all dealt with technologies to manage and breed from germplasm, hence the skills developed in the acacia hybrid and oyster projects have similar elements to those listed for the SAT and DAT projects.

We asked the scientists for a subjective judgement about the contribution to final project outcomes of capacity building activities relative to knowledge discovery activities in the form of experimental work. Both Australian and Vietnamese scientists for the acacia hybrid project rated capacity building to knowledge discovery as 20:80. For the SAT/DAT projects and the oyster project the Vietnamese rated the two equally (50:50) whereas the Australian scientists credited capacity building activities more highly (about 70:30) in achieving final outcomes. As expected, both the capacities developed and the trials and experiments were necessary to achieving the projects' outcomes of more profitable varieties but neither were sufficient on their own.

This interdependency makes sense. Projects with a strong knowledge discovery component leading to farm ready technologies are most likely to have opportunities to develop valuable skills and capacities. Projects that focus entirely on capacity building will not lead to farm ready technologies in the life of the project.

Evidence that capacity built is being utilised

While capacity building may have some non-use value to society, generally it has value when used to develop new technologies adopted within the economy. The gold standard for demonstrating that capacity built has actually been utilised is to be able to report the adoption by farmers of technologies or varieties that can be traced back to the initial projects while recognising that such outcomes result not just from the original capacity building but from subsequent research and extension investments and from changes in economic conditions. We did not achieve the gold standard, partly because appropriate data were unavailable, but also because of inexperience on the part of scientists and economists in being able to develop plausible (though still conjectural) impact pathways linking capacity building and other activities with outcomes beyond the life of the initial projects.

However, in all three cases, scientists were able to demonstrate that capacities built in the initial projects were key building blocks for succeeding ACIAR projects, for other research programmes in their institutions and for their own professional development. For example, Dr Nghiem Quyen Chi and Dr Le Son were awarded John Allwright Fellowships to undertake graduate study in forestry at the University of Tasmania (UTAS). Dr Chi has since returned to lead tissue culture research at VAFS, continuing research into polyploidy in acacias, and is a lead scientist in a new ACIAR project to breed resistance to crown wilt disease in acacias. In 2016 she was awarded an Australia–APEC Women in Research Fellowship allowing her to spend 3 months at UTAS.

The capacities developed in our three case studies related to the ability of scientists to conduct sophisticated breeding programs, certainly in forestry, and increasingly so in oyster production. There is an associated scientific infrastructure component in the form of the creation of sources of genetic material and the ability of nurseries and hatcheries in various environments in Vietnam to be able to use this genetic material.

Specific outputs can also be identified. In the case of forestry, the Ministry of Agriculture and Rural Development (MARD) has released a further 14 acacia hybrids since the first project and 70 varieties of parent acacia varieties, eucalyptus varieties and eucalyptus hybrids since 1998 but data on adoption by variety, for example, were unavailable. Other outputs include a stream of scientific publications.

Increased human capacity in individual scientists has likely ‘spilled over’ into ‘institutional strengthening’ in the words of Gordon and Chadwick (2007) or institutional capacity. For the capacity of the institution to exceed the sum of the capacities of individual scientists there must be gains from cooperation and teamwork. Institutional capacity is explored more fully in the companion study by Morris et al. (forthcoming 2017). The scientists we interviewed remarked that formal training (through John Dillon Fellowships in particular) improved their project management skills, and informal training through bilateral research projects gave them a greater appreciation of the gains from cross-disciplinary teamwork.

Both Australian and Vietnamese scientists commented that working on ACIAR projects gave them a greater appreciation of the benefits from working in multidisciplinary teams. Some evidence for this teamwork comes in the form of jointly authored scientific papers. Increasing international recognition of Vietnamese scientists has led to increasing international recognition of VAFS and RIA1 and leadership in multilateral research partnerships—all evidence of increasing institutional capacity.

The Vietnamese scientists said that the SAT and DAT projects allowed them to enter a network of international scientists and from this network they both advance their own skills but also contribute to skill development in other countries. With Thailand they lead forestry research in South East Asia and work collaboratively with scientists in South Africa and Brazil, countries at the forefront of plantation research particularly with respect to eucalypts.

Implications for the management of capacity building by ACIAR

One of our objectives has been to assess the feasibility of making more explicit the path by which capacities developed might be, or have been, utilised in later projects. Given the impossibility of objectively identifying and separating the impact of knowledge discovery and capacity building processes, it seems to us that the only feasible way of making credible subjective judgements about capacity building is through plausible impact pathways through to projected adoption of technologies on farm, even if conjectural.

Developing explicit impact pathways is a key recommendation of reports by Davis et al. (2008) and by Gordon and Chadwick (2007) on impact assessment processes. Generally these pathways have been limited to the immediate outcomes of the projects under assessment. Our expectation is that enriching impact pathways by tracing out potential pathways by which capacity may be utilised in the future and how new technologies developed might end up on farm is not an onerous task.

The impact of capacity building is likely to be more easily identified if more attention is spent on describing capacity building at all stages of the project development and reporting processes and in impact assessment studies. The intent is to develop a plausible causal pathway from capacity building activities to gains in economic welfare for farmers even if some of the evidence is subjective, anecdotal and conjectural. Such pathways provide evidence that capacity building activities are chosen purposefully.

Some minor amendments to project proposal and reporting processes may lead to more clearly defined and useful impact pathways and improvements in the reporting of capacity building activities. Clearer guidelines appear warranted for those sections projecting economic, social and environmental impacts.

Ideally, proposals and reports would make projections from a project's resources and activities about the impact of the technology on farm level costs and/or profits, about the target population for the technology, and about likely adoption and how adoption will be achieved. As the project moves to conclusion these key impact parameters would be revised as adoption begins. Parameter values become more certain at the time of an impact assessment, but future adoption levels are still somewhat conjectural.

Potential impacts should be clearly related back to the pool of resources available to the project through an impact pathway.

Effort presently spent speculating about project impacts on aggregate economic measures, such as changes in imports or exports, could be better directed to developing impact pathways focussing on farm level impacts during the initial project but also making conjectures about future farm level impacts from capacities developed during the project.

Integrated into the impact pathway should be a similar process for capacity building, although because of the likely long lags before increased capacity is reflected in new technologies, the pathway is more conjectural. In the project planning and proposal stages, capacities to be developed could be described. As the project moves to completion, capacities built can be identified and subsequently, in final reports and later impact assessments, projections made about a plausible pathway through later research programs (and the resources or activities required) to the eventual development and adoption of technologies by farmers. Capacities and skills developed in the course of projects can be more systematically reported than is presently the case.

These improvements in reporting capacity building activities and outcomes are possible without adding significantly to reporting and assessment costs and are likely to improve project design and final impact.

1 Introduction

Research funders like ACIAR typically invest in activities across a spectrum, including human capacity building, in pursuit of economic, social and environmental benefits. The nature of capacity development varies from institutional and organisational strengthening, informal individual on-the-job training, including mentoring and learning by doing, to formal individual qualifications from Australian and partner country institutions. Economists would suggest that ideally they allocate their resources such that the returns from these activities at the margin are similar, but information about marginal returns is scarce.

ACIAR has a strong record in estimating the impact of research leading to new technologies. However, there is much less experience in valuing research activities that add to human scientific capacity through either discrete training programs or the learning-by-doing component of every research program. ACIAR commissioned Gordon and Chadwick (2007) to review the literature, devise an evaluation framework and apply their approach in two case studies. They partitioned an estimate of total welfare gains from a new technology between capacity building and research components, only qualitatively recognising spillovers to later technology development.

Gray et al. (2015) were commissioned to develop a program of research extending the work of Gordon and Chadwick to provide further confidence in the value of ACIAR's investment in capacity building and to develop practical processes by which investment in capacity building and the benefits from capacity building could be routinely incorporated in its project development, reporting and impact assessment processes. They agreed with the view of Gordon and Chadwick (2007), who concluded their report saying:

> Applying quantitative techniques to capacity-building investments presents many empirical challenges. But it is important to persevere in trying to quantify the impacts in order to understand the relative benefits of the capacity-building investments . . . . The simple process of thinking through capacity built, how capacity is utilised and what the impact of this has been or will be will raise the quality of these investments in the future and allow better recognition of the value added by capacity building in the future. (p. 97)

This new project follows the recommendations of Gray et al. (2015) to focus on forestry and fisheries projects funded by ACIAR in two research institutions in Vietnam: the Research Institute for Aquaculture No 1 (RIA1) and the Vietnam Academy of Forest Science (VAFS). Companion research initiatives have been developed to address capacity-building impacts from two perspectives.

The companion project to this impact assessment: 'The Value of Capacity Building in Bilateral Research Projects: Institutional and Individual Perspectives in Vietnam' (Morris et al., forthcoming 2017) has examined the impact of capacity building at the level of whole research institutions, namely the RIA1 and the VAFS in Vietnam.

An important goal of ACIAR is to build the capacity of institutions in developing countries to develop, administer and undertake research in their agriculture, fisheries and forestry sectors. The objective of this companion project was to document, at least qualitatively, the way in which the two Vietnamese institutions have changed because of ACIAR-funded capacity building activities. An important component of this project was to identify the impact of formal training programs such as the John Allwright and John Dillon

Fellowships, not only on the research programs of the Fellows but also on the two institutions.

The second study, described here, examines the impact of capacity building from a traditional project perspective. A number of research projects in the two institutions have been subject to ACIAR impact assessment processes. In the case of VAFS, the impact of research leading to the widespread adoption of hybrid acacia and improved varieties of acacia and eucalypts for plantation forestry in Vietnam has been assessed and reported in Impact Assessment Series (IAS) 27 (van Bueren 2007) and 47 (Fisher and Gordon 2012). The estimated rates of return to the projects evaluated were very high.

Both of these impact assessment reports have been reviewed either by Raitzer and Lindner (2005, IAS 35) or by Linder et al. (2013, IAS 86) and were rated in the highest category, 'convincing', based on their sound methodology, plausible assumptions and demonstrated adoption. However, both reports (IAS 27 and 47) predated the work of Gordon and Chadwick (2007) and hence little attention was paid to identifying and reporting on the capacity building outcomes from the research projects.

Within RIA1, ACIAR has partly funded projects towards developing an oyster industry in Vietnam. The key component of the initial project was to develop nursery and hatchery facilities and skills in Vietnam to produce oyster seed stock for farmers. While not undertaken within the ACIAR impact assessment program, this project was subject to a benefit–cost analysis by Johnston (2012) who found positive though modest returns to investment by ACIAR and its Australian and Vietnamese partners. Capacity building was not directly addressed in this report but training Vietnamese scientists in hatchery technologies in Australia was an important component of the project.

1.1 Objectives

The focus of this study was on the contribution of capacity building to the outcomes of bilateral research projects. It was beyond the resources available to us to review all bilateral projects in RIA1 and VAFS. Instead we focussed on three research areas that have been subject to benefit–cost analysis and found to deliver high rates of return to ACIAR and its partners. The three research areas were:

- Acacia Hybrids in Vietnam
- Improved Australian Tree Species in Vietnam
- Building Bivalve Hatchery Production Capacity in Vietnam and Australia

Our objectives in reviewing these projects were to:

- revisit some of the key parameters driving the economic gains reported in these previous studies to confirm that these technologies were still likely to be profitable for farmers;
- more carefully assess the importance of capacity building in these projects and contributions to later projects to establish that capacity building is an important component of successful projects and hence is an efficient use of the resources provided by ACIAR and partners;
- describe more clearly the capacity built during these projects and link as objectively as possible specific capacities developed with specific examples of how this capacity was used in later research to develop technologies adopted by farmers; and
- develop guidelines to assist ACIAR to more consistently identify and report on capacity building activities in its project development, reporting and impact assessment processes.

We purposely chose to work with VAFS and RIA1 in Vietnam because ACIAR has had a history of successful projects with these organisations. No doubt this means that we were also working with highly motivated and successful scientists. For similar reasons, we chose as case studies in this report three projects that had previously been assessed as being good investments for ACIAR. Obviously this raises concern about selection bias and attributing to ACIAR benefits that would have accrued anyway. In the case of capacity building, highly motivated Vietnamese scientists may have found other avenues to develop their scientific capacity. In our view, there is no need to be apologetic about our choices.

There has been little research done in this difficult area of assessing capacity. It made sense to us to start with successful institutions, scientists and projects to see what could be learnt about capacity building without confounding our enquiry with trying to understand why projects had been less successful than anticipated. We hope that our findings can be applied across the ACIAR portfolio.[1]

The appropriateness of case study methods to test hypotheses and generalise findings has been extensively debated (Flyvbjerg 2006). Formally, we were interested in testing the hypothesis that capacity built in one research project spills over to other research areas, providing additional economic benefits. Our case studies (at both the level of the institutions chosen and the three research areas) can be thought of as critical cases (in Flyvbjerg's terms). If we were unable to identify spillover economic gains from capacity built in these successful projects, then the prospects of finding spillovers in less successful projects would be much lower. Yin (1994, as referenced in Crosthwaite et al. 1997) argues that such case studies are analogous to a series of experiments and as such need not necessarily be representative of a population.

Perhaps more importantly, the case study approach allowed us to test processes to elicit capacity built and how it was utilised and to develop guidelines for how ACIAR might do this routinely in future.

1.2 Structure of the Report and the Three Cases Studies

In the next section the methodology applied and the theoretical and practical difficulties of identifying the contribution of capacity building from other project activities are described.

In Sections 3 to 5 the three cases studies are presented. The objective in each case study was to describe a plausible pathway linking capacity built during the projects under review with the later use of these capacities and subsequent development of technologies adopted by farmers. The common structure of these case studies is:

1. Revisit benefit–cost analyses of the project(s) under review to ascertain that the technologies developed remained attractive to farmers.
2. Identify and describe capacities developed and their contribution to project outcomes relative to the contribution of knowledge discovery processes such as experimental trials.
3. Trace out how capacities built have been applied and strengthened in later projects leading to outcomes enhancing the welfare of Vietnamese farmers.

[1] Projects for impact assessment have not typically been selected randomly and yet the returns from the sample of projects assessed have more than exceeded ACIAR's total investment over the same period.

2 Methodology

There are three dimensions to the methodology used in this study. One dimension, discussed in Section 2.1, is the economic framework used to assess the impact of the research activities in general on the welfare of farmers and the consequent estimated rates of return to investment in R&D. In Section 2.2, the framework is disaggregated to consider the impact of capacity building activities on economic welfare conceptually and the practical and theoretical difficulties of separating the impact of capacity building from other research activities. The third dimension, Section 2.3, concerns how processes and difficulties by which capacities built during the three case studies were identified and described and our attempts to develop plausible pathways linking capacity built during the projects with the later use of these capacities and subsequent development of technologies adopted by farmers.

2.1 The Welfare Analysis Framework

ACIAR generally requires that impact assessments are based on traditional principles of welfare analysis as described in Davis et al. (2008). The main principles can be distilled from a market model (Figure 1).

The change in economic welfare (or economic surplus) from a technology that lowers the unit cost of

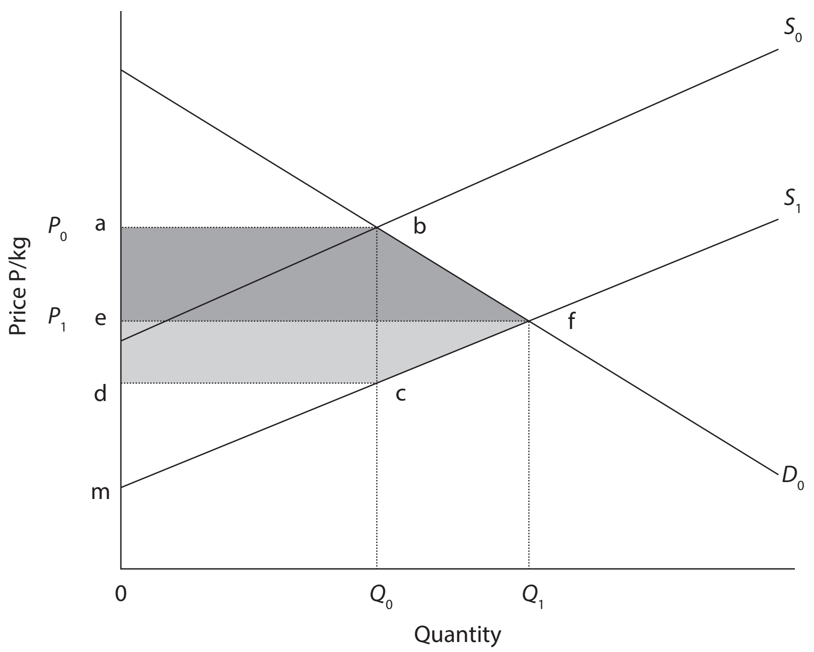

Figure 1. Approximating the impact of new technology

production by *bc* in Figure 1, often referred to as the K–shift, is given by the sum of the two gray shaded areas where the darker area is the gains to consumers, CS, and the lighter area is the gain to producers, PS. The change in total economic surplus, TS, can be estimated as:

$$\Delta\ TS = \Delta\ CS + \Delta\ PS$$
$$= P_0 \times Q_0 \times k(1 + 0.5 \times Z \times n) \text{ where}$$
$$Z = \frac{ke}{(e+n)}$$

where P_0 and Q_0 are industry price and quantity at the farm gate before the introduction of the technology, e and n are the elasticities of supply and demand, and $k = K/P_0$. The new technology has allowed the cost of producing Q to fall by an absolute amount of K, represented by *bc*. The supply curve shifts to the right from S_0 to S_1 and the new industry equilibrium position is a price of P_1 and output of Q_1.[2] An approximation of this total gain in economic surplus is given by kPQ, represented by the area *abcd*, which is total industry revenue at Q_0 times the relative change in the unit cost of production. It underestimates total welfare gain by the area *bfc*. Note also that this is a measure of benefits accruing to all in the marketing chain from producers through to consumers and not just a measure of return to producers.

The elasticities of demand and supply have little impact on the size of total welfare gains but are critical to how these gains are shared. When supply is less elastic than demand, often the case in the short term, then producers capture a larger share of the total benefits.

In some situations, such as when costs and yields are influenced by another enterprise in a rotation or when there are long lags between costs and returns, kP is approximated by the change in profit per unit of the rotation which is then applied to production Q. This change in profit approach was used in the three benefit–cost analyses reviewed below.

Figure 1 is a very heuristic representation of the impact of research. Typically, it might represent the market for oysters in Vietnam, say, in a typical year. Note that in this simple model the impact of research in terms of a supply shift is both contemporaneous and the technology is fully adopted across the industry (or that part of the industry to which the technology pertains).

To estimate benefits through time, the lag between research activities and the availability to farmers of the new technology, and the rate and extent of adoption of the technology must be projected and the usual techniques of financial analysis applied.[3]

The impact assessments undertaken by van Bueren (2007) of acacia hybrids and by Fisher and Gordon (2012) of the SAT and DAT projects followed this practice and were judged to be 'convincing' in meta-analyses of the set of impact assessments analysed by Raitzer and Lindner (2005) and subsequently by Lindner et al. (2013). The analysis by Johnston (2012) of the oyster seed project largely followed the same framework. However, as it was a smaller study commissioned within an active project, it was not published in ACIAR's Impact Assessment Series. The three impact assessments reviewed all used discount rates of 5%, which is the usual ACIAR perspective (but may not be appropriate from a Vietnamese perspective).

