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Impact assessment of investment in aquaculture-based livelihoods in the Pacific islands region and tropical Australia

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Impact assessment of investment in aquaculture-based livelihoods in the Pacific islands region and tropical Australia

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ACIAR Impact Assessment Series Report No. 96



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Foreword

Since the early 1990s, the Australian Centre for International Agricultural Research (ACIAR) has funded projects to improve aquaculture-based enterprises, which are the primary source of income and support of livelihoods for small communities of Pacific island countries. ACIAR-supported projects also provide valuable opportunities for women and youth who are often under-represented in village economic activity.

This impact assessment study sought to understand the influence of two major aquaculture-based livelihood projects through the lens of the 40 mini-projects they spawned. This novel approach to research and development delivery was a collaboration between ACIAR project leaders and stakeholders in Pacific island countries. Bottlenecks were identified that could be resolved with short-term projects to help advance a wide range of aquaculture topics in seven Pacific island countries: Fiji, Vanuatu, Papua New Guinea, Tonga, Samoa, Kiribati, Solomon Islands and Nauru; one Pacific island territory, Wallis and Fortuna; and Australia.

The appraisers adopted a staged approach to deal with the obvious challenge of assessing 40 mini-projects. They undertook a preliminary assessment of all 40 projects, using rapid appraisal techniques in a framework adapted from the work of two Australian rural research and development corporations. From this overview, three case studies emerged for further quantitative analysis, and a fourth case study emerged for both qualitative and quantitative analysis.

The preliminary assessments affirmed that most mini-projects were successful—adoption pathways were clear, capacity was built, scientific knowledge was created and community economic, social and environmental benefits were generated. The appraisers rated the mini-project approach as a useful model for wider ACIAR application.

In all three quantitative case studies, the technologies developed were found to be practical and applicable to the communities for which they were intended. But in every case, obstacles of reliable supply, distance from markets and enterprise sustainability were encountered.

The fourth case study was a qualitative and quantitative assessment of three mini-projects addressing a winged pearl oyster hatchery, nursery culture, training and mabé (half-pearl) production in Fiji and Tonga.

Advances in aquaculture achieved through these projects, combined with advances from linked ACIAR project investments, are forecast to produce a positive return on investment. The appraisers found that final users have adopted research outputs, which is largely attributable to the holistic approach of maintaining research team continuity and in-country presence, taking a long-term view focused on developing an industry, partnering with governments in Fiji and Tonga, and working in collaboration with the commercial sector. An added benefit for the research environment for these projects was the absence of negative social and environmental impacts.

ACIAR gives particular attention to research that can help women in developing countries. From this perspective, the impact assessment revealed the recognition of women involved in mabé production and the pearl industry in Fiji, and their prospects for controlling productive assets through better opportunities for leadership and decision-making.



Andrew Campbell
Chief Executive Officer, ACIAR

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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
FAO	Food and Agriculture Organization of the United Nations
IAS	impact assessment study
IP	intellectual property
MAFFF	Ministry of the Agriculture, Forestry, Food and Fisheries (Tonga)
n.d.	no date
NDAL	National Department of Agriculture and Livestock (Papua New Guinea)
NFA	National Fisheries Authority (Papua New Guinea)
PARDI	Pacific Agribusiness Research for Development Initiative
PICs	Pacific island countries
PNG	Papua New Guinea
Qld	Queensland
USP	University of the South Pacific
WA	Western Australia
WEAI	Women's Empowerment in Agriculture Index

Executive summary

This document is an impact assessment study (IAS) of two ACIAR-funded aquaculture-based livelihood projects completed in Pacific island countries (PICs) and tropical Australia. The two projects were:

- FIS/2001/075 (*Sustainable aquaculture development in the Pacific islands region and northern Australia*)
- FIS/2006/138 (*Developing aquaculture-based livelihoods in the Pacific region and tropical Australia*).

The projects used a novel approach to research and development delivery. Project leaders worked with stakeholders in PICs to identify 40 mini-projects that addressed short-term and specific aquaculture bottlenecks and opportunities. Mini-projects targeted practical outcomes, the continuity of fledgling aquaculture industries and research effort between larger and more complex ACIAR investments.

To assess the impact of the two projects selected for the IAS, a preliminary assessment of all 40 mini-projects was completed, using rapid appraisal techniques and a framework adapted from two of the Australian rural research and development corporations.

The assessment of the 40 mini-projects was used to identify prospective case studies for detailed analysis. Qualitative analysis was completed on three case studies, and a fourth case study was subject to both qualitative and quantitative analysis. An assessment of the impacts on women was also completed as part of the fourth case study. Analysis of linked projects was completed to ensure that impacts were correctly ascribed to the total ACIAR investment.