It was never the intention of this project to thoroughly reassess the impact of this set of projects. In fact it became apparent, as explained below, that to achieve a similar standard the analyses would require a thorough re-working, not just a simple update of parameters, and resources did not permit this (nor was it essential to meet the objectives of our project).

Our approach was to assess, where possible, whether parameters such as industry size and price, and the costs savings (K) and adoption rate associated with the technology had changed so markedly that it was now unlikely that the returns to investment in these projects were similar to the earlier assessments.

We limited our attention to enquiring of scientists whether there had been marked changes in the key parameters that influence the area of welfare change, *abcd*, K, P and Q. In the three cases considered here, adoption was implicitly reflected in Q, the trend in industry production. An attraction of using this approximation for our purposes is that scientists often use the kPQ approximation in their funding

2 A detailed description of the welfare analysis of new technology can be found in a variety of sources including Alston et al. (1995).

3 Up to when the impact assessment was undertaken actual adoption data can be used.

applications, and so they are aware of the implications of judgements about these parameter values.

When undertaking benefit–cost analysis using the framework of Figure 1, the boundaries of the economic system within which the impact of research is to be estimated must be defined. In the three impact assessments reviewed here, the analysts defined the boundaries as the relevant industry within Vietnam. They did not attempt to estimate impacts elsewhere in the Vietnamese economy nor did they attempt to estimate benefits in other countries partner to the research such as Australia and Malaysia.

2.2 Distinguishing the Impact of Capacity Building From Other Research Activities

As noted, research funders like ACIAR typically invest in activities across a spectrum, including human capacity building, in pursuit of economic, social and environmental benefits. Mullen et al. (2015) described a model of how the various research activities that comprise ACIAR projects have an impact on farm productivity as some combination of the following paths:

- Sometimes directly through increments to the stock of knowledge and technologies available to farmers, K_t, through advancing the rate of technology development and adoption, such as through the release of new varieties.
- Indirectly through additions to the stock of human scientific capacity, C_t, through training programs and mentoring.
- Indirectly through additions to the stock of scientific knowledge, L_t, from the development of new techniques that do not have an impact on farm productivity during the current project but require further development and application.
- Directly through rural policy settings but perhaps more through changes in the prices of farm inputs and outputs of trade.
- Indirectly through gains in efficiency in the use of research resources through better priority setting, for example, which are later reflected in K_t.

The contributions of these various sources of efficiency (welfare) gains cannot be empirically disaggregated in any theoretically sound manner (certainly not at the level of case studies). In more technical terms, the various components of any research process are jointly demanded and supplied. Judgements about the relative importance of components are necessarily subjective.

Despite these difficulties, it is legitimate to enquire about the contribution of capacity building to final outcomes and to devise efficient processes to monitor capacity building activities and the later application of this capacity.

It is important to be clear that our focus is on identifying and describing capacity built during specific projects, and its contribution to those projects, and attempting to trace out how this capacity has been used in later research projects to deliver additional welfare gains. We are trying to relate capacity built to a specific bundle of resources as distinct from a more general view of capacity building across a major research program or institution.

Any of ACIAR's research areas provide opportunities for capacity building. To make our discussion less abstract here we describe more fully the various ways by which capacity built in a project expected to yield a farm ready technology might contribute to gains in economic welfare. The concepts developed could be generalised to research activities delivering other outcomes–– environmental or policy outcomes, for example.

To be of value, capacity building must eventually result in a new technology that is profitable for farmers to adopt and hence result in a supply shift, as illustrated in Figure 1. The schematic below,[4] Figure 2, illustrates in a general way the paths by which capacity built in a specific project might result in a supply shift that flows through to welfare gains. The upper paths trace out potential gains realised from the adoption of technology developed during the project. The capacity built may contribute directly to the extent to which the new technology reduces costs and increases farm profits— through yield gains, for example. Another possibility is that it results in the more rapid development and adoption of the technology, as illustrated in Figure 3 for acacia hybrids. These benefits from capacity building are

[4] Suggested by this report's referee.

captured as part of the total gains in economic welfare estimated in typical impact assessments.

The bottom paths in Figure 2 describe how capacity built in one project may enhance later projects and hence deliver welfare gains. Usually additional resources are required to develop farm ready technologies but some share of welfare gains are attributable to capacity building activities in the original project. This bottom path has generally received little attention in past impact assessments apart from a brief acknowledgement of its potential. Here we have attempted not only to more fully describe capacity building activities from the upper path but also to trace out their actual and potential impacts along this later bottom path.

Often, capacity built in one project feeds through to subsequent projects in the same area. In the three cases studies considered here, ACIAR funded a succession of projects utilising capacity built in the original project. We expected that pathways to impact in these scenarios would be easy to identify and describe. But there is potential for capacity built to spill over more broadly to other research areas; skills in farming algae for oysters may also be applied in aquaculture research, for example. Again, these benefits may accrue as a direct cost saving or as a reduction in the lag to the availability of the technology. Capacity built may also contribute to institutional capacity or be of value in sectors of the economy outside agriculture. These spillovers, or externalities, are much more difficult to identify and attribute back to the original project. When spillovers occur in other industries then welfare gains must be estimated in markets for these other industries.[5]

To date, impact assessment processes employed by ACIAR and others have usually stopped at limited attempts to identity capacities built but have left implicit the benefits likely to flow thereafter. The benefits of capacity building could be made more explicit by describing plausible pathways to final impact in terms

5 Perhaps using general equilibrium models rather than the partial equilibrium approach described here.

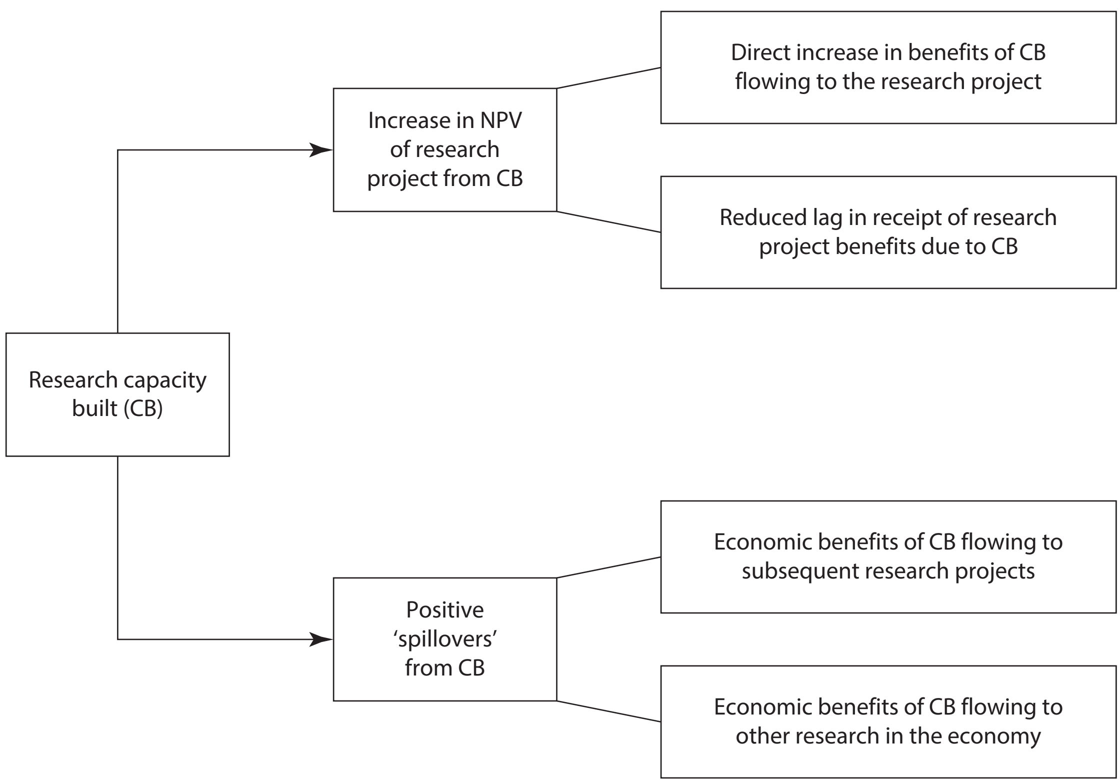

Figure 2. Pathways by which capacity building in a specific R&D project increases economic benefits

of changes in farm practice projected to occur as capacity is utilised. Of course, these impact pathways are conjectural in that these outcomes are both uncertain and attributable to a range of other influences, but all impact assessment processes are at least partly based on projections about future adoption of technologies and confront difficult attribution issues. The use of impact pathways has been recommended and applied in many ACIAR impact assessment reports, including Davis et al. (2008) and Gordon and Chadwick (2007). For each of the three cases studies, we attempted to elicit from the scientists how capacities developed during each project were used in that and later projects.

Some skills acquired during capacity building are technical in nature and closely related to the project's research processes and the technology being developed. The potential future uses of these skills in developing technologies are relatively easy to conjecture. The Vietnamese scientists were also quick to identify the contribution of ACIAR projects to the development of softer skills such as scientific writing and English language and presentation skills. The pathway to changes in farm practice is more indirect for such capacities. Nevertheless, these skills likely increase the access of Vietnamese scientists to the international scientific community and make new knowledge more accessible sooner. Indicators of capacity built include output measures such as scientific papers published and conference papers delivered. One perspective on these skills is that they may increase the efficiency and effectiveness of R&D investments by reducing the lag before new technologies are disseminated and adopted.

Moreover, increasing human capacity in individual scientists may spill over into 'institutional strengthening' in the words of Gordon and Chadwick (2007) or institutional capacity. These gains arise if institutions allocate research resources more efficiently, perhaps through improved priority setting and/or if the gains in institutional capacity over and above the gains in capacity of individual scientists lead to a greater rate of research discovery and development of technologies profitable for farmers. For the capacity of the institution to exceed the sum of the capacities of individual scientists there must be gains from cooperation and teamwork. Institutional capacity is explored more fully in the companion study by Morris et al. (forthcoming 2017).

2.3 The Interview Process

An important consequence of the close interrelationships between the various research activities is that framing issues arise when interviewing scientists that potentially lead to responses (or interpretations of response) that do not accurately reflect the intent of the questions.

We used the term 'knowledge discovery' to refer to K, the stock of new knowledge immediately available to farmers in the form of new varieties and management practices.[6] We used the term 'capacity building', C, to encompass activities that either led to gains in human capacity through formal and informal training and/or to additions to the stock of scientific knowledge—both of which, while not immediately valuable in the form of technologies for farmers, could potentially be building blocks for the development of farm ready technologies in later projects.

During interviews we asked scientists to rate the contribution to the on-farm outcomes of the projects of capacity building activities relative to knowledge discovery processes. In hindsight, the use of the term knowledge discovery may not have been a good choice. Our intention was that trial and experimental processes in Vietnam that generated knowledge necessary for encouraging the adoption by farmers of new varieties and management practices be classed as knowledge discovery. However, the initial perception of Australian scientists was often that these activities were capacity building because in many cases they did not add to the stock of scientific knowledge. This may partly explain why Australian scientists rated the contribution of capacity building to project outcomes relative to knowledge discovery processes more highly than their Vietnamese colleagues, as reported below.

While recognising that it is not possible to separate either inputs into, or outputs from, capacity building and knowledge discovery processes using accounting means in a theoretically sound way, Gray et al. (2015) sought an indicator of investment in capacity building

6 Unfortunately K is also used to describe the shift in the supply function from new technology in the partial equilibrium models used to estimate changes in economic surplus.

that could be inexpensively derived from ACIAR's project budgets. They trialled a process of estimating expenditure on informal capacity building as the sum of expenses incurred in travel, subsistence and the salaries of Australian scientists and technicians while in Vietnam, and the travel and subsistence of Vietnamese scientists and technicians visiting Australia. The salary component was estimated as the number of days that the project leader or other Australian scientists travelled to Vietnam. Each day was valued at 800 AUD for a project leader and 600 AUD for a scientist. This indicator is reported for the SAT and DAT and oyster case studies but not the hybrid acacia study because the project was undertaken in Malaysia.

There is no a priori reason for this indicator to have a consistent bias from the unknown true investment in capacity building. ACIAR program managers requested that we continue to trial this indicator in these case studies because it appeared a useful starting point despite its known limitations.

Other framing issues arose in the design and conduct of interviews. The scientists were aware that our project was principally about improving the ability of ACIAR to plan for and recognise the importance of capacity building whether by formal or informal means. Whenever possible we asked respondents to focus on the balance between knowledge-discovery and capacity building processes but because most of the time during interviews was spent on capacity building, we wonder about the extent to which bias was introduced. We are unable to assess this—except to note that we did not expect to make any recommendations about either the total level of funding or its distribution between these two main activities, and we hope this was clear to respondents.

Framing issues also arose because the interviews related to the three impact assessment reports were conducted in close proximity to the more general enquiries into institutional and individual capacity building. We asked the respondents to focus on the capacity building activities associated with the particular set of resources relevant to each specific project. Again there is no way for us to assess the extent to which respondents were able to separate their general thoughts about capacity building over several projects (some not funded by ACIAR) and the capacity building processes of particular projects.

Perhaps another dimension of framing is language. In a research environment, the distinction between capacity building and knowledge discovery is conceptual, and it was unlikely that there was always a common understanding of terms used in our discussions. In these circumstances, it is more likely that interviewers will listen for phrases consistent with their preconceptions. Three of the authors were involved in recording and reviewing notes from most interviews and often we were assisted by staff from the research institutions and ACIAR Vietnam Country office staff.

A further problem is that the extent to which capacity has been built cannot be directly observed; there are indirect indicators of capacity such as courses attended, degrees attained and papers written. More tangible evidence comes in the form of technologies developed and adopted on farm, but then the difficulties arise of attributing some share of these more tangible gains to capacity building. The difficulties of observing capacity built and utilised are further exacerbated when the observers are not specialists in the specific capacities under consideration. We have sought plausible causal pathways, in the language of impact assessment, to identify and recognise capacity built and utilised.

Our study was based on personal interviews with Vietnamese and Australian scientists who were involved in the project. This process had several challenges. Some scientists were unavailable. Recall was likely to have been a problem—particularly for the hybrid acacia project which was undertaken from 1988 to 1992. Another challenge for the scientists was to associate capacity building and the impact of technology with the specific set of resources associated with the three projects rather than with the broader research program (including projects from the Government of Vietnam and other donors) within which the projects were situated.

To ameliorate these problems, separate questionnaires were developed for each project which included specific information derived from project proposals and reports and the impact assessment reports about the project, the technology developed and capacity building activities. The scientists were also asked to identify specific skills developed during the project and the importance of these skills both to the success of the original project and their contribution to the development, in subsequent projects, of new technologies that were adopted by farmers. Where possible scientists were interviewed in teams, partly to save time but also because discussion among team members was expected to lead to more complete and accurate responses.

One of the survey questionnaires is attached in Appendix 10.1.

Gordon and Chadwick (2007) revisited several earlier impact assessment reports. They more carefully described capacity building activities during these projects and elicited from scientists subjective judgements about the share of costs and benefits estimated in the impact assessment analysis that could be attributed to capacity building activities. Note that under their process, the total return to ACIAR's investment remains unchanged even though a proportion of the total welfare gains from the technology developed during the project was attributed to capacity building. We too invited scientists to make subjective judgements about the importance of capacity building activities relative to knowledge discovery activities, hence a proportion of total welfare gains estimated in the impact assessment analyses we reviewed could also have been attributed to capacity building.

Gordon and Chadwick (2007) did not attempt to value later benefits from capacity building except through the application of some rules of thumb that might be applied in indicating the value of capacity building to the earnings of scientists and the institutions they belonged to. We have not pursued their approach in these case studies. Our expectation was that discerning the contribution to an institution of capacity building supported by ACIAR was best investigated at a more aggregate level than the project level. This issue was pursued in Morris et al. (2016) from discussions with scientists and science managers about the influence of ACIAR over the range of its bilateral research and fellowship contributions. We did not pursue rules of thumb applied to a scientist's income because of the difficulty in determining formal and informal salaries and uncertainty about progression and promotion processes in Vietnam.

3 Acacia Hybrids in Vietnam (FST/1986/030 as reported in IAS 27)

3.1 Data Gathering Process

Mullen and de Meyer interviewed Dr Rod Griffin and Dr Jane Harbard at UTAS via Skype on 10.2.16. Professor Le Dinh Kha, Dr Ha Huy Thinh and Dr Phi Hong Hai were interviewed at VAFS on 17.02.16 with respect to the acacia hybrid questionnaire. Mullen and Gray visited a forestry research centre at BaVi on 23.02.16. Further helpful suggestions were received at a feedback presentation to a small number of VAFS staff on 26.2.16. Griffin, Harbard and Dr Chris Harwood (CSIRO) provided useful comments on a late draft of this section.

3.2 Project Background and Outputs

Back in the early 1980s when this project was being developed, there was considerable interest in growing Australian species of tropical acacia for timber production in South–East Asia. Despite this interest there had been little research conducted into the breeding of acacias, and hybridisation techniques were in their infancy.

Many of the opportunities and problems presented by hybridisation in acacias were similar to those with eucalypts; the main difference was that techniques for mass vegetative propagation of acacia species and their hybrids were not yet developed. The value of vegetative propagation in forestry was well understood: the transfer of characteristics with low heritabilities, such as growth and cellulose yields, is difficult through seed regeneration but is routinely possible when using vegetative propagation. Vegetative propagation is especially useful for hybrids.

Consequently, after a series of meetings of scientists in South–East Asia, a project (FST/1986/030) was put forward for ACIAR funding in the mid-1980s. The research, starting in 1988, was conducted in Malaysia and Australia and had the following objectives:

4. To develop a reliable methodology for manipulated hybridisation of tropical acacias, as a basis for genetic improvement programs, and to evaluate potential for open-pollinated hybridisation in seed orchards.
5. To develop methods for mass vegetative propagation of tropical acacias and their hybrids as a means of rapid capture of genetic gains from breeding.

The lead Australian scientists were Dr A.R. Griffin, at that time from the CSIRO Division of Forestry and Forest Products, and Dr M. Sedgley, at that time from the Waite Agricultural Research Institute, University of Adelaide.

When the project was in progress, Vietnam was not a partner to ACIAR projects because of the political situation. However, in 1991, naturally occurring acacia hybrids were observed growing at the Ba Vi research station, 70 kilometres to the west of Hanoi. The parents of these natural hybrids were identified to be *A. mangium* and *A. auriculiformis*. In the following year, Professor Le Dinh Kha, from what is now VAFS, became aware of the technologies that had recently been developed by the ACIAR-funded Malaysia project on acacia hybridisation and propagation (FST/1986/030). With some UN funding, he attended conferences in Malaysia and Bangkok where the acacia hybridisation work was reported.

The workshop in Malaysia, held in July 1991, consisted not only of presented papers but also a field trip where newly discovered techniques for hybridising acacias were demonstrated (Carron and Aken 1992). After the workshop, Professor Kha initiated some trials with funds provided from a SIDA–SAREC project to develop hybridisation skills based on information from the Malaysia research, and after four years of initial research the Vietnamese government provided ongoing funding.

Vietnamese scientists soon established a close working relationship with the CSIRO researchers who had been involved in the ACIAR-funded project and who visited Vietnam as a result of the contact made at the workshop. The clonal selection techniques and propagation methods developed by CSIRO in partnership with Dr Russell Haines, Queensland Forestry Research Institute, and Malaysian scientists were adopted and adapted by the Vietnamese in their hybrid selection program, which began in 1992 using hybrid plants from Ba Vi.

The hybrid specimens (or clones) underwent extensive screening before being selected for commercial release. In order to ensure the selected clones were indeed superior to their parent species, the clones were tested under a variety of environmental zones. This testing process took four years from the time of first selections in 1992 to the first commercial release in 1996.

3.3 IAS 27 by van Bueren (2004)

Van Bueren described ACIAR's contribution as follows:

> The ACIAR-funded research on acacia hybrids (project FST/1986/03) was an important input to Vietnam's research program. The selection and propagation techniques developed by the joint Malaysia–Australia project in the early 1990s helped the RCFTI (Research Centre for Forest Tree Improvement) to establish its own breeding program . . . However, the contribution made through the ACIAR-funded project was part of a larger effort by the Vietnamese and other sponsors, including AIDAB (the predecessor of AusAID), FAO, and SIDA (Swedish International Development Cooperation Agency). Note that the ACIAR-funded project did not provide the hybrid germplasm to Vietnam or direct financial support. Instead, its pivotal role was to provide the technical know-how to conduct a successful breeding program and subsequent propagation of hybrids. Discussions with Vietnamese scientists suggest that this technology has helped reduce the time taken to develop a suitable hybrid clone for commercial release. (p. 13)

Figure 3 shows how van Bueren represented ACIAR's contribution. Hybrid acacias would have been developed and traditional varieties replaced without ACIAR, but contact with CSIRO scientists on the ACIAR project advanced the use of hybrids by four years. In brief, he estimated that the total benefits to Vietnamese farmers from the commercial release of acacia hybrids in 1996 were $300 million by 2004 when he wrote his report and that of this sum, $37 million (or a little over 10%) could be attributed to ACIAR, with the remaining 90% attributed to the research team in Vietnam led by Professor Kha. It was a highly profitable investment with a benefit–cost ratio of 35:1 and an internal rate of return of 37%. The area between the two curves represents the economic gains from the ACIAR contribution, $37 million.

Van Bueren's estimates of gains in economic welfare were driven not only by this adoption profile and the 'without' scenario of a 4-year lag in the commercial release of acacia hybrids, but also by assumptions made with respect to yield gains, reduced growing costs and timber prices. Here we present only the key parameters that could be more readily discussed with Vietnamese and Australian scientists during our study.

From Table 1 it can be seen that acacia hybrids gave a higher yield and a reduced growing rotation than the parent species, which meant that there was effectively a large reduction in the unit cost of growing timber, K. However, van Bueren instead estimated a difference in the net present value of parent species and hybrid acacias from a time series of costs and returns rather than a partial equilibrium model based on K. This approach is common in the analysis of forestry projects with long rotation lengths.

At the time of van Bueren's report, hybrid acacias were expected to completely replace parent species over time as the existing stands of the latter were harvested. The projected area of acacia hybrids was set at 430,000 ha, which was about 20% of the 2010 target set by the government for production plantations. This was a conservative projection in van Bueren's view.

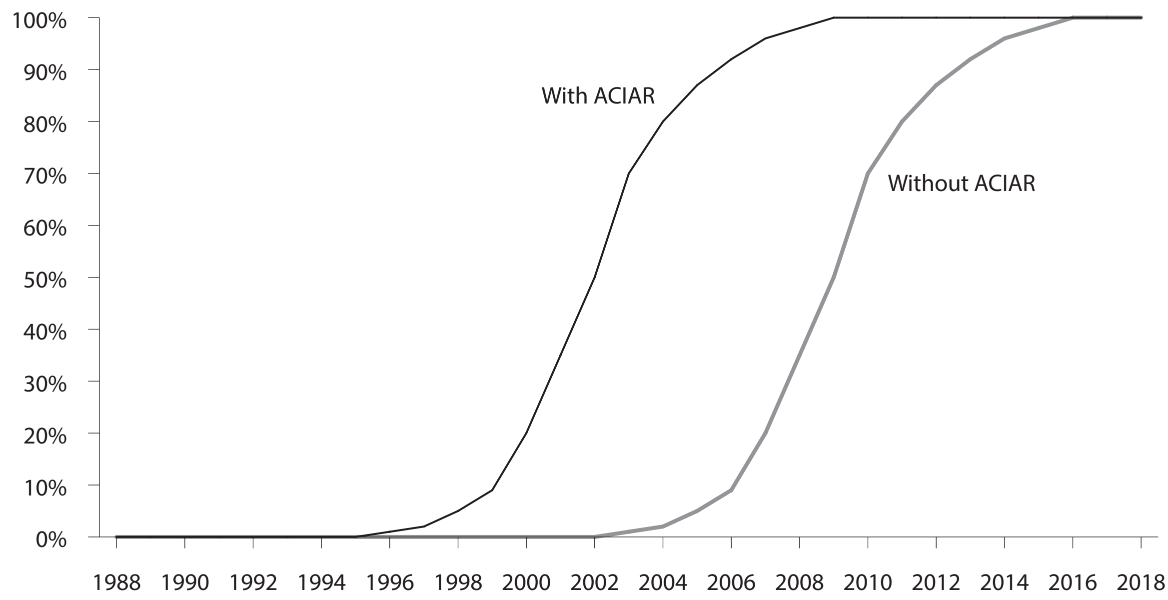

Figure 3. Proportion of hybrids in the acacia plantation estate. Source: IAS 27

Table 1. Van Bueren's assumptions for key parameters

	Parent Acacia Species	Hybrid Acacias
Mean annual increment (m^3/ha/year)	12	22
Rotation length (years)	7	5
Price (000VND/m^3 in 2004)	300	300
Projected share of total area (%)	0	100
Projected total area (ha)	0	430,000

3.4 Review of Impact Assessment Parameters

We reviewed key parameters with the scientists we interviewed. There are few published data on the release of new varieties and their planted areas, or on prices and quantities, and we have had to rely on the judgement of the scientists familiar with the industry.

Speaking with Australian scientists prior to visiting Vietnam, some concern was expressed that van Bueren was claiming a share of benefits for ACIAR at the expense of the Vietnamese collaborators. It was suggested that perhaps the ACIAR link only advanced the release of the first acacia hybrid by 2 to 3 years because Professor Kha already had the skills and experience to quickly adapt the Malaysian research to Vietnam. We thought that perhaps this disquiet arose because van Bueren's methodology may not have been well understood.[7] We were careful in Vietnam to explain that by van Bueren's methodology only about 10% of total gains from acacia hybrids were attributed to the CSIRO/ACIAR link. The Vietnamese scientists involved in this research who we spoke to thought that it might have taken at least four years before the first hybrid

7 It is unlikely that van Bueren had an opportunity to present a seminar on his analysis to either Australian or Vietnamese scientists.

was released had Professor Kha not become aware of the research in Malaysia.[8] This is a highly conjectural parameter, as discussed again later in this report, but the grounds to substantially alter van Bueren's assumption do not seem strong.

Van Bueren assumed a mean annual increment (MAI) for hybrid acacias of 22 m^3/ha/year as compared to 12 m^3/ha/year for the parents (Table 1). Nambiar et al. (2015) reported similar MAI figures to the estimate used by van Bueren (except that MAI was 17.6 in the north compared to 23.0 m^3/ha/year in the south). Dr Thinh and Dr Hai accepted van Bueren's assumptions. However, Griffin and Harwood (personal communication) thought that the assumption that the yield of hybrids was twice that of traditional species (in 2004) would now be considered optimistic. They suggested that, more conservatively, the yields would likely have been in the range of 15 to 20 m^3/ha/year.[9]

Van Bueren assumed that acacia hybrids would replace traditional varieties entirely and projected that 430,000 ha would be planted with hybrids by 2014. The experience since 2004 has been quite different, however. Traditional acacia varieties have proved to be more suitable than the hybrids in some environments, and the total area planted to acacias has far exceeded van Bueren's expectations. Recent data on areas planted to acacia and eucalyptus varieties are presented in Table 2. The total plantings of acacia are much larger than anticipated by van Bueren, and the area of acacia hybrids also exceeds the area projected by him.

Van Bueren used a stumpage price of 300,000 VND per m^3 in his analysis, which is almost 800,000 VND in 2015 prices. There are no published data on stumpage prices for timber in Vietnam: from discussions with foresters, VAFS scientists said that the stumpage price for acacia for pulpwood is in the range of 440,000 – 600,000 VND per m^3 in central Vietnam[10] and is as high as 1,200,000 VND per m^3 in northern Vietnam. Beadle (2015), in a project-final report (FST/2014/017), quoted a stumpage price for acacia pulpwood in south–east Vietnam of US\$32.1/m^3, which is about 720,000 VND per m^3. Price varies with market conditions and distance of woodlots from mills and ports.[11] We were unable to obtain estimates of the cost of growing timber but the industry has continued to grow, suggesting it has remained profitable.[12]

8 We did not directly ask Professor Kha for his views on how soon an acacia hybrid could have been released in the absence of his collaboration with CSIRO scientists.

9 Timber yields depend not only on genetics but also on how plantations are managed. The partial equilibrium approach to assessing the impact of hybrids requires a subjective judgement about the difference in yield between varieties at similar standards of silviculture.

10 Converted from 550,000 – 770,000 VND per tonne at the rate of 1m^3 = 0.8 tonne.

11 Note that the growth of an industry associated with new varieties is likely to cause prices to fall except where the world price rules. A rise in price is more likely to come from a demand shift (perhaps policy driven) unrelated to the technology except in the case of quality change.

12 Profitable to the industry without considering any benefits and costs arising from any government intervention.

Table 2. Areas planted to acacia and eucalyptus varieties

	Nambiar et al. (2015)	**Dr Phi Hong Hai (personal communication 2016)**
	Areas in 2013 (ha)	**Areas in 2015 (ha)**
A. mangium	600,000	732,972
A. mangium × A. auriculiformis	400,000	517,350
A. auriculiformis	90,000	52,484
A. crassicarpa	5,000	6,491
Eucalyptus hybrid		54,464
Eucalyptus urophylla		156,154

In summary, Van Bueren's assumptions about price, yield and the areas of hybrids seem to have held, and there seems no reason to downgrade his estimate of the rate of return to this project.

3.5 Capacity Building Activities and Outcomes During FST/1986/030

So far we have followed van Bueren in not accounting for the contribution of human capacity built during the original project to the development and adoption of new varieties in later years, and therefore the full economic impact of the project is likely understated. We have noted the difficulties of valuing this build-up in capacity. Recognising that if it is to be of value, capacity must eventually be applied in developing technologies profitable for farmers, we attempted to identify specific capacities/skills developed during the project and then to trace a pathway through their continued use in VAFS (and elsewhere if possible) to new technologies, either realised or projected, that are likely to be profitable to farmers.

As explained above, FST/1986/030 was aimed at understanding and manipulating the sexual and vegetative reproduction of acacia species. Research to develop hybridisation techniques for acacias was a key component of the project, as well as developing the capacity of scientists to use them.

The scientists we interviewed said the following set of skills were developed during the ACIAR project in Malaysia:

- hybridisation techniques for acacias
- vegetative propagation techniques for acacia hybrids
- knowledge of the acacia breeding system
- tissue culture for acacias.

Professor Kha took some or all of these skills back to VAFS. The first three were necessary for the commercial release of acacia hybrids in Vietnam but were not sufficient in themselves because considerable effort was additionally required to apply these skills in Vietnam and to trial and select acacia hybrid varieties suitable for commercial release.

We asked the Australian and the Vietnamese scientists to make a subjective judgement about the importance of capacity building relative to knowledge discovery to advancing the release of commercial acacia hybrid varieties. Both groups rated the contribution of capacity building to knowledge discovery at 20:80. Perhaps this reflects the research in Malaysia required to develop the new skill in hybridising acacia and then the adaptive trial work in Vietnam to select varieties for commercial release. Following Gordon and Chadwick (2007) this implies that 20% (or ($7.4 million) of the $37 million of total benefits attributed to ACIAR could in turn be attributed to capacity building activities

The Australian scientists said that there have been no economic gains to Australia from this project because there is no commercial acacia industry in Australia. However, the skills they developed in the course of the project have helped them maintain a seed centre in Australia and also helped in developing projects in other countries.

3.6 Subsequent Capacity Building Through Formal Postgraduate Training

Some Vietnamese who worked on the early project were given the opportunity for formal postgraduate training. Dr Nghiem Quynh Chi and Dr Le Son were awarded John Allwright Fellowships (JAF). Dr Le Son was first awarded a JAF to undertake a master's degree in Forestry at Southern Cross University and now, on another JAF, he is pursuing his PhD at UTAS.

Dr Chi worked on ACIAR-funded forestry projects (FST/2003/002) at VAFS in the early 2000s (Moorehead and Bartlett 2016). She was awarded a JAF in 2007 to do her PhD on acacia polyploidy at UTAS. She subsequently returned to VAFS to lead the tissue culture program and work on ACIAR's project FST/2008/007. Dr Chi has been working to breed triploid acacia and hybrid acacia seedlings. The pace of this work is likely to quicken since ACIAR has funded a flow cytometer for Dr Chi's laboratory that will allow her team to test for polyploidy much more rapidly, hence reducing the cost of identifying potential new clones.

The Government of Vietnam has recognised the importance of this research by awarding Dr Chi a grant of US$300,000 to continue her work which may lead to the release of new varieties to farmers over the next five years. Dr Chi is one of the lead scientists in a new ACIAR project FST/2014/068. This year she was awarded an Australia–APEC Women in Research Fellowship. These Fellowships provide support for high-achieving female researchers from developing APEC economies to pursue research opportunities in partnership with Australian education and research institutions. Dr Chi will spend three months at UTAS to pursue research interests with staff there.

3.7 Contribution of Capacity Building to Later Technologies

Our intention in this part of the impact assessment was to describe a plausible impact pathway from capacity built in the initial project, strengthened in following projects, and then leading to breeding and adoption by farmers of acacia hybrids. The gold standard for demonstrating that capacity built has actually been utilised is to be able to report areas planted by farmers of a stream of acacia hybrids released by MARD since the first acacia hybrid project.[13] Not unexpectedly, we did not achieve the gold standard because data on plantings by variety were unavailable. New varieties bred by VAFS are released and distributed to clonal nurseries by MARD, and there has been a focus on developing cloning technology at the provincial level to expedite the mass release of acacia hybrid clones. Farmers obtain seedlings from the clonal nurseries that presumably concentrate on varieties most suitable to their environment, but they may be unaware of exactly what mixture of varieties they are using and unfortunately no record is kept of plantings by farmers and plantations through time that would meet gold standard requirements.

However, VAFS does have records on which varieties have been released by MARD through time. According to these unpublished data, a further 13 acacia hybrid varieties have been released to date by MARD since the first seven up to 2000, or 20 varieties in total (Table 3). This accords closely with data published by Kha et al. (2012) who reported that by 2008 MARD had released a total of 19 hybrid clones.[14] MARD has released three varieties since 2008 (included in the 13). Kha et al. noted that six varieties were widely used by plantations, but little seems to be known about the varieties used by farmers.

Underlying this record of hybrid releases by MARD is a significant breeding program that is at least partly attributable to capacity built in the first project and developed further in subsequent projects. There are presently over 500 acacia hybrid genotypes under evaluation, and from this large pool more than 40 clones are undergoing second-stage testing prior to MARD approval and release.

The skills developed in the original project were necessary building blocks for the next two projects part-funded by ACIAR (FST/2003/002 and FST/2008/007). These closely linked projects aimed to further develop the scientific capacity to breed high-performing varieties of acacia hybrids and *A mangium* and *A auriculiformis* in Vietnam. These projects had a high research component based on polyploidy techniques to develop sterile triploids and more efficient clonal deployment through clonal seed orchards and nurseries. The intention was to increase the number of clonal lines available to Vietnam's breeding program, eventually releasing to farmers varieties adapted to various environments in Vietnam with high growth rates, improved wood quality and reduced opportunities for acacia weed problems. A new ACIAR project (FST/2014/068) has the objective of using polyploidy techniques to develop resistance in *A. mangium* to crown wilt disease, now a major problem in Vietnam. Polyploid acacias were developed by Griffin while working with Shell in the UK and have been introduced to the VAFS breeding program. Weediness has been a problem with acacias, and polyploid technology allows the creation of triploid varieties that are sterile and hence eliminates the weed problem.

There was also significant capacity building and research progress implemented through two multi-country

13 Not forgetting that areas planted result not just from the original capacity building but from subsequent research and extension investments and from changes in economic conditions.

14 The unpublished VAFS data note three clones released since 2008, which is difficult to reconcile with the paper by Kha et al. (2012). Another inconsistency is that van Bueren only reported six varieties up to 2000.

Table 3. Year of Release by MARD of Acacia Hybrid Varieties

	Acacia hybrid varieties					
1996	BV10					
1997						
1998						
1999						
2000	BV16	BV32	TB3	TB6	TB12	TB5
2001						
2002						
2003						
2004						
2005						
2006	BV71	BV73	BV33	BV75		
2007	AH1	AH7				
2008		AM2	AM3	MA1	M8	
2009						
2010	AH4					
2011						
2012						
2013						
2014						
2015	AH9	AH15				

ACIAR projects (FST/1993/118: Seeds of Australian Trees and FST/1998/096: Domestication of Australian Trees) discussed in more detail in the next section. These projects guided the development of pure-species breeding of *A. mangium* and *A. auriculiformis* in Vietnam and established the expanded genetic base on which all Vietnam's acacia breeding now rests. Of particular relevance to acacia hybrid development was the establishment of large progeny trials of *A. mangium* and *A. auriculiformis* in the north and south of Vietnam, followed by adjacent clonal seed orchards of the two species in southern Vietnam. Seed collected from open pollination among these paired clonal seed orchards generated most of the 500+ new acacia hybrid genotypes that are currently under evaluation by VAFS. Methods to identify and test the new hybrid clones were developed under project FST/2008/07, but the breeding infrastructure to generate these hybrids and to progress pure-species acacia breeding was implemented under the SAT and DAT projects.

Both Australian and Vietnamese scientists identified a range of more general capacities developed during these ACIAR-supported acacia hybrid projects and the other tree breeding projects (discussed below) but it is difficult to attribute them to particular projects. Capacities developed included:

- experimental design and management
- breeding strategy development
- statistical analysis of trial data
- tree breeding databases

- scientific networks
- scientific writing skills
- English language and presentation skills.

The Australian scientists pointed out that an important factor contributing to the maintenance of skills in VAFS was the sequence of ACIAR-supported projects. Some skills depreciate quickly if they are not being applied or when there is staff turnover. Australian scientists have been invited back at the expense of the government of Vietnam, which is evidence of the value the Vietnamese place on maintaining the scientific network that has developed over this sequence of projects.