Preliminary assessment findings

Mini-projects were completed in seven PICs, one Pacific island territory and Australia. Mini-projects addressed aquaculture, mariculture and hatchery design. Preliminary assessment showed that most mini-projects were successful—adoption pathways were clear, capacity was built, scientific knowledge was created and community economic, social and environmental benefits were generated.

The additional administrative burden of managing 40 mini-projects was minimised by ACIAR

by integrating mini-project management with other ACIAR projects. There was a high degree of collaboration among the technical teams, and regional and Australian experts contributed to project success.

A positive feature of the mini-project approach was strong support from PICs, where stakeholders saw mini-projects as providing immediate and tangible benefits for their aquaculture sectors. Mini-projects were effective when delivered on an established farm, and were particularly successful when integrated with a commercial enterprise. They were able to act as a bridge while larger ACIAR initiatives were being planned and executed. Mini-projects developed solutions to aquaculture bottlenecks that can be applied to other PICs.

The major problem with the mini-project model was its high transaction costs. Mini-projects require more time in development, monitoring, mentoring and implementation than single large projects. Other problems included instances of an overly ambitious research agenda, a lack of resources and enthusiasm from local researchers and villagers, a lack of awareness of mini-project grant opportunities, no follow up from previous success and a lack of strategic focus in the mini-projects that were funded. Mini-projects may successfully address a single research question, but answers to multiple questions may be required before impacts are realised.

Given that factors leading to mini-project success are equally applicable to other ACIAR geographies and investment priorities, and that mini-project problems are mostly manageable, the preliminary assessment found that the mini-project approach was a useful model for wider ACIAR application.

Qualitative analysis of three case studies

Case study 1 was a qualitative analysis of two mini-projects addressing native freshwater prawn (*Macrobrachium lar*) capture and culture in Vanuatu and Wallis and Futuna. These two mini-projects were technically successful, and outputs from the project were immediately adopted by smallholders. However, over the subsequent 6 years smallholders have stopped using the methods, with the total number of farms adopting mini-project technology declining from

a peak of 16 in Vanuatu in 2011 to between three and four in 2017. There was no sustained adoption in Wallis and Futuna.

Smallholder adoption of mini-project outputs was facilitated by various replicable techniques, including use of participatory action approaches and strong engagement by the research team with potential prawn farmers.

The mini-projects focused on a product that is considered to be a delicacy, and for which a high-value local market already exists. One of the case study mini-projects was larger than average, and funds from this project were allocated to socioeconomic, supply chain and market research. Researchers were able to use these data to make a compelling case to smallholders for adoption of research outputs. Mini-projects were part of a continuum that culminated in the provision of training by the Australian Government Department of Foreign Affairs and Trade (DAFT) to extend project results to additional communities.

The decline in farms adopting case study outputs was attributed to the geographical and cultural disconnect between resource access (such as wild juvenile prawns) and aquaculture interest. Further research is required to address this issue and commercialise the hatchery production of *M. lar*.

With ongoing investment, there is scope to further shift *M. lar* from opportunistic catch to self-sustaining smallholder enterprise in multiple Pacific island communities.

Case study 2 was a qualitative analysis of a single mini-project addressing rainbow trout (*Oncorhynchus mykiss*) production in Papua New Guinea (PNG). The mini-project showed that while an imported diet led to better rainbow trout growth rates, a locally formulated diet was satisfactory, cost less and was more accessible to highland fish farmers.

Case study 2 produced modest outcomes. A community trout farm closed since 1991 was temporarily reopened when locally manufactured feed became available, and four tilapia farms converted to trout production for a single season. New skills in aquaculture research were developed by PNG institutions and fish farmers improved their husbandry techniques. Preliminary success was attributable to a clear research objective, sound project design, a close working relationship with the relevant trout farms and an encouraging initial sale price for fish.

Adoption was not sustained, however. While a low-cost feed was produced, this on its own was not enough to sustain trout aquaculture in the Highlands. Warmer than anticipated water temperatures worked against the ongoing production of fingerlings in Goroka, Eastern Highlands Province.

Initially favourable local market prices collapsed when rainbow trout supply increased. There was no supply chain in place to ensure fresh product delivery to more remote and lucrative markets. For example, product could not be directed to mining industry areas or the emerging supermarket sector in Port Moresby. Further work is required on market development if rainbow trout aquaculture is to be successful.

Rainbow trout aquaculture is capital intensive and high risk compared with tilapia farming, which is low production cost and returns a low sale price. Rainbow trout aquaculture, with its reliance on higher altitudes, has limited applicability to other PICs.