The scientists at VAFS rarely spoke about the adoption by farmers of varieties they have bred. Perhaps this is because there is a separate extension pathway through Provincial Departments of Agriculture and Rural Development, which the Australian and Vietnamese scientists view favourably. The Vietnamese scientists volunteered that they are an applied research institution and that there is now a strong push from the government towards benefits to society.

Despite the lack of data on plantings by variety by farmers and plantations, acacia production has expanded in Vietnam, and much of this growth is likely based on varieties developed by VAFS—hence the likelihood is high that capacity initiated during FST/1986/030 and consolidated in later projects has led to welfare gains by farmers and plantation producers of acacia hybrids. A future assessment of the impact of acacia hybrids in Vietnam would have to be conducted over this set of three projects.

4 Improved Australian Tree Species in Vietnam (FST/1993/118 and FST/1998/096 as reported in IAS47)

4.1 Data Gathering Process

Mullen and de Meyer interviewed Mr Khongsak Pinyopusarek (CSIRO) on 4.2.16. Professor Le Dinh Kha, Dr Ha Huy Thinh and Dr Phi Hong Hai were interviewed at VAFS on 17.02.16 with respect to the SAT and DAT projects. Mullen and Gray visited a forestry research centre at Ba Vi on 23.02.16. Further helpful suggestions were received at a feedback presentation to a small number of VAFS staff on 26.2.16. Dr Hai and Dr Chris Harwood provided comments and data on drafts of this section.

4.2 Project Background and Outputs

AIDAB (subsequently AusAID) funded development projects in Asia from 1983 with the objective of providing Australian germplasm and assistance in trials to evaluate this germplasm in developing countries. As noted above (Section 3), Vietnam did not receive aid from Australia directly until 1993, but there were indirect links and assistance provided by CSIRO scientists. ACIAR continued funding the SAT project (FST/1993/118) from 1993 to 1998. According to project documents, the objectives of the SAT project were:

- provision of certified seed of proven and promising Australian species
- provision of up-to-date information on selection, improvement, silviculture, utilisation and management
- provision of training courses for knowledge and technology transfer to recipients.

The aim of DAT, a project with a higher research component, was to support more effective domestication and use of Australian tree species in the poorer developing countries, targeting South–East Asia, south Asia, China and certain African countries. A number of other organisations were involved, including key forestry research organisations in Vietnam, principally the Forest Science Institute of Vietnam (FSIV), and a number of international aid organisations, including ACIAR, AusAID, SIDA (indirectly) and the United Nations Forestry Tree Improvement Program.

Fisher and Gordon (2007, p. 15) identified the following set of outputs from the SAT and DAT projects:

- The information provided through requests and the research trials established under the SAT and DAT projects significantly increased the knowledge of the best species and provenances to plant in particular environments. Information was also provided on silviculture, utilisation and management of Australian trees.
- The seed provided to Vietnam under the projects widened the genetic base of Australian trees in the country.
- The SAT and DAT projects assisted with the establishment of seed production areas, seedling seed orchards and clonal seed orchards. These seed production areas and seed orchards are providing Vietnam with a domestically produced source of high-quality seed, which is crucial to the sustainability of the productivity improvements achieved.

- Formal training and collaboration with Australian researchers significantly increased the knowledge and skills of Vietnamese researchers.

The projects established different sources of genetic material:

- SPAs (seed production areas): single species: selection intensity 1:10
- SSOs (seedling seed orchards): multiple species: selection intensity 1:10
- CSOs (clonal seed orchards): selection intensity 1:100 or 1:1000

These sources of seed required increased skills in designing, managing and analysing breeding trials. The Vietnamese scientists said that while there was some information and genetic material for eucalypts and acacias prior to the SAT and DAT projects, these projects greatly expanded the range of genetic material (from the Australian Tree Seed Centre). This broader base of genetic material has allowed a wide range of species and provenances to be tested. The breeding populations originally set up during the SAT and DAT projects are now in their third generation.

4.3 IAS 47 by Fisher and Gordon (2007)

ACIAR commissioned Fisher and Gordon (2007) to undertake an assessment of the impact of the SAT and DAT projects in Vietnam. A key challenge in this impact assessment was to identify the *incremental* impacts from the ACIAR-funded SAT and DAT projects as distinct from the total returns to the forestry research program in Vietnam to which other organizations contributed.

The SAT and DAT projects gave rise to large gains in economic welfare in Vietnam. At a 5% discount rate, they estimated the net present value to be $127 million (in 2006 $s), the benefit–cost ratio to be almost 80:1 and the internal rate of return to be over 30% (Table 4). The very high returns to ACIAR-supported forestry projects has been surprising to economists. Mr Khongsak suggested that tree breeding programs were in their infancy in many developing countries and hence high gains in yields could be expected in early generations, but these are likely to decline over time. Perhaps the embodied nature of the technology, in the form of new varieties, leads to high rates of adoption although, for acacia, the gains from targeting species and provenances to their most suitable environments were as significant as the genetic gains.

Fisher and Gordon focussed on the gains from improved acacia (excluding additional benefits from hybrid acacia) and eucalypts (although smaller areas of melaleucas and casuarinas were grown). The economic gains arose from the higher yields and faster growth rates of improved varieties (compared to traditional varieties) from these different seed sources and the rate at which these new varieties replaced older varieties. They used a traditional partial equilibrium approach to estimating welfare gains with the added difficulty of long production lags in forestry.

One of our tasks is to check whether the assumptions made by Fisher and Gordon in their assessment of the SAT and DAT projects still hold. Some of the key tables and figures that summarise the assumptions of Fisher and Gordon are reproduced here along with the key parameters that were readily discussed with Vietnamese and Australian scientists during our project.

A key parameter driving the cost of production and profitability is the yield of timber. Yields for acacias and

Table 4. Summary measures

	Present value of benefits A$000	Present value of costs A$000	Net present value A$000	Benefit–cost ratio	Internal rate of return %
1%	432.4	2.0	430.5	220.6	32.2
5%	128.7	1.6	127.0	79.3	32.2
10%	34.7	1.3	33.4	26.3	32.2

Source: Centre for International Economics' estimates eucalypts increase as seed is sourced from germplasm bred under progressively more intensive selection pressure from unimproved germplasm through to clonal material (Tables 5 and 6).

Higher yields drive unit production costs down and profits up. Fisher and Gordon's model is driven by estimated reductions in the unit cost of production from the various sources of genetic material. The unit cost reductions estimated by Fisher and Gordon (Table 10, p. 25) were derived from estimates of plantation and production costs for acacia and eucalypts (Tables 7–9, pp. 23–25). We did not attempt to revisit the historical budgets and the estimated reduction in unit costs, the K– shifts, derived from them.

The reductions in costs from improved germplasm, which gave higher yields and faster growth, led to the adoption of new varieties. The actual adoption of varieties of acacia and eucalypts from the various sources of germplasm up to 2007, and projections by Fisher and Gordon thereafter, are shown in Figures 4 and 5. As breeding skills developed over time, so more material came from the more technically based sources

Table 5. Acacia wood yields

	Mean annual increment[a] (m^3/ha/year)	Yield at harvest pulpwood[b] (m^3/ha)	Yield at harvest sawlogs[c] (m^3/ha)
Unimproved germplasm	8.0	56	80
Identified provenances (+10%)	8.8	62	88
Seed from seed-production areas (+12%)	9.0	63	90
Seed from seedling-seed orchards (+15%)	9.2	64	92
Seed from clonal-seed orchards (+20%)	9.6	67	96
Clone (+25%)	10.0	70	100

[a] As growth rates through time are not linear, the mean annual increment is likely to vary with rotation length. However, for this exercise it is assumed to be the same.

[b] The average rotation for pulpwood is assumed to be 7 years.

[c] The average rotation for sawlogs is assumed to be 10 years.

Source: Centre for International Economics' estimates based on consultation with researchers.

Table 6. Eucalypt wood yields

	Mean annual increment[a] (m^3/ha/year)	Yield at harvest pulpwood[b] (m^3/ha)	Yield at harvest sawlogs[c] (m^3/ha)
Unimproved germplasm	7.0	63	84
Identified provenances (+10%)	7.7	69	92
Seed from seed-production areas (+12%)	7.8	71	94
Seed from seedling-seed orchards (+15%)	8.1	72	97
Seed from clonal-seed orchards (+20%)	8.4	76	101
Clone (+25%)	8.8	79	105

[a] As growth rates through time are not linear, the mean annual increment is likely to vary with rotation length. However, for this exercise it is assumed to be the same.

[b] The average rotation for pulpwood is assumed to be 9 years.

[c] The average rotation for sawlogs is assumed to be 12 years.

Source: Centre for International Economics' estimates based on consultation with researchers.

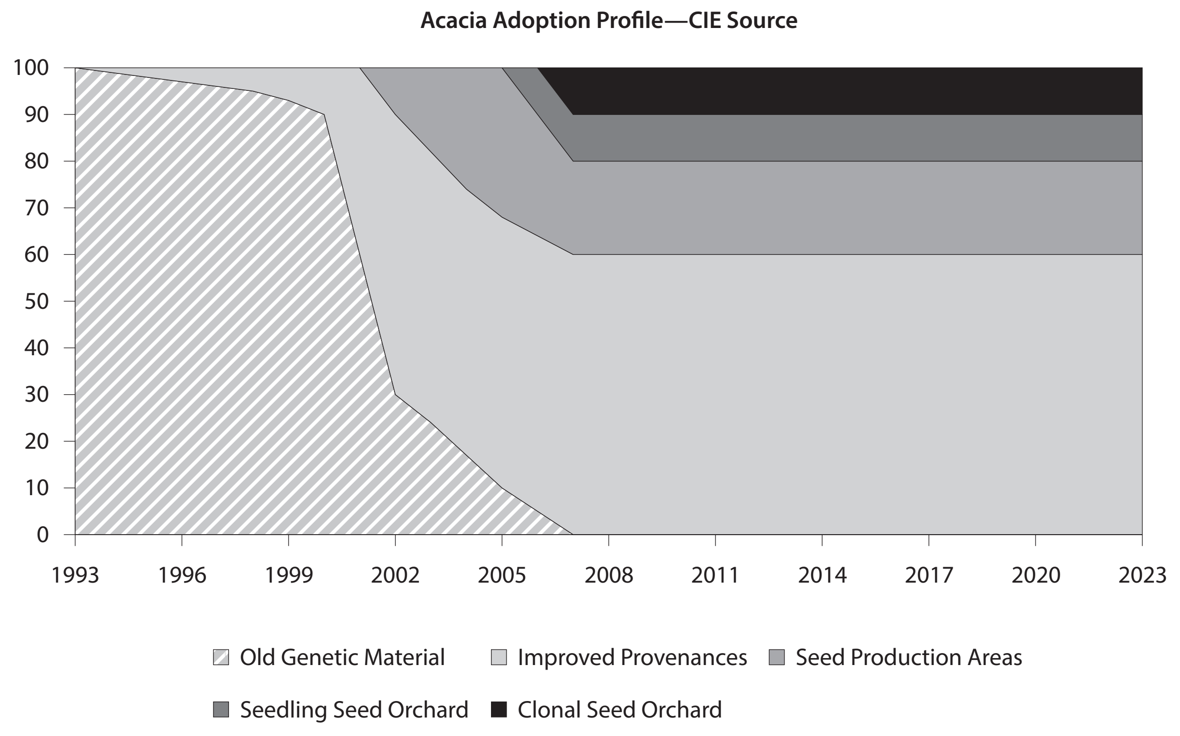

Figure 4. Acacia adoption profile by source of seed

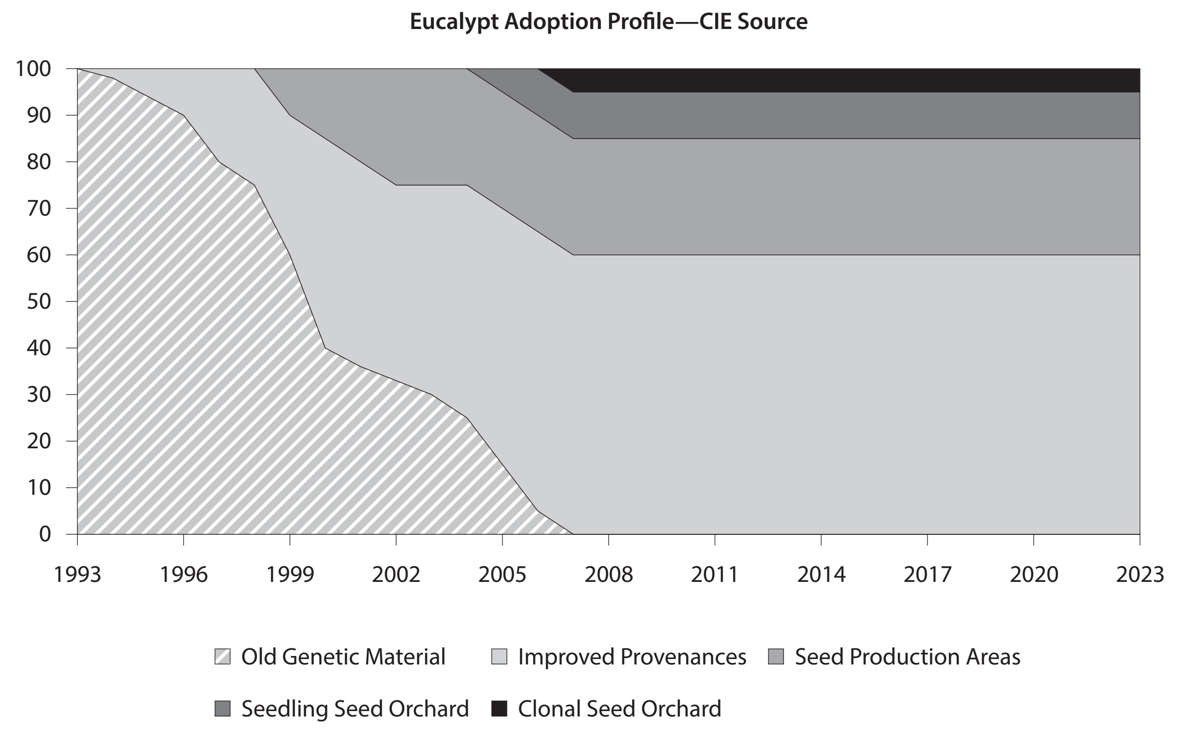

Figure 5. Eucalypt adoption profile by source of seed

delivering lower unit production costs; however, the largest source of material remained improved provenances.[15]

Areas planted and harvested and rotation lengths used by Fisher and Gordon, other important drivers of the total economic gains, are shown in Table 7.

Gordon and Fisher sourced Midgley (2006) for an estimate of plantings of acacia from all sources of about 350,000 ha. They noted that this included plantings of acacia hybrids. They argued that acacia hybrids were being developed from the improved provenances of the SAT and DAT projects and hence it was reasonable to attribute some share of the benefits of acacia hybrids to these two projects. There have been additional benefits from higher growth rates in acacia hybrids, but Fisher and Gordon claim that they have not counted these additional benefits. The area planted to eucalypts was based on Ha Huy Thinh (2004).

15 Improved seed is obtained from seed orchards or seed production areas comprising a mix of superior provenances identified from earlier testing that have been planted in an area together with the stand developed for seed production.

4.4 Review of Impact Assessment Parameters

Key parameters were reviewed with the scientists we interviewed. We reviewed not only the historical data used in the analysis but also the forward projections. There are few published data on the release of new varieties and their planted areas, or on prices and quantities, and we have had to rely on the judgement of the scientists familiar with the industry.

Both the Australian and Vietnamese scientists suggested that the yields used by Fisher and Gordon were quite conservative. Higher yields are now being achieved. Nambiar et el. (2015) quoted yields from *A. mangium* in the north of 12 m^3/ha/year (from superior natural provenances or seed from SPAs of superior provenances) and noted that yields are higher in the south. Yields depend on both the environment and the variety. These are the only published data we have found but they are consistent with the limited data for acacia hybrids described above.

The Vietnamese scientists suggested that rotations may be shorter in length than those assumed by Fisher and Gordon. Trees for pulp may be harvested after 5 to 6 years and for sawlogs after 10 to 12 years. The government is trying to encourage a shift towards more sawlogs but with little success so far.

Table 7. Estimated plantings and annual harvest

	Estimated plantings (ha)	Average rotation length (years)	Area harvested annually (ha)	Estimated annual harvest (m3)
Acacias				
Pulp (70%)	245,000	7	35,000	2,205,000
Sawlogs (30%)	105,000	10	10,500	882,000
Total[a]	350,000			
Eucalypts				
Pulp (85%)	295,800	9	32,867	2,070,600
Sawlogs (15%)	52,200	12	4,350	365,400
Total[b]	348,000			

a From Midgley (2006)

b From MARD (2002), referred to in Ha Huy Thinh (2004).

Source: Centre for International Economics' estimates.

Recent data on areas planted to acacia and eucalyptus varieties are re-presented from Table 2. The areas planted to these two species account for more than half the total plantation area in Vietnam. The area planted to acacia is more than three times larger than projected by Fisher and Gordon. The area planted to eucalypts is presently about 2/3 the area of 348,000 ha assumed by Fisher and Gordon but is reported to be again increasing. This large increase in plantings cannot be attributed solely to the SAT and DAT projects or even to later projects. Government policy encouraging forestry, including allocating forest land to households, is also likely to have played a role, alongside the wider research program of VAFS and changing economic conditions.

While we have not been able to re-estimate the adoption profiles for acacia and eucalypts (Figures 4 and 5), Vietnamese scientists observed that the proportion of planting material from cloning technologies may be in the order of 50%. Acacia and eucalypt hybrid varieties are all clones. About half of *E. urophylla* and *A. auriculiformis* varieties are clonal but none of the *A. mangium*, and *A. crassicarpa* varieties are from clones (Chris Harwood, personal communication). Clonal varieties generally have higher yields.

Fisher and Gordon did not provide information on the prices they used. The price for acacia timber for pulpwood was discussed in the previous section. Price seems to increase from south to north and no doubt varies with distance from mills and ports. Perhaps in the north real prices have remained similar to those reported by van Bueren, but in the south the real price may have drifted down as might be expected when new, relatively more profitable varieties encourage an increase in supply. The Vietnamese scientists suggested that the price of timber from eucalypts at the farm gate might be about 0.5 million VND/m^3. We were unable to obtain estimates of the cost of growing timber currently but the industry has continued to grow, suggesting that it has remained profitable.

In summary, the assumptions made by Fisher and Gordon seem to have held. Yields are higher and areas planted are larger. We have no new information on prices and costs but the growth in the industry suggests that the industry has remained profitable. There seems little reason to downgrade van Bueren's estimate of the rate of return to this project.

4.5 Capacity Building Activities and Outcomes During FST/1993/118 and FST/1998/096

Fisher and Gordon (2007, p. 16) documented a range of capacity building activities during the projects but made no attempt to value the outcomes from this capacity building in developing further new varieties and so the full economic impact of the project is likely understated.

We have noted the difficulties of valuing this build-up in capacity. Recognising that to be of value, capacity must eventually be applied in developing technologies profitable for farmers, we attempted to identify specific capacities/skills developed during the project and then to trace a pathway through their continued use in VAFS (and elsewhere if possible) to new technologies, either realised or projected, that are likely to be profitable to farmers.

As recorded by Fisher and Gordon (2007, p. 16), the set of formal training activities undertaken within the SAT and DAT projects included:

- Mr Phi Quang Dien, from the Research Centre for Forest Tree Improvement, undertook a professional attachment with the Queensland Forest Research Institute for one month. He learned about practical control pollination in *Pinus caribea*. These techniques are applicable to indigenous pines in Vietnam.
- Mr Ha Huy Thinh and Mr Luu Bu Thinh successfully completed a 7-week training course in tree seed technology and seed orchard management. The course incorporated seed testing, storage and collection.
- A short course in experimental design and analysis was conducted at the Research Centre for Tree Improvement in July 1994.
- A paper entitled 'Genetic improvement of *Acacia* and *Eucalyptus* in Vietnam' was delivered to the Project Technical Workshop, Forest-Based Development of the Long Xuyen Quadrangle, held on 3–5 August, 1995.
- SAT contributed $30,000 towards the cost of a conference on 'Tree Improvement for Sustainable Tropical Forestry'. The conference was attended by Dr Nguyen Nghia and Dr Hoang Chuong from Vietnam.

- A 6-day training course on seed technology was given in Vietnam. The emphasis was on developing competency in analysing assessment data from progeny trials and seed orchards, and using the information to successfully develop seed production in seed orchards and selection of superior trees. The course was attended by 17 Vietnamese participants from six forestry organisations.
- Mr Nguyen Viet Cuong from the FSIV undertook a professional attachment with the isozyme laboratory at the Australian Tree Seed Centre for 6 weeks. His attachment focussed on learning techniques and analysis that can be applied to his work in Vietnam.
- A 6-week professional training attachment of Mr Phi Hai Hong and Mr Nguyen Tran Nguyen from the Research Centre for Forest Tree Improvement. [They] analysed growth data from progeny trials, which will be used for the development of these trials into seedling seed orchards.
- Mr Tran Duc Vuong from the Research Centre for Forest Tree Improvement received four weeks of training in starch–gel electrophoresis.
- A training course on seed orchard management, safe seed collection and processing was conducted in Vietnam in April 2004. There were 11 Vietnamese participants.

The Vietnamese scientists commented on the value of these short courses. In addition, informal capacity building in the form of mentoring and learning by doing was also very important. The Australian and Vietnamese scientists distilled the following set of skills as having been developed from formal and informal training during the SAT and DAT projects:

- hybridisation
- cutting propagation
- seed technology skills (including seed extraction and storage)
- managing a seed database (documentation and characterisation of seed)
- trial management
- experimental design
- breeding strategy
- data analysis
- scientific writing.

These skills were developed progressively through the course of the projects. The Vietnamese thought they probably started with the skills necessary to manage a SPA where parents are not tracked, but to develop more sophisticated breeding programs—where families with certain characteristics are identified and tissue culture and cloning technologies can be applied—requires higher levels of skills that were developed and maintained across the projects. These skills allowed varieties to be objectively assessed across a range of environments in Vietnam. Hence, both the capacities developed and the trials and orchards were necessary to achieving the projects' outcomes of new more profitable varieties but neither was sufficient on their own.

The Vietnamese scientists involved in these projects have a strong record on scientific publications. For example, Dr Hai has written about 40 scientific papers (including eight ISI papers) and three books, and Dr Kien has authored or co-authored at least six scientific papers in English-language journals. They have endeavoured to pass on the skills they have acquired to others at VAFS. More broadly, Dr Hai for example now lectures in tree breeding at Vietnam Forestry University. Dr Hai and Dr Kien run courses at VAFS and at the forestry companies, Asia Pulp and Paper (APP and Sumitomo), on data analysis.

We asked Mr Khongsak, Dr Thinh and Dr Hai to make a subjective judgement about the importance of capacity building relative to knowledge discovery processes to the outcomes of the project. Mr Khongsak rated capacity building to knowledge discovery as 50:50. Dr Thinh's rating was 60:40, and Dr Hai rated these activities as 70:30. Mr Khongsak suggested that for research within CSIRO the ratio would be more likely 30:70.

Fisher and Gordon (2007) estimated that around 20% of the projects' budgets were spent on formal training activities. Gray et al. (2015) estimated that, based on the information from project documents, capacity building ranged from 7 to 29% with an average of 17% (Table 8).

Perhaps then a third to a half of the benefits estimated by Fisher and Gordon for the SAT and DAT projects can be attributed to capacity building activities.

Table 8. Percentage of project budget spent on training activities in project[16]

Project ID	ACIAR contribution	Total budget	JAF (PhD)	JAF (MSc)	Total reciprocal travel budget	Days in Vietnam PL	Days in Vietnam SC	Workshop, seminars etc.	Travel value informal training	% of Vietnamese allocation in the budget
FST/2002/112	$386,083	$931,444	1		$12,300	5	6	$7,633	$27,533	7%
FST/1999/095	$682,611	$1,972,155	2		$15,260	11	28	–	$40,860	9%
FST/2010/034	$1,643,437	$2,226,991			$33,010	24	24	–	$66,610	11%
FST/2008/007	$1,102,344	$2,878,896	1		$171,280	39	249	–	$351,880	12%
FST/2001/021	$519,932	$1,385,695			$37,670	34	17	–	$75,070	13%
FST/2008/039	$1,101,028	$1,719,032	1		$87,240	120	145	–	$270,240	16%
FST/1996/005	$572,857	$572,857			$41,340	7	7	–	$51,140	20%
FST/2003/002	$506,054	$846,561		1	$38,840	20	102	–	$116,040	26%
FST/2006/087	$927,862	$1,231,374	4		$99,850	154	238	–	$365,850	30%
FST/1997/024	$1,145,013	$2,361,280		1	$22,840		31	$73,726	$115,166	33%
10 Projects	$8,587,221	$16,126,285	9	2	$559,630	46	85		$1,480,389	17%

16 For details of calculation see Gray et al. (2015).

4.6 Subsequent Capacity Building Through Formal Postgraduate Training

There were no John Allwright Fellows from Vietnam who applied under the SAT or DAT projects. However, there were a number of successful JAFs who applied under later projects (also managed by the Tree Breeding Centre). Dr Phi Hong Hai, a project scientist on the SAT and DAT projects was later successful in obtaining a John Dillon Fellowship (in 2010). Further, Australian scientists co-supervised Vietnamese scientists in their graduate studies after the SAT and DAT projects. Dr C. Harwood co-supervised the PhD studies by Drs Hai and Kien at the Swedish Agricultural University at Uppsala, 2004–2009. In parallel, under the polyploid projects, Rod Griffin, Jane Harbard, Anthony Koutifides (UTAS) and Haywood all contributed to the supervision of Tran Duc Vuong (MSc 2009), Nghiem Chi (PhD 2012) and currently Le Son (PhD) at UTAS under John Allwright Fellowships.

4.7 Contribution of Capacity Building to Later Technologies

The scientists we interviewed stressed the importance of capacity built in the SAT and DAT projects to their current research capabilities. Mr Khongsak pointed out that tree breeding is a continuous process, with Vietnam entering the third generation of the process. Now characteristics such as timber and pulp quality and disease resistance are being bred for.

There has been a steady stream of new varieties released by MARD that have been bred by scientists at VAFS. The releases of acacia hybrids were reported in Table 3 in the previous section. Tables detailing the releases of other acacia and eucalyptus varieties can be found in Appendix 10.1 and 10.2. In summary, between 1998 and 2015, 10 *A. mangium*, 27 *A. auriculiformis*, 18 *Eucalyptus urophylla*, 10 *E. camaldulensis*, 18 Eucalyptus hybrids, 3 *E. tereticornis* and 2 *E. brassiana* varieties have been released. Unfortunately, data on the adoption of these varieties were unavailable, although we know plantings of acacia have increased dramatically. Plantings of eucalyptus, particularly hybrids, are expected to increase in the future.

This strong record of variety release can at least be partly attributed to the genetic material introduced together with the development of the wide range of skills at VAFS initiated during the SAT and DAT projects that were partly funded by ACIAR.

As further evidence that capacity built during these projects has been applied elsewhere, Australian scientists (Chris Harwood, personal communication) have pointed out that VAFS has independently experimented to optimise capture and cloning of selected genotypes of pure-species acacias (*A. mangium*, *A. auriculiformis* and *A. crassicarpa*) and acacia hybrids. They have evaluated different options to find the best age to capture selections, the procedure of pollarding (cutting back) to stimulate re-sprouts, and collection and rooting of harvested cuttings, followed by optimization of tissue culture and clonal nursery protocols for individual clones. As a result, they can capture and propagate a higher percentage of selected clones. These technologies have been used to establish clonal seed orchards, and to bring selected clones into commercial mass-propagation in clonal nurseries. VAFS is now recognized as a world leader in these areas of propagation technology.

The Vietnamese scientists said that the SAT and DAT projects allowed them to enter a network of international scientists and from this network they have both advanced their own skills and also contributed to skill development in other countries. Vietnamese scientists play a lead role in South–East Asia and work collaboratively with forest scientists in South Africa and Brazil, both of which are at the forefront of plantation research, particularly with respect to eucalypts.

5 Building Bivalve Hatchery Production Capacity in Vietnam and Australia (FIS/2005/114)

5.1 Data Gathering Process

Mullen interviewed Dr W. O'Connor and Dr M. Dove at the Port Stephens Fisheries Institute on 9.2.16. Both had worked on project FIS/2005/114 (O'Connor et al. 2012), the subject of the Johnston (2012) benefit–cost analysis, and are engaged on FIS/2010/100. Dr O'Connor is the leader of these projects. We held discussions with RIA1 staff including Dr Than Thi Van, Ms Vu Thi Lien, Dang Thi Lua, Nguyen Viet Khie and Ms Nguyen Thi Hien on 18.2.16. None of these people were directly involved in the first project though some are involved in the second project. We spoke about present conditions in the oyster industry. On 20.2.16 we met with Dr Le Thanh Luu, the Director of RIA1 at the time of the first project. On 24.2.16 we interviewed Dr Le Xan now retired from RIA1 but a leading scientist in the first project and in the subsequent development of the oyster industry in Vietnam. Mullen visited the Cat Ba research station where the projects and oyster hatchery are located and held discussions with Mr Vu Dinh Thuy, Ms Dang Thi Hanh and Nguyen Van Phong. Further helpful suggestions were received at a feedback presentation to a small number of RIA1 staff on 26.2.16. O'Connor, Dove and Johnston commented on a draft of this section, and Dr Vu Van In has provided data and insights into the oyster industry in Vietnam.

5.2 Project Background and Outputs

Historically the oyster and other mollusc aquaculture industries in Vietnam have been small relative to its coastal resources, relying on wild catch as a source of seed. Several events led to RIA1 and the New South Wales Department of Primary Industries (NSW DPI), with part funding from ACIAR, developing project FIS/2005/114 'Building Bivalve Hatchery Capacity in Vietnam and Australia'. The Vietnamese Minister of Fisheries visited the NSW DPI's oyster hatchery at Port Stephens and a reciprocal visit of bivalve culture facilities and farms in North Vietnam was made by Dr W. O'Connor and Dr G. Allan (from the NSW DPI) in December 2005. The development of the oyster industry became a government priority. In 2006, Dr Le Xan of RIA1 visited Taiwan and brought back what were thought to be seed of Pacific oysters. To this point, Vietnamese scientists had been working on molluscs without external funding. The development of mollusc aquaculture was a strategic goal of the Ministry, and the government had secured financial support from Denmark and the US for the construction of a hatchery and had also requested support from Australia for technical expertise. As it turned out, the hatchery at Cat Ba was built in 2006 before final approval of the ACIAR project came through.

The ACIAR project, FIS/2005/114, began in 2007 and finished in 2012. The Australian project leader was Dr Wayne O'Connor assisted by Dr Mike Dove and other scientists and technicians. Key scientists in Vietnam were Dr Le Xan and Dr Luu.

The aim was to overcome constraints on the development and diversity of small-scale bivalve culture businesses through the establishment of reliable hatchery-based seed production capacity. The specific objectives were:

- to foster the development of the bivalve hatchery facility under construction at Cat Ba Island;

- to establish the knowledge base required for the selection of suitable species and their hatchery production;
- to assist the establishment of nursery facilities to bridge the gap between hatchery production and the provision of suitable sized seed to farmers; and
- to assess chemical-free methods to produce triploid shellfish in Australia and their use in Vietnam.

In Vietnam, research was conducted on milky oysters (known as Hau Sua in Vietnam and Portuguese oysters elsewhere) and Tu Hai (a type of clam).

5.3 Johnston's Benefit–Cost Analysis

While not formally part of the ACIAR impact assessment program, O'Connor commissioned Bill Johnston from the Queensland Department of Primary Industries to undertake an impact assessment of the project in 2012 to assist in meeting final report requirements (Johnston 2012). In a companion study, Pearce (2011) was commissioned to report on social impacts of the project.

The most tangible output was the development of a capacity to supply seed oysters to commercial farmers at a far greater rate than through wild capture, and this in turn led to a rapid expansion in Vietnam's oyster industry. Johnston noted a range of other outputs, including publications and significant gains in stocks of knowledge and human capacity.

When expressed in real or constant terms (using 2012 as a base and including an estimate of on-costs), the costs for the project were assessed as $5.1 million (nominally $4.9 million) or about 80 billion VND (Johnston 2012), which is about 90 billion VND in 2015 dong.

Johnston (2012) used two methods to estimate the benefits from the ACIAR project that each gave similar results. One approach was to apply the set of formulae from Section 2 to estimate the total change in economic surplus, TS. Johnston followed Lindner (2005), assuming a k of 10% (adjusted by demand and supply elasticities) based on his impact assessment of an ACIAR-funded mud crab project in Vietnam.

Johnston's second approach was based on the kPQ approximation of the total welfare change. In reviewing the growth of oyster farming in Quang Ninh Province, Dong (2011) observed that oyster farmers were earning a profit of 3,000 to 5,000 VND/kg although no budget to support this estimate was provided. Since oyster farming was almost non-existent prior to this ACIAR-supported project, it is reasonable to assume that the change in profit associated with the project delivering hatchery spat and the efforts of RIA1 and provincial extension services in extending the technology to farmers is in the order of 3,000 VND/kg. Only results from this second method are reported (Table 9) because these estimates were based on economic conditions facing oyster farmers at the time.

Table 9. Johnston's estimates of returns to investment in FIS/2005/114

	'Without' project technology would have been developed in:		
	5 Years	**10 Years**	**Never**
Net Present Value[a]	A$19,349,170	A$28,329,543	
Benefit–Cost Ratio	1.66	2.38	8.42

[a] Can be scaled to 2015 values using Vietnam CPI factor of 89.56 if exchange rate changes are ignored.

The BCR was quite sensitive to judgements made about how long before the technology to deliver cheap spat to farmers would have become available in the absence of the ACIAR funded project.[17] Johnston did not express a preference between the 5- and 10-year lag scenarios. A 'without' scenario in which the R&D is delayed by some years is much more conjectural than many of the other parameters on which the analysis is based. Davis et al. (2008, p. 25), while stressing the importance of developing a plausible counterfactual, warned against too readily accepting 'without' scenarios that posit the research would have occurred with a delay of some years, saying: "In general, this 'it would have happened anyway' idea does not constitute a sound baseline and should be

[17] The BCR is higher if the 'without' project scenario is that the technology would not otherwise have been developed. As time to the development of the technology in the 'without' scenario comes closer to the 'with' scenario, the BCR falls.

considered only if it can be rigorously demonstrated." It remains a contentious issue for practitioners.

At the time leading up to the development of the original project, the oyster industry in Vietnam was virtually non-existent, and research capacity was similarly small. Perhaps technology could have been imported from China. Perhaps a research project in RIA1 supported by the University of Ghent may have made similar advances. O'Connor and Dove are now of the view that a lag of only five years was too optimistic. In developing countries where domestic research resources are scarce, assuming that the research would have been undertaken a few years later seems a highly conservative counterfactual. It may be that the Vietnamese scientists would have found other avenues to develop their capacity, but it is likely it would not have been in oysters.[18]

In contrast, in the case of acacia hybrids, scientists (specifically Professor Kha) were already investigating acacia hybrids and would likely have eventually developed the skill of acacia hybridisation themselves. In this case, a 'without' scenario where the ACIAR project in Malaysia advanced the pace of hybridisation in Vietnam by four years seems a reasonable one.

By this line of reasoning, our view is that the projected BCR for the original project in 2012, when Johnston conducted his analysis, was in the range of 2 to 8.5.

These estimates are based on key parameters such as the size of the industry, Q, the price of oysters, P and the estimated increase in profit from growing oysters. There were actual data for these parameters up to about 2012, but beyond that the estimates were based on projections about future trends to 2036.

5.3.1 Production

Table 10 sets out oyster production data from 2007 to 2012. It was taken directly from Johnston's report although 2012 was a projection. It is not clear how these data were assembled because Vietnam's central statistical agency does not collect data on oyster production. A key assumption was that all this growth could be attributed to the original project. Prior to its commencement there had been no commercial oyster industry in the region of Cat Ba.

Table 10. Industry production data

Year	Production (t)
2007	100
2008	1,000
2009	2,500
2010	4,000
2011	7,000
2012	10,181

Johnston used a logistic function to project the growth in oyster production out to 2036. From this graph (Figure 6), oyster production in 2015 should have been about 18,000 and was expected to peak at around 20,000 tonnes in 2018.

5.3.2 Price

According to data from the Quang Ninh Department of Agriculture and Rural Development in Vietnam (Dong, 2011), the market price of oysters fell from 25,000 to 30,000 VND/kg in 2009 down to 10,000 to 15,000 VND/kg in 2011 (Figure 7). It is possible this can partly be explained by the growth in the industry over these years. Johnston assumed a price of 12,000 VND/kg in his analysis, which is about 13,400/kg in 2015 VND.

At these prices, profits were estimated to range from 3,000 to 5,000 VND (Dong 2011), and a breakeven price 9,000 VND/kg (0.42 AUD/kg) was established (in 2012 VND). At a price of 12,000 VND, profit was estimated at 3,000 VND/kg (0.14 AUD/kg). A breakeven price or cost of production of 9,000 VND/kg in 2012 is equivalent to just over 10,000 VND/kg in 2015. These prices are in-shell. The implication of Johnston's analysis was that because the efforts of the team involved in the ACIAR project led to the development of the oyster industry in Quang Ninh, this estimate of profit is also an estimate of the change in profit attributable to the project. An implicit assumption is that the opportunity cost of resources used to grow oysters is very small.

18 When we disaggregate to alternative activities within a research project, then conceptually there is a counterfactual for each activity such as the resources used for capacity building. This relates also to the discussion about selection bias in Section 1. We do no more than acknowledge this complexity and focus on the counterfactuals for the projects as a whole.