Case study 3 was a quantitative analysis of a single mini-project addressing the transfer of live rock culture knowledge from Tonga to Indigenous communities in Australia. Live rock is the term given to either natural or artificial rock that has spent time in the sea and developed a covering of marine bacteria, plants and animals. It is used in home and commercial aquariums. More recently the technology has been applied at a larger scale to reef construction and restoration.

The mini-project resulted in the training of representatives from three Indigenous communities, the building of capacity in those communities, an improved understanding of live rock production risks by Western Australia aquaculture licensing officers and the successful licensing of the Indigenous owned Buba Abrolhos Live Rock Pty Ltd.

Subsequently, the Buba Abrolhos Live Rock Pty Ltd was able to commercialise live rock production, reposition it for reef restoration and turn live rock production into intellectual property, license it and overcome distance from market barriers. The Buba Abrolhos Live Rock Pty Ltd has achieved some initial export success with their approach.

Other Indigenous communities have not been successful with their live rock production enterprises. Enterprises have been located too far from market, and transport of live rocks requires shipment of heavy, and therefore expensive, sea water.

Initiatives that might contribute to further adoption of artificial live rock production by final users include working with Indigenous communities closer to market, and further research to develop lighter substrata and water-free live rock transport techniques.

Artificial live rock production using training provided by the case study mini-project has proved successful for a single Indigenous enterprise that is now selling intellectual property in the form of live rock 'know how'. Further growth in this opportunity for Indigenous Australians, with existing technology, is likely to be modest.

Impact assessment of mabé production in Fiji and Tonga

Case study 4 was a qualitative and quantitative assessment of three mini-projects addressing winged pearl oyster (*Pteria penguin*) hatchery, nursery culture, training and mabé production in Fiji and Tonga. Case study analysis was completed using ACIAR's impact assessment guidelines, and included detailed consideration of linked ACIAR projects.

Mabé are half-pearls or blister pearls that are made by gluing 'seed' material to the inside of living oysters, which then cover the 'seed' with nacre (mother-of-pearl).

After 6–9 months the mabé is harvested and fashioned into jewellery and handicraft products. The mabé and pearl industries provide enterprise and employment opportunities in Fiji and Tonga in hatchery operation, spat (juvenile oyster) collection, mabé production on community oyster farms and jewellery and handicraft making.

ACIAR research funded as part of case study 4:

- showed that high-quality mabé can be produced in Fiji
- developed protocols for the successful hatchery culture of the winged pearl oyster in Tonga
- induced spawning in a hatchery outside of the species' natural May season
- proved that commercial microalgae concentrates could be used as a low-cost larval food simplifying hatchery production
- determined the optimal larval density and food ration for different ages of winged pearl oyster
- mapped and managed the winged pearl oyster genetic resource.

Technologies developed through ACIAR research included:

- protocols for ocean capture of spat
- nursery protocols to increase oyster survival and shorten the oysters' nonproductive period
- new oyster farming techniques that address optimal depth of placement in the water column
- optimal stocking rate and cleaning requirements
- improvements in anaesthetising and seeding oysters for pearl production
- techniques for producing quality mabé jewellery and mabé business analysis tools.

Adoption of research outputs has been achieved by final users, and this has been attributed to:

- research team continuity and in-country presence
- taking a long-term view focused on developing an industry
- partnerships with government in Fiji and Tonga
- working with the commercial sector
- a lack of negative social and environmental impacts.

Capacity was developed in Australia, Fiji and Tonga in both the scientific community and the villages adopting research outputs. Capacity building included the establishment of pearl industry infrastructure.

Improved project delivery techniques were developed by both ACIAR Research Program Managers and project team leaders. Mariculture scientists obtained masters and doctorate qualifications, remained in-country and engaged with the mabé and pearl industries. Private sector technicians and farmers were trained in mabé production. Village-based training was completed in spat collection, oyster farming and handicraft making. Women were trained in oyster shell cutting, polishing and jewellery making. Business skills training was provided to spat collectors, mabé farmers and jewellery makers.

Impact assessment has shown that the benefits from case study mini-projects, together with linked ACIAR project investments, are forecast to be sufficient to produce a positive return. Benefits mostly accrue to villagers in remote low-income areas.

Total investment in projects linked to case study 4 was \$9.09 million (present value terms), and has been estimated to produce gross benefits of \$10.37 million (present value terms),

providing a net present value of \$1.28 million and a benefit:cost ratio of 1.14:1 (over 30 years, using a 5% discount rate). Realisation of this return will depend on both the ongoing adoption of research outputs, and the development of a profitable and discerning market for mabé products.

In addition, the assessment of impacts on women involved in mabé production and the pearl industry in Fiji has shown positive outcomes for capacity development, access and control of productive assets and income and an additional role in decision-making and leadership. These gains in women's empowerment have been realised without an excessive increase in women's work hours.

Conclusions

This impact assessment