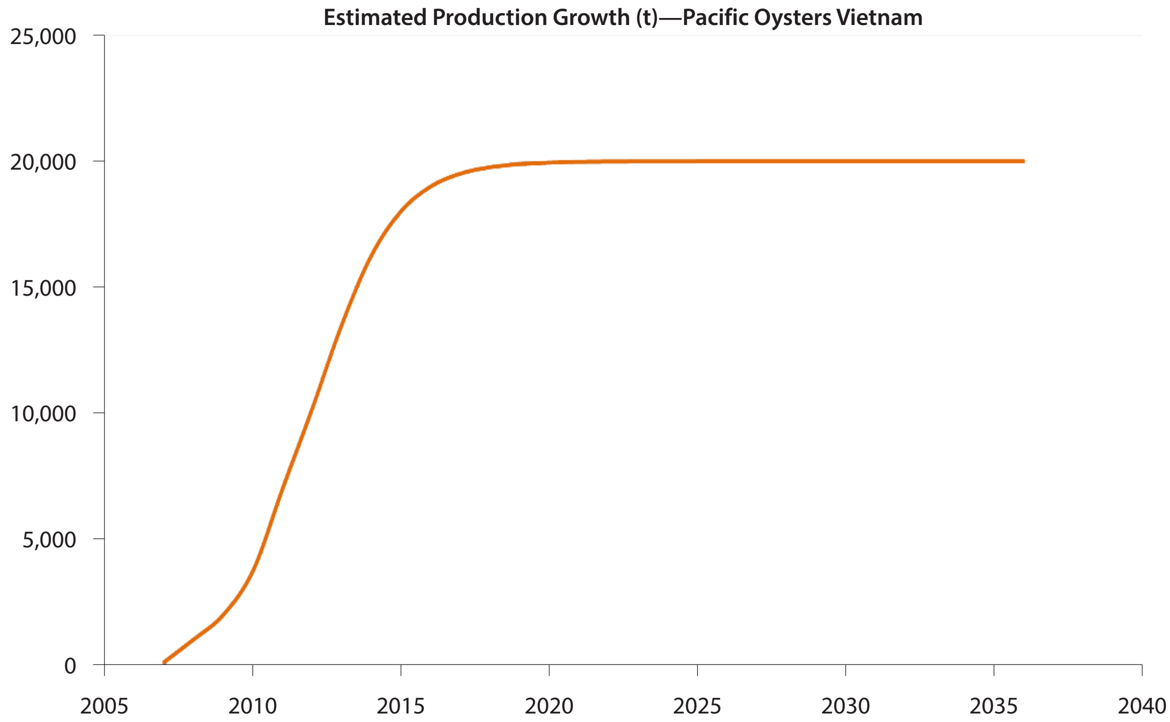

Figure 6. Logistic function for growth of oyster production in Vietnam

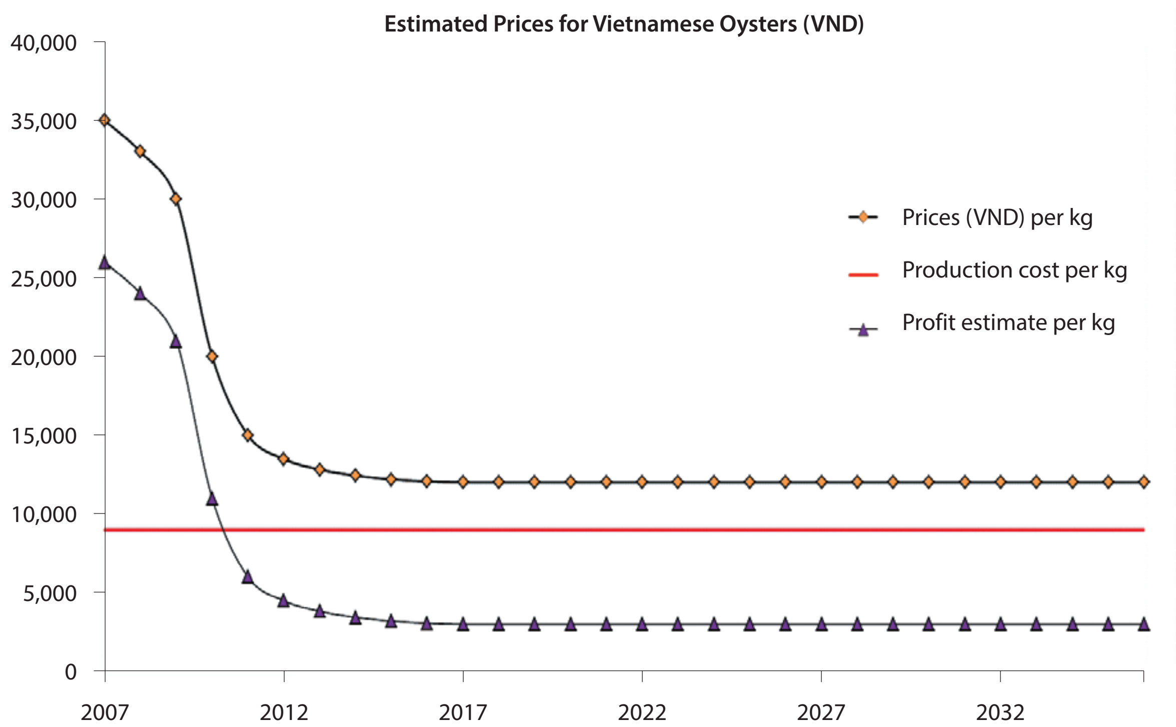

Figure 7. Estimated prices and profit margins for Pacific oysters per kilogram

The change in profit was multiplied by the production series to get a time path of industry benefits to 2036 that were aggregated into financial measures such as net present value and the BCR using discounting processes.

5.4 Review of Impact Assessment Parameters

Key parameters were reviewed with the scientists we interviewed. We reviewed not only the historical data used in the analysis but also the forward projections of key parameters. There have been no published data on prices and quantities since 2012, hence we have had to rely on the judgement of the Vietnamese scientists familiar with the industry. Staff at Cat Ba (Dr Vu Dinh Thuy, personal communication) suggested that the current on-farm price of oysters might be 14,000 VND/kg compared to 13,400VND/kg assumed by Johnston and the cost of growing oysters might be 11,000 to 12,000 VND/kg compared to 10,000 VND/kg estimated by Johnston. Prices and costs are both a little higher, and profit/kg may be a little lower, but the changes in these parameters do not appear to have been large.

Dr Le Xan (personal communication) observed prices of 30,000 VND/kg retail on a trip to southern provinces. He thought that the farm gate price might be 60% of the retail price giving an on-farm price of 18,000 VND/kg. If the marketing margin is larger than 40% then the farm price falls towards the Cat Ba estimate.

There is similar uncertainty about the quantity of oysters presently being produced. O'Connor (personal communication) suggested that because of present high rates of mortality, production may only be about 11,000 tonnes (i.e., not much above the 10,000 tonnes achieved in 2012), and some Vietnamese scientists supported this view. Dr Le Xan, working across the 28 provinces now growing oysters, thinks production may have reached 15,000 tonnes/year. Johnston's projections of 18,000 tonnes in 2015 and 20,000 tonnes/year soon after have not been reached.

Production from the Cat Ba hatchery before 2012 was in the order of 10 to 20 million spat depending on demand, but Cat Ba has difficulty in supplying spat year round because of low temperatures and weather. Farmers near Cat Ba have recently been sourcing low-cost spat from China, and production at Cat Ba in recent years has fallen to about 5 to 10 million spat (Dr Vu Van In, personal communication). However, the spat from China are smaller and have a lower survival rate than the Cat Ba spat. Average yields have fallen from about 1.5 to 0.5 tonnes per raft.

Particularly in view of the lack of current data on all the key parameters, we do not have the capacity to re-estimate Johnston's benefit–cost analysis. On the other hand, we can form expectations about changes in the BCR based on changes in actual and projected production, the main parameter to change since Johnston's analysis. At 15,000 tonnes/year, production is about 25% lower than Johnston projected. Much of this production was projected for years following the analysis and hence because returns in these years are discounted back, we might expect that the reduction in the BCR to be less than 25%.[19] A reduction of 20% puts the BCR in the range 1.6 to 6.8. If the profitability of oyster production has also fallen as indicated above then the BCR may even be lower. Much of this discussion applies to the industry in Quang Ninh close to China and Cat Ba. Even less is known (to us) about key production parameters in the rest of Vietnam.

Dr Phan Thi Van, Director of RIA1, offered to assemble missing price and quantity data and budgets for oyster growing. We declined this offer because we felt the benefits to our study did not outweigh the costs. However, we did advise that this information would be critical to any future assessment of the impact of both oyster projects and suggested the data be assembled during FIS/2010/100.

5.5 Capacity Building Activities and Outcomes During FIS/2005/114

So far we have followed Johnston in not accounting for human capacity built during the original project and hence the full economic impact of the project is likely understated. Similarly to the review of the forestry projects, we have noted the difficulties in valuing this build-up in capacity. Recognising that to be of value, capacity must eventually be applied in developing technologies profitable for farmers, we attempted to

19 Most models estimating economic impact are linear.

identify specific capacities/skills developed during the project and then to trace a pathway through their continued use in RIA1 (and elsewhere if possible) to new technologies, either realised or projected, that are likely to be profitable to farmers.

The Australian and Vietnamese scientists we interviewed clearly identified a set of skills developed during the project comprising:

- algal culture
- spawning
- larval rearing and settlement
- hatchery management.

These are highly specific technical skills that were all judged necessary to achieving the project's objective of reducing the cost of delivering spat to farmers. The growth in the industry over the course of the project is evidence that these skills were developed.

The Australian scientists saw the development of these skills as the bare minimum to be able to produce oyster seed consistently. Without these skills, a program to breed for growth rate or disease resistance was not possible (and was not attempted in this first project). This set of skills was also needed to conduct research into other species.

Vietnamese scientists identified other more general capacities that were developed during the project that perhaps were not necessary to achieving the original project's objectives but which nevertheless may hasten the development of technologies in the future.

Though not part of the project team, Dr Van identified the development of skills in writing scientific papers as an important outcome from the project. The final report from the project lists nine publications and five extension products from the project, with about half having Vietnamese co-authors. A manual for producing Pacific oysters written by Le Xan et al. (2009) was probably quite influential both in extending the technology to farmers and private hatcheries and in developing writing skills. Dr Le Xan suggested that the professionalism and work ethic of the Australian scientists and technicians was a great example to their Vietnamese colleagues. He found working with the DPI scientists and technicians a very rewarding experience and used the term 'growing together' to describe this.

O'Connor and Dove wrote a small number of scientific papers during the project. O'Connor (personal communication) reported that the flow of papers from these projects is beginning to increase as the academic skills of the team improve and as the knowledge discovery component of the projects increases. This lag also reflects what can be a lengthy 'pipeline' between concluding some research activities and eventual publication of findings.

In Australia, an important focus was on pipis. The population in the Sydney region had crashed, and prices rose from about $15/kg to $50/kg. During the project, knowledge about pipi biology was advanced but has not yet led to immediately applicable technology—a bottleneck in this process has been the lack of a nursery for re-seeding the population. Research was also carried out for producing triploid oysters (which are sterile) using physical processes rather than the chemical processes (using carcinogens) presently used. While knowledge was advanced in this area, commercial applications have not yet been developed.

O'Connor and Dove identified two more general benefits from the project to the NSW DPI. First, the project contributed to maintaining a research capacity in the NSW DPI and, second, DPI scientists gained insights and experience from working on other molluscs in a different and low-cost environment.

We asked O'Connor, Dove and Le Xan to make a subjective judgement about the importance of capacity building relative to knowledge discovery processes to the outcomes of the project. The view of O'Connor and Dove was that because the main requirement of their first project was to build up the set of four skills identified above, capacity building rather than knowledge discovery made the largest contribution to the project's outcome—namely, an ability to deliver low cost seed to farmers either directly or through private hatcheries. O'Connor rated capacity building to knowledge discovery as 75:25. Dove's rating was 70:30. Dr Le Xan rated these activities as 50:50, perhaps reflecting the greater proportion of knowledge that was new to the Vietnamese scientists compared to that of their Australian collaborators. Based on these ratings, more than half the benefits from the project estimated by Johnston could be attributed to capacity building activities.

For the Australian component of the research into pipis and triploid oyster production processes, the Australian scientists rated the importance of capacity building relative to knowledge discovery as 25:75.

Gray et al. (2015), as previously described, trialled a process of estimating expenditure on informal capacity building as the sum of expenses incurred in travel, subsistence and the salaries of Australian scientists and technicians while in Vietnam and the travel and subsistence of Vietnamese scientists and technicians visiting Australia. The salary component was estimated as the number of days that the project leader or other Australian scientists travelled to Vietnam. Each day was valued at 800 AUD for a project leader and 600 AUD for a scientist.

For this project the resources devoted to capacity building were estimated to be 24% of the budget, which is markedly lower than the subjective judgements of the scientists involved.

5.6 Subsequent Capacity Building Through Formal Postgraduate Training

In Vietnam, two RIA1 staff members involved with the previous ACIAR project were accepted as John Allwright Fellows to study in Australia. The first, Dr Vu Van In, has completed a PhD on oyster genetics at the University of the Sunshine Coast and has now undertaken a survey of oyster brood stock available to this program for breeding in Vietnam. These stocks were used in 2014 to create 100 pair-mated breeding lines. Initially this involved the design and construction of a highly replicated, small-scale oyster-larval production system. This system can be used for other replicated scientific studies in the future or be used for the production of family lines of other species. Dr In has now started back at Cat Ba and is supervising the second project.

Dr In's research has proved valuable to the Sydney rock oyster industry. He tested the diversity in Sydney rock oysters and the extent of in-breeding, the subject of a scientific paper he wrote, which is assisting in operating a breeding program.

The second JAF, Cao Truong Giang, has completed additional English training at the University of the Sunshine Coast and has now commenced a program on selective breeding to develop a genetically improved strain of Pacific white leg shrimp *(Litopenaeus vannamei)*.

At least four other scientists identified during the first project are now undertaking PhD studies with funding from RIA1. Some of these students are being supervised by O'Connor and Dove.

We did not get a chance to interview either the JAFs or the non-JAF students and so were not able to ask about skills being acquired and how these skills might potentially be used.

5.7 Contribution of Capacity Building to Later Technologies

Capacity built has the potential for economic impact if it is later used to develop technologies adopted by farmers. The rates of return estimated by Johnston may be understated if capacity built during the project contributes to on-farm outcomes from later projects.[20]

Mullen visited Cat Ba and observed a laboratory where algae were being grown and a hatchery where oyster spats segregated by family were being reared. Staff there also pointed to the use of these skills in other research areas at the hatchery. Marine fish and shrimp, for example, are fed on rotifers that feed on algae grown at the hatchery. Mullen did not attempt to assess the extent to which research into marine fish and shrimp at Cat Ba enabled by the algae technology has resulted in technologies adopted by Vietnamese farmers.

Dr Le Xan pointed out that oysters are now grown in 28 provinces in Vietnam rather than six as at the time of the original project. Private hatcheries provide spat to farmers and they are using skills developed in the original program which have been extended to them by staff of provincial government extension services who were trained by scientists from Cat Ba. The picture here

20 However, investments in the later projects delivering these technologies on-farm must also be considered in any full accounting of benefits and costs.

is somewhat muddied by the widespread use of spat from China and associated biosecurity risks.

A key resource in this provincial training program was a manual written during the original project. It is intended that the manual be rewritten during the second project.

The capacity built during the first project is being exploited in the second project, FIS/2010/100, which requires a higher level of skill for its success. The first project developed a capacity to provide oyster spat either directly or indirectly to farmers and required the development of the skills and technologies identified above. The second project has the more ambitious objectives of breeding for disease resistance and faster growth rates. The first project provided the building blocks for the second. Another important capacity to be developed during the new project relates to disease monitoring.

Quoting directly from the project proposal document for FIS/2010/100 (p. 6):

> The overarching aim of this project is to increase hatchery-based bivalve production in Vietnam and New South Wales, Australia, to expand opportunities for coastal communities to rear bivalve molluscs. Our objectives are to:
>
> 1. improve hatchery reliability (in government and private facilities) for the production of oysters and clams and increase seed outputs
> 2. improve oyster brood stock management and establish the basis for bivalve breeding programs to improve seed quality
> 3. develop the basis for cultivation systems designed to increase oyster marketability
> 4. develop a bivalve health and environmental management program
> 5. develop the capacity for researchers, technicians, managers and farmers to safely and sustainably regulate the development of the bivalve industry
> 6. extend the scientific, social and economic benefits of improved bivalve culture technology to other areas of Vietnam
> 7. investigate three species (flat oysters, pipis and razor clams) that show potential for successful aquaculture in Australia.
>
> The key outputs from this research will include:
>
> - quantification of genetic variability in current oyster brood stock and a plan to enhance or maintain the existing stocks as required
> - inclusion in the Vietnamese hatchery operations manual of improved methods of production and protocols for small-scale, replicated rearing systems
> - production of selectively bred clam families with known heritability for key traits
> - scientifically derived information on the performance of various nursery and grow-out systems for oyster production and their impact on oyster quality
> - guidelines for health and environmental management for oyster and clams
> - a review of molluscan quality assurance requirements for Vietnam and plans for the development of molluscan diagnostic, biosecurity and quality assurance capacity within MARD.

The proposal indicated that these outputs would be extended through on-farm experimentation and farmer workshops; presumably private hatcheries will also be involved. There were few details about this pathway to the adoption of technologies by oyster farmers.

The breeding program has commenced, and if successful then Vietnamese farmers will increasingly be able to buy spat from hatcheries supplied by Cat Ba which have higher yields even if more expensive than spat from China.

So the potential is strong that the capacity built in the first project, which was identified but never valued in the benefit–cost analysis, may lead to welfare gains for oyster farmers provided the second project delivers on its objectives. New varieties developed during the project will presumably be transferred to private hatcheries. They will be adopted by farmers if they are more profitable to grow. Oyster production will most likely expand as these improved varieties become available. Thus we expect that Johnston's projection of 20,000 tonnes per year will be met if the project is successful. A future assessment of the impact of ACIAR investment in oysters in Vietnam would include the costs associated with both these projects. Consequently, unless the output exceeds 20,000 tonnes per year or unless the reduction in costs from these new varieties exceeds that estimated by Johnston, the rate of return estimated by Johnston may not be attained.

6 Experiences in Eliciting Capacity Built and Utilised

Our study was based on personal interviews with Vietnamese and Australian scientists who were involved in the project. This process had several challenges. Eliciting subjective judgements many years after the completion of projects is a source of uncertainty. Another challenge for the scientists was to associate capacity building and the impact of technology with the specific set of resources associated with the initial projects rather than with the broader research program within which the projects were situated, especially since it had been many years since the projects were completed.

There were a set of what might be termed framing challenges arising from the difficulties of clearly distinguishing between capacity building and knowledge discovery processes that arose from the preconceptions of scientists, the capacity building context of the study, and language issues associated with abstract concepts like capacity building and knowledge discovery.

To ameliorate these problems, separate questionnaires were developed for each project that included specific information derived from project proposals and reports and the impact assessment reports about the project, the technology developed and capacity building activities. The scientists were also asked to identify specific skills developed during the project and the importance of these skills both to the success of the original project and their contribution to the development, in subsequent projects, of new technologies that were adopted by farmers.

At this early stage of research into capacity building, we purposely chose as cases studies institutions with which ACIAR has had strong relationships and a set of projects highly likely to have delivered strong gains in economic welfare to Vietnamese farmers. We expected that developing processes for identifying capacities built and utilised to guide ACIAR project development and reporting was more feasible for projects where outcomes had been achieved.

The scientists we interviewed were unanimous in the importance they placed on the capacity building contributions of ACIAR-supported projects. Generally they rated capacity building as at least as important as knowledge discovery processes to the successful outcomes achieved in the three case studies (except for acacia hybrids)—in other words, both components were necessary and neither was sufficient in its own right to the successful outcomes.

This interdependency makes sense. Projects with a strong knowledge discovery component leading to farm ready technologies are most likely to have opportunities to develop valuable skills and capacities. Projects that focus entirely on capacity building will not lead to farm ready technologies in the life of the project and unless used later are likely to depreciate rapidly.

We found that scientists could easily identify skills and capacities developed during a project and judge whether they were necessary to the project's outcome. We had not anticipated the importance that Vietnamese scientists placed on general skills with respect to language, scientific writing, research strategy, developing scientific networks and project management in addition to technical skills developed. It was also possible to identify whether the skills still existed and were being used in ongoing later research projects.[21]

21 The referee wondered why the Vietnamese scientists had not noted their mentoring skills as an important capacity built. We did not specifically prompt them in this area but there did appear to be a spirit of collegiality in the two institutions that made it likely that mentoring was enhanced as a result of working with Australian scientists. See also our discussion on institutional capacity below.

While capacity building may have some non-use value to society, generally it has value when used to develop new technologies adopted within the economy. While some capacity building contributes to the development of technology adopted by farmers within the life of the project, many of the benefits from capacity building are not reflected at the farm level for many years until these skills are applied in later projects. These long lags make valuing capacity built difficult. Usually those conducting assessments of the impact of ACIAR's projects have pointed to the potential of capacities built but stopped short of projecting how these capacities might be used in the future, leaving this implicit.

Generally we were disappointed in the ability of scientists interviewed to explicitly identify how capacity built in the course of the ACIAR projects we studied had been used to develop new technologies attractive to farmers. One possible explanation for this is that the capacities built had not been used. However, all the scientists interviewed spoke about the importance of these skills to their ongoing research programs. Moreover, there is little reason to think that current projects building on these successful past projects will not also be successful in delivering technologies likely to be adopted by farmers.

In most cases the scientists we interviewed left implicit the eventual utilisation and hence value of capacity built, or they required prompting to talk about the outcomes expected from their research. Perhaps the framing issues with respect to the context of our capacity building study encouraged scientists not to make the pathway to on-farm outcomes explicit. It seems this reluctance was not confined to Vietnamese scientists but was shared by their Australian collaborators.

Perhaps the pathways to adoption in the three cases assessed here were taken for granted because the technology delivered to the farmers was embedded in the variety of tree or oyster they were presented with—adoption of such embedded technologies is usually high because the incentives for farmers to adopt are clear. The qualification here is that important hatchery management skills not embedded in oysters had to be transferred from oyster scientists to the private oyster hatcheries. We think it wise to make pathways to adoption explicit even in the case of embedded technologies.

Perhaps scientists and economists lack experience or are uncomfortable in making the conjectures necessary to describe a plausible pathway to future impact.

6.1 Gains in Institutional Capacity

There were two main pathways by which ACIAR may have contributed to increased institutional capacity in VAFS and RIA1, and these pathways may well be applicable to other institutions that ACIAR works with.

First, ACIAR has awarded John Dillon Fellowships to scientists from VAFS and RIA1. The focus of the Fellowships on research management indicates a potential for ACIAR to have had some influence on the efficiency with which research resources are used in the two institutions, although this influence is likely to have been small relative to the influence of central economic and political agencies in Vietnam in the allocation of resources. We have made no attempt to trace out how processes for allocating research resources in VAFS and RIA1 have changed, nor the role of ACIAR in fostering these changes. Nevertheless, many of the Fellows described benefits from their Fellowship in terms of increased project management skills. Improved management skills of individual scientists are likely to have institutional benefits where scientists are working in teams to develop and undertake projects.

Apart from the John Dillon Fellowship scheme, ACIAR has not funded projects directly focussed on improving institutional capacity. The influence of ACIAR's bilateral research program on institutional capacity is indirect. Important components of bilateral research projects (additional to the immediate technologies developed) are gains in the scientific capacity of individual scientists and gains in the stock of scientific knowledge which later lead to new technologies profitable to farmers. Gains in individual capacities arise from formal and informal training opportunities.

If these gains in individual capacities spill over, such that technical change attributable to VAFS is more rapid (in ways described in Figure 2) than would be expected from the contributions of scientists acting individually, then there has been an increase in institutional capacity. These spillovers only occur if there is increased cooperation between scientists or more teamwork.

In each of the three case studies reported here, initial projects were forerunners to a sequence of later projects. As teamwork continues through time, gains to institutional capacity are likely to increase. Gains in institutional capacity may arise in various ways, including better management of research projects (mentioned by several scientists) and improved priority setting and research resources allocation, for example.

Teamwork and change in teamwork are other concepts difficult to measure. However, during our interviews, both Australian and Vietnamese scientists commented that working on ACIAR projects gave them a greater appreciation of the benefits from working in multidisciplinary teams. Some evidence of this teamwork comes in the form of jointly authored scientific papers. Increasing international recognition of Vietnamese scientists has led to increasing international recognition of VAFS and RIA1 and leadership in multilateral research partnerships—all evidence of increasing institutional capacity. Several scientists noted that through their participation in ACIAR projects, their reach into scientific networks also increased with further benefits to their scientific capacity and to their institutions.

Institutional capacity is dealt with more thoroughly in the companion report by Morris et al. (forthcoming 2017).

7 Implications for ACIAR

An important objective of our project was to develop guidelines for ACIAR's project development and reporting processes whereby human scientific capacities built and the welfare gains arising from their use in initial and later research projects can be more routinely described and assessed, even if qualitatively. Being able to identify how capacities might be applied (often in later projects) to develop new technologies attractive to farmers indicates how economic welfare may be increased and adds weight to the claim that impact assessments understate the returns to ACIAR's investment because capacity building is rarely valued.

It has not been our brief to comprehensively review ACIAR's project proposal, reporting and impact assessment processes, and we are aware that ACIAR constantly reviews these processes. In this IAS, we have only examined a small number of project proposals, final reports and impact assessment reports. At present, the likely economic, environmental and social impacts flowing directly from the project are described and sometimes quantified. However, little attention is paid to capacity building inputs and outcomes which may also contribute directly to project outcomes but which may predominantly spill over contemporaneously and through time to other research programmes.

We have already described the difficulties in capturing the benefits flowing from the capacity building components of bilateral projects many years hence. In our view these benefits can best be captured by developing plausible causal pathways from capacity building activities to gains in economic welfare for farmers even if some of the evidence is subjective, anecdotal and conjectural. The potential benefits of capacities built, which may be apparent to those closely involved, are too easily dismissed by others if a pathway to a plausible economic outcome is left implicit.

Developing explicit impact pathways is a key recommendation of reports by Davis et al. (2008) and Gordon and Chadwick (2007) on impact assessment processes. The value of well-defined impact pathways is that they are likely to improve project design—particularly in identifying how new technologies will be delivered to farmers—leading to projects with higher rates of return. Generally, these pathways have been limited to the immediate economic outcomes of the projects under assessment. For projects we have reviewed, the impact pathways could have been more informative, certainly in the project proposal and project reporting phases. The links between project resources and activities and proposed economic, social and environmental impacts were not always well made.

Explicit pathways encourage capacity building activities and other research activities to be chosen purposely during planning stages and provide evidence at reporting and assessment stages that scarce research resources have been put to the best use. In project planning and development, it will be helpful to identify specific skills required for successful project outcomes, whether these skills are already available in the research institutions and, if not, how these skills are to be developed. In project reporting, the acquisition of specific skills and their contribution to the project needs to be documented. Comprehensively enumerating skills developed through mentoring or training programs, conferences attended and publications prepared are obvious metrics of outputs from capacity building that are relatively inexpensive to collect and report and is already the practice for good projects. In project review and impact assessment processes, the ongoing use of these skills, their contribution to the development of later technologies, and their adoption by farmers needs to be identified even if these contributions are not expressed as gains in economic welfare.

Ideally, project proposals[22] would make projections from the project's resources and activities about the impact of the technology on farm level costs and/or profits, even if based on simple enterprise budgets; about the target population for the technology; and about likely adoption and how adoption will be achieved. As the project moves to conclusion these key impact parameters would be revised as adoption begins. Parameter values become more certain at the time of an impact assessment, but future adoption levels are still somewhat conjectural.

Projecting outcomes from capacity building is more conjectural because of the likely long lags before increased capacity is reflected in new technologies. As the project moves to completion, capacities built are identified, and in final reports and later impact assessments projections can be made about a plausible pathway through later research programs (and the resources or activities required) to the eventual development and adoption of technologies by farmers. It does not seem unreasonable to expect project scientists to be able to project how capacities built are expected to contribute to later research programs. Nor does it seem unreasonable to be able to project in general terms the likely technologies that might emerge and the population of farmers to whom these technologies are applicable. It may be useful to distinguish between outcomes for next users of the initial project and outcomes for final users as suggested by Davis et al. (2008). Guidelines can be developed from our survey instruments and are also discussed in a companion paper from this project (Morris et al., forthcoming 2017).

Our intention has been not to add substantially to resources required for project development and reporting. In the first instance, scientists are likely to have to rely on the judgements of themselves and colleagues in choosing key parameters. It is not our intention that these initial parameters be the subject of a major research enquiry; rather, it is the process of identifying likely benefits and costs associated with the project that is important, and to concentrate on the expected farm level impacts of the technology and the population of likely adopters. We have noticed that sometimes resources are wasted describing economic impacts in terms of macroeconomic parameters like exports and imports that are too far down the chain to be confidently related to the projects' resources, hence providing little guidance in priority setting.

22 Or the first annual report.

8 Conclusions

ACIAR has a strong record in assessing the economic impact of the new technology developed during bilateral research projects. However, within any project, resources can be put to alternative uses—trials to develop farm ready technology or building human scientific capacity, for example. There is no theoretical or empirically sound way of attributing total economic welfare gains between these alternative investments. Nevertheless, good project design and better accounting of the use of funds requires an understanding of the contribution of capacity building to economic, social and environmental outcomes.

Capacity building within bilateral research projects through mentoring, learning by doing and short courses may contribute directly to the outcomes of a particular project, but because it adds to the stock of human scientific knowledge, it also has the potential to enhance economic welfare many years into the future when applied to the development of profitable farm ready technologies in later research programs.

We purposely chose to revisit three bilateral research projects which had previously been assessed as developing technologies profitable for farmers and earning high rates of return to the research resources invested in them, namely:

- Acacia Hybrids in Vietnam (FST/1986/030)
- Improved Australian Tree Species in Vietnam (FST/1993/118 and FST/1998/096)
- Building Bivalve Hatchery Production Capacity in Vietnam and Australia (FIS/2005/114).

We found that:

- The returns from the two forestry projects remained high because projections about yield and growth rates had been exceeded, and production (at least for acacias) has continued to expand. On the other hand, oyster production has been less than projected, and the rate of return likely lower than projected. A new breeding program focussing on growth rates and disease control may lead to the industry expanding again.
- Eliciting subjective judgments about capacity building was difficult; however, scientists could identify specific capacities, both of a technical and a softer nature, built during the projects.
- Scientists judged that at least half the gains estimated for the DAT and SAT projects, and the oyster project, could be attributed to capacity building, while knowledge discovery processes required to develop hybridisation for acacias accounted for the largest share of benefits in that project.
- While scientists made a strong case that capacities built in these initial projects were building blocks in later continuing research projects, we had little success in eliciting examples of how these capacities led farm ready technologies adopted by farmers. Perhaps this lack of success can be attributed to inexperience in making this type of judgement, especially since these projects were completed many years earlier.

We argue that for ACIAR to better plan for—and capture—the results from its investments in capacity building, its ongoing efforts to develop project proposals, annual and final reports, and impact assessments around explicit impact pathways linking project resources through project activities and outputs to economic, social and environmental outcomes need to be strengthened. Key elements of an impact pathway are projections about farm level cost savings from the new technology and about the likely level and rate of adoption.

Capacity building activities and outcomes are other key elements, although these are likely more conjectural since their impact extends well beyond the life of the project. In the project planning and proposal stages, capacities to be developed could be described. As the project moves to completion, capacities built could be identified, and in final reports and later impact assessments, projections could be made about a plausible pathway through later research programs (and the resources or activities required) to the eventual development and adoption of technologies by farmers. Explicit impact pathways facilitate sound impact assessments.

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10 Appendices

10.1 Questionnaire for Capacity Building in Bilateral Research Projects: the SAT/DAT Projects

ACIAR Capacity Building Study: Impact Parameters and Capacity Building in FST/1993/118 and FST/1998/096 (Australian trees projects assessed in IAS 47)

A. Personal Information about Respondent

Name:

Present position:

Contact details:

Email

Describe your position and role in FST/1993/118 and FST/1998/096

Date of interview:

Place of interview:

B. Introductory Comments Explaining Our Project and Methodology

As you are aware there has been strong growth in forestry production in Vietnam. Much of this growth can be explained by the research program undertaken by the Forest Science Institute of Vietnam FSIV and now VAFS, and its partners including the CSIRO from Australia with funding from ACIAR.

Perhaps you are also aware that ACIAR has a strong record of evaluating the impact of the research it funds. Understanding the impact of the research it funds is important for at least two reasons:

- To demonstrate to government that it is using funds wisely.
- To improve the design of projects for greater impact on the welfare of farm families in developing countries and in Australia.

There are difficult attribution problems in trying to identify the contribution of ACIAR to the economic welfare of tree farmers in Vietnam. An obvious problem is that ACIAR projects are only a part of the total research effort of VAFS and hence can only claim to have contributed to a share of the total benefits. We are not really concerned with this issue in our project except to note that we recognise that only a share of the total gains in welfare to tree growers can be attributed to ACIAR funding.

The second attribution question is the balance within project funding between alternative activities such as:

- capacity building through formal and informal (learning by doing and mentoring) activities
- knowledge discovery through research in the form of trials and experiments leading to new technologies or tree species ready for farmers to use.

It is important to get the right balance between knowledge discovery activities and capacity building activities. A sole focus on trials and experiments by Australian scientists over the length of a project might lead to a potential new technology, but the chances of sustainable adoption by many farmers is small. Similarly, a sole focus on capacity building not directed to developing new technologies ready for use by farmers will not deliver gains in economic welfare to farmers.

The balance is very important, but there are difficult subjective attribution problems here.

ACIAR employs economic consultants to estimate the economic benefits to farmers from new technology developed in the project. This is done through discussions about key parameters with Australian and Vietnamese scientists involved in the development and adoption of the technology by farmers. These benefits are related to investment by ACIAR and its Vietnamese partners to arrive at a measure of the returns to these investments.

Generally, these impact assessments have focussed on the total gains in welfare for farmers. Usually no attempt is made to attribute these benefits between discovery and capacity building activities and the future benefits from capacity developed during the project are noted but not explored in any detail.

ACIAR has funded our project to develop a greater, less vague, understanding of the benefits of capacity building and how future projects might better plan and recognise the benefits of capacity building in project design, reporting and impact assessment processes. The aim is to be able to make better judgements about the balance between discovery and capacity building activities

Last year we undertook a scoping study which examined how the benefits of capacity building might be measured both theoretically and practically using ACIAR project budgets.

This project has been designed to more intensively study capacity building in the Research Institute for Aquaculture No 1 (RIA1) and FSIV/VAFS. These institutes have a strong history of collaboration with ACIAR.

Because capacity building is so difficult to identify and measure separately from research discovery activities, this Vietnam project will examine capacity building from several perspectives.

One perspective can be gained by interviewing Vietnamese scientists who had formal training funded by ACIAR either as John Allwright or John Dillon Fellows. We also intend to interview the managers of the two institutes for their perspective on the contribution made by ACIAR activities to capacity building in their institutes.

The perspectives of Australian and Vietnamese scientists working on ACIAR projects are also most important to us.

One component of our work is to examine in some detail the small number of ACIAR projects in the two institutes that have been subject to a formal impact assessment process. The main reason for choosing these projects is that their impact assessments have demonstrated that these projects have likely been successful in contributing to the development of technologies that have been adopted by farmers and which have increased their income.

We have four objectives in revisiting these impact assessments:

1. We want to re-examine some of the key parameters such as the extent of adoption of the technology to assess whether the anticipated returns from the projects have been realised.
2. We want to assess the balance between knowledge discovery and capacity building activities and their importance to the success of the projects.
3. We want to assess how capacity built during the course of the projects was used in later research (not necessarily funded by ACIAR).
4. We want to develop a set of questions that will help ACIAR identify capacity building activities and their contribution to project success without imposing unreasonable reporting burdens on scientists.

We will examine these four objectives in turn but first some information about the project. This may seem a bit tedious but in this part of our study it is important that we all focus on the gains in total economic benefits and gains in human capacity that can be attributed to this particular ACIAR project. It is difficult but we are trying to identify the gains that can be attributed to this project as distinct from the gains that can be attributed to the much larger research effort into forestry at this institute.

C. Some Information about FST/1993/118 and FST/1998/096

Here we want to focus on two ACIAR projects: FST/1993/118 and FST/1998/096 (Australian trees SAT and DAT projects) which were assessed by Fisher and Gordon in IAS 47.

Background ***Extracted from project proposals and reports***

Project objectives

According to project documents, the objectives of the SAT project were:

- provision of certified seed of proven and promising Australian species
- provision of up-to-date information on selection, improvement, silviculture, utilisation and management
- provision of training courses for knowledge and technology transfer to recipients.

The aim of DAT was to support more effective domestication and use of Australian tree species in the poorer developing countries, targeting South-East Asia, south Asia, China and certain African countries.

The SAT and DAT projects were conducted over about 12 years from 1993 in several countries. Fisher and Gordon restricted their attention to estimating the benefits of the projects in Vietnam. In nominal terms, about $1.6m were invested in the projects in Vietnam and the contribution from Vietnam was about 15%.

It has involved collaboration and funding from key forestry research organisations in Vietnam, principally the Forest Science Institute of Vietnam (FSIV), and a number of international aid organisations, including ACIAR, AusAID, the Swedish International Development Agency and the United Nations Forestry Tree Improvement Program. A key challenge in this impact assessment was to identify the incremental impacts that the ACIAR-funded SAT and DAT projects had in the context of this broader research program. This impact assessment estimates only the *additional* contribution arising from the SAT and DAT projects. It should be noted that this is only a small portion of the total value of the broader research program.

From IAS 47 (p. 15):

> The SAT and DAT projects made a significant contribution to a number of important outputs.
>
> - The information provided through requests and the research trials established under the SAT and DAT projects significantly increased the knowledge of the best species and provenances to plant in particular environments. Information was also provided on silviculture, utilisation and management of Australian trees
> - The seed provided to Vietnam under the projects widened the genetic base of Australian trees in the country. Inbreeding had been a major cause of productivity decline in Australian trees species in many developing countries
> - The SAT and DAT projects assisted with the establishment of seed-production areas, seedling-seed orchards and clonal-seed orchards. These seed-production areas and seed orchards are providing Vietnam with a domestically produced source of high-quality seed, which is crucial to the sustainability of the productivity improvements achieved.
> - Formal training and collaboration with Australian researchers significantly increased the knowledge and skills of Vietnamese researchers.

The projects established different sources of genetic material:

- SPAs (seed production areas): single species: selection intensity 1:10
- SSOs (seedling seed orchards): multiple species: selection intensity 1:10
- CSOs (clonal seed orchards): selection intensity 1:100 or 1:1000

Q1. Is this an accurate interpretation of the outputs of the projects?

YES *NO*

Is there anything you would like to add?

Fisher and Gordon focused on the gains from improved acacia and eucalypts although smaller areas of melaleucas and casuarinas are grown. The economic differences seem to be different rates of per unit cost reduction arising from different rates of yield increase with improved genetics.

The SAT and DAT projects gave rise to large gains in economic welfare in Vietnam.

Table 4. Summary measures

	Present value of benefits A$000	Present value of costs A$000	Net present value A$000	Benefit–cost ratio	Internal rate of return %
1%	432.4	2.0	430.5	220.6	32.2
5%	128.7	1.6	127.0	79.3	32.2
10%	34.7	1.3	33.4	26.3	32.2

Source: Centre for International Economics' estimates

One of our tasks is to check whether the assumptions made by Fisher and Gordon in their assessment of the SAT and DAT projects still hold. Some of the key tables and figures that summarise the assumptions of Fisher and Gordon are reproduced here for you to make a judgement about whether they are still reasonable.

Q2. Is it possible to name the species/varieties developed during the SAT and DAT projects as distinct from those developed in later projects?

Please List:

Table 5. Acacia wood yields

	Mean annual increment[a] (m^3/ha/year)	Yield at harvest pulpwood[b] (m^3/ha/year)	Yield at harvest sawlogs[c] (m^3/ha/year)
Unimproved germplasm	8.0	56	80
Identified provenances (+10%)	8.8	62	88
Seed from seed-production areas (+12%)	9.0	63	90
Seed from seedling-seed orchards (+15%)	9.2	64	92
Seed from clonal-seed orchards (+20%)	9.6	67	96
Clone (+25%)	10.0	70	100

[a] As growth rates through time are not linear, the mean annual increment is likely to vary with rotation length. However, for this exercise it is assumed to be the same.

[b] The average rotation for pulpwood is assumed to be 7 years.

[c] The average rotation for sawlogs is assumed to be 10 years.

Source: Centre for International Economics' estimates based on consultation with researchers.

Q3. Have these estimated gains in yields for Acacias occurred?

YES *NO*

Q4. Have these estimated gains in yields for Eucalypts held up?

YES *NO*

Comments?

Based largely on the implications of these increased yields, Fisher and Gordon estimated how the per-unit costs of producing timber decreased with improved genetics. Changes in unit production costs along with adoption drive the estimated gains in economic welfare.

Table 10. Reduction in unit cost (in VND/m^3) of production

	Acacia pulpwood	Acacia sawlogs	Eucalypt pulpwood	Eucalypt sawlogs
Unimproved genetic material	–	–	–	–
Identified provenances	28,285	26,626	31,937	33,672
Seed from seed-production areas	31,923	30,065	36,121	38,169
Seed from seedling-seed orchards	38,382	36,152	43,456	45,949
Seed from clonal-seed orchards	48,428	45,621	54,865	58,053
Clone	57,671	54,332	65,361	69,188

Q5. Have you any reason to think that these estimated changes in unit costs are no longer realistic?

YES *NO*

Comments?

Now we turn to the other key parameter—the rate of adoption of the new genetic material. Unfortunately I could not get the X-axis to copy over. In both graphs the X-axis is the time scale from 1993, when the project commenced, to 2032, the time horizon for the impact assessment. Big changes in adoption occur around 2007–2008, when adoption of old varieties fall to zero and the proportions of new genetic sources stabilise.

The sudden dis-adoption of old genetic material was directly related to government requiring the use of improved material.

The Y-axis is % of total area.

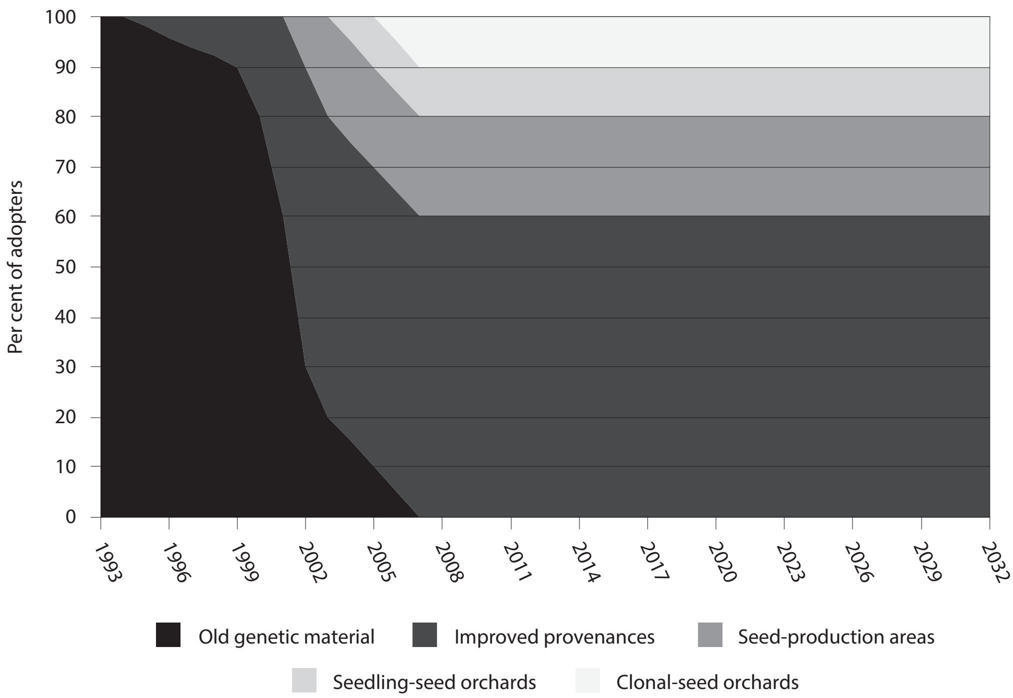

Figure 2. Acacia adoption profile. Source: Centre for International Economics' estimates

Q6. Does this adoption path for Acacias excluding hybrids look reasonable?

YES *NO*

Comments?

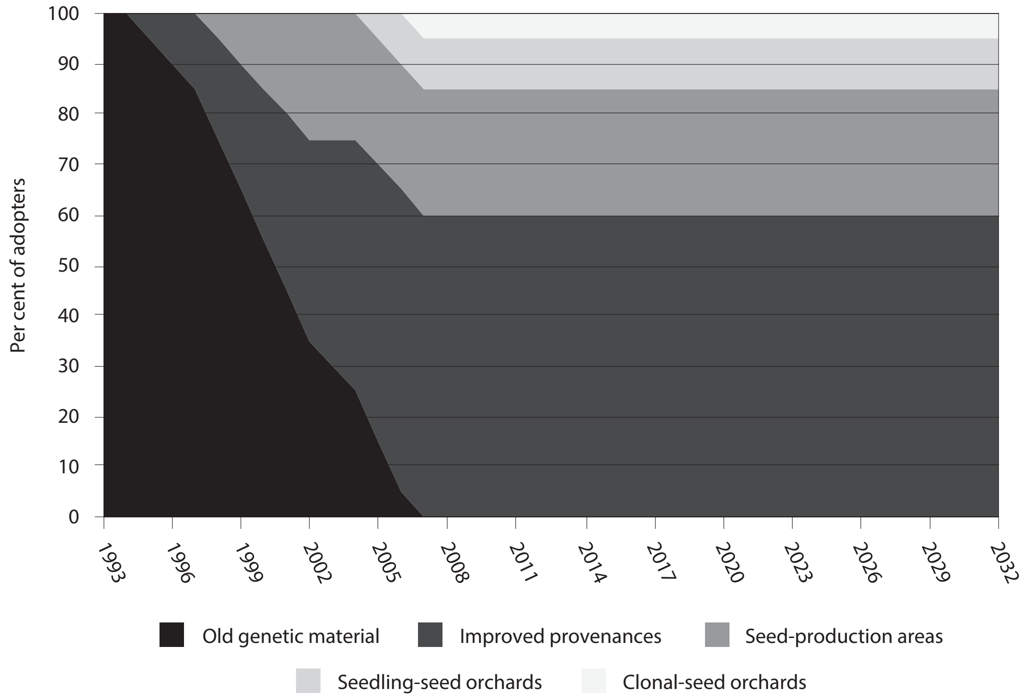

Figure 3. Eucalypt adoption profile. Source: Centre for International Economics' estimates

Q7. Does this adoption path for Eucalypts look reasonable?

YES *NO*

Comments?

Table 7 below summarises assumptions made about the area of forestry associated with the two projects.

Table 7. Estimated plantings and annual harvest

	Estimated plantings (ha)	Average rotation length (years)	Area harvested annually (ha)	Estimated annual harvest (m^3)
Acacias				
Pulp (70%)	245,000	7	35,000	2,205,000
Sawlogs (30%)	105,000	10	10,500	882,000
Total[a]	350,000			
Eucalypts				
Pulp (85%)	295,800	9	32,867	2,070,600
Sawlogs (15%)	52,200	12	4,350	365,400
Total[b]	348,000			

a From Midgley (2006)

b From MARD (2002), referred to in Ha Huy Thinh (2004).

Source: Centre for International Economics' estimates.

Note that the 350,000 ha of acacia does not include the 430,000 of hybrid acacias from van Bueren's assessment of the acacia hybrid project FST/1986/030.

Fisher and Gordon seem to be assuming that there would be no further increase in planting attributable to these projects after about 2004—the Midgely (2006) estimates. Revenue rises until about 2016, and area harvested continues to increases but then stabilises; replanting occurs but no increased areas attributable to project.

Later increases in plantation area arise in part from later R&D and capacity built during these projects.

Q8. Do these assumptions about areas of acacias and eucalypts seem reasonable?

YES *NO*

Comments?

The growth in Vietnam's forestry industry has been much greater than anticipated by Gordon and Fisher.

According to Nambiar et al. (2015) quoting Kien et al. (2014), by 2013, 51% of plantation area was devoted to acacias:

A mangium	600,000 ha
A hybrids	400,000 ha
A auriculiformis	90,000 ha

Q 8a. Do these numbers sound about right?

YES *NO*

Nambiar et al. did not give an estimate for the area of eucalypts.

Q 8b. Have you an estimate for the area of eucalypts?

D. Human Capacity Building

Let's move on to the capacity building component of this discussion.

We have already noted that the term 'research' covers a wide variety of activities and that these activities are often difficult to separate out in any objective way. By necessity we are dealing with subjective judgements here.

For our discussions, let's define these different activities in the following way, just so we have a common understanding:

- Research activities are discovery processes which add to the stock of knowledge. This knowledge stock can be used immediately in developing and delivering technologies to famers—the availability of improved tree species for example.
- But some of this knowledge stock is not immediately useful to farmers but is used in later research projects to develop species with even higher performance parameters.
- Capacity building encompasses formal training (often leading to some qualification) and informal training through 'learning by doing' or mentoring during a research project. Human capacity is also capital stock which can be useful in later projects.
- These knowledge discovery and human capacity building activities are inextricably linked in most projects.

What we would like you to think about first is the relative importance of knowledge discovery v capacity building in these projects, and then we want to spend some time identifying how this human capacity has been used in more recent projects.

Just repeating that an important impact of this project was the more rapid expansion of forestry in Vietnam.

Q9. By providing a supply of improved tree species, timber production costs/m3 were reduced and the economic welfare of growers improved.

YES *NO*

Q10. Were the trials and experiments conducted in Vietnam sufficient to deliver these benefits for tree growers, i.e., could the benefits have been attained by Australian scientists running the trials without devoting resources to developing the skills and knowledge of Vietnamese scientists and forestry staff?

YES *NO*

Let's turn to the human capacity building activities and ask similar questions. Again as a reminder (from the final report):

Fisher and Gordon (2007) identified capacity building as very important to the projects. They estimated that formal capacity building might account for about 20% of the total budgets of the projects.

They identified ten examples of formal capacity building activities.

- Mr Phi Quong Dien: 1 month Queensland Forest Research Institute, pollination techniques for indigenous pines, not eucalypt or acacia
- Mr Ha Huy Thinh and Mr Luu Bu Thinh: 7-week training course in tree seed technology and seed orchard management; also seed testing, storage and collection
- Short course in experimental design and analysis
- Conference paper
- SAT partly funded a conference on sustainable forestry attended by Dr Nguyen Nghia and Dr Hoang Chuong
- Training course on seed technology: 6 days in Vietnam—17 participants from 6 organisations
- Mr Nguyen Viet Cuong: professional attachment with isozyme lab at Australian Tree Seed Centre (6 weeks)
- Mr Phi Ahi Hong and Mr Nguyen Tranh via a 6-week professional training attachment—analysing growth data from progeny trials
- Mr Tran Duc Vuong: 4 weeks training in starch gel electrophoresis
- Training course on seed collection and processing, April 2004 (11 Vietnamese participants).

Q11. From this list of activities can you identify a smaller set of specific skills that were important to achieving outcomes from the SAT and DAT projects and which likely have been used in later successful projects?

We would like you to classify skills as either:

- necessary but not sufficient to the development of the new technology and growth of the industry
- sufficient to the development of the new technology and growth of the industry
- whether these skills continued to be used in the next phase of research.

Skill	N but not S	S	Used in next project
E.g., Learning by doing alongside Australian scientists			

Q12. Did some or all of these skills already exist in VAFS before the start of the project?

YES *NO*

Comments?

General mentoring activities are another important component of capacity building. During the project you worked closely with Australian scientists.

Q13. What skills did you acquire from them that were critical to your ability to manage the project's experiments in their absence and in your role in analysing and reporting the results of the experiments?

Now we would like you to make some judgement about the relative importance of capacity building and research discovery processes to the success of the project. Again this will be a subjective judgement on your part. It is important to make your judgement in relation to this project rather than in relation to the total bivalve research program.

We would like you to make some judgement about how the gains in economic welfare identified by Fisher and Gordon could be attributed between capacity building and research discovery processes.

Q14. How would you rate?

Capacity building	----- %
Research discovery processes	-----%

How has this human scientific capacity been used in subsequent research in Vietnam and Australia?

Capacity building is important not just for its contribution to the success of the original project but because it has the potential to be used in later projects in the development of technologies which further increase the economic welfare of farmers.

This benefit is only ever briefly acknowledged in final reports and impact assessment reports and we hope to show how greater recognition can be made of this dimension of capacity building.

We have just listed in the table above important skills developed in the course of your original project.

Q15. Do these skills still exist and are used in VAFS?

YES *NO*

Comments?

Now I want to revisit those skills in the hope that you will be able to give me specific examples of where these skills have since been used. Perhaps the easiest way to think about this is to think of technologies that have since been developed which relied heavily on the skills developed in this original project.

Skill 1:

Skill 2:

Skill 3:

Skill 4:

Q16. Can you list some technologies developed since the end of this project and using skills developed in this project?

Q17. What is the extent of adoption of these technologies by farmers?

Q18. Can you give examples of other tangible outputs from these projects—published scientific papers for example?

GENERAL COMMENTS (if it makes more sense to answer the question more generally than for each skill)

Impact of Capacity building on progression and on institution

This is the final component of this survey.

Q19. Did this development in skills assist in your promotion/advancement in VAFS?

YES *NO*

Q20. Did you pass on skills acquired during the project to other staff at VAFS?

YES *NO*

Q21. Do you still work with the Australian scientists involved in the project?

YES *NO*

Q22. Do you think that research planning and execution in VAFS was influenced in any way by this collaboration with Australian scientists?

YES *NO*

How?

Q23. Have you any further comments you wish to make about our approach to understanding the balance between knowledge discovery and human capacity building processes?

10.2 Varieties by Year of Release Tables

Table 10.2.1. *Acacia Mangium* releases

	***Acacia Mangium* releases**			
1996				
1997				
1998				
1999				
2000	Pongaki	Cardwell	Iron range	
2001				
2002				
2003				
2004				
2005	SW Cairns	Bloomfield		
2006				
2007				
2008				
2009				
2010	M5			
2011				
2012				
2013				
2014				
2015	MF04	MF11	MF15	MF18

Table 10.2.2. *Acacia auriculiformis* releases

	***Acacia auriculiformis* releases**						
1996							
1997							
1998							
1999							
2000	Coen River	Mibini	Moreheat				
2001							
2002							
2003							
2004							
2005							
2006	B Vit25	B Vit83	B Vit84				
2007	AA1	AA9	AA15				
2008							
2009	Clt7	Clt57	Clt64	Clt98	Clt133		
	Clt1	Clt8	Clt19	Clt171	Clt26	Clt42	
2010							
2011							
2012							
2013							
2014							
2015	AA42	AA53	AA56	AF03	AF58	AF12	AF13

Table 10.2.3. *Eucalyptus urophylla* releases

	***Eucalyptus urophylla* releases**			
1996				
1997				
1998	PN2	PN14		
1999				
2000	Lembata	Mt Egon	Lewoboti	
2001				
2002				
2003				
2004	PN46	PN47	PN10	
2005	PN54	PN116		
2006	PN3d	PM21	PN24	PN108
2007				
2008				
2009				
2010				
2011				
2012				
2013	892	1088	821	416
2014				
2015				

Table 10.2.4. *Eucalyptus camaldulensis* releases

	***Eucalyptus camaldulensis* releases**			
2007	SM16	SM23	EF24	EF55
2008				
2009	C9	C55		
2010	SM51	B28	B32	B34
2011				
2012				
2013				
2014				
2015				

Table 10.2.5. *Eucalyptus tereticornis* and *Eucalyptus brassiana* releases

***Eucalyptus tereticornis*[1]**	***Eucalyptus brassiana*[2]**
Sirinumu	Jacky Jacky
Oro Bay	SM7
Laura River	

1 all released in 2000

2. Jacky Jacky released in 2000, SM7, 2007

Table 10.2.6. Hybrid eucalyptus releases

	Eucalyptus hybrid releases							
2007	UC1	UE3	UE23	UE33	UE73	CU91	UC80	UE24
2008	CU90	UC75	UU8	UE27				
2009								
2010								
2011								
2012								
2013	UP35	UP54	UP72	UP95	UP97	UP99		
2014								
2015								

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

IMPACT ASSESSMENT SERIES <CONTINUED>

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	

IMPACT ASSESSMENT SERIES <CONTINUED>

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
93	Mullen, J.D., de Meyer, J., Gray, D. and Morris, G. 2016.	Recognising the contribution of capacity building in ACIAR bilateral projects: Case studies from three IAS reports.	FST/1986/030, FST/1993/118, FST/1998/096, FIS/2005/114

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Recognising the contribution of capacity building in ACIAR bilateral projects

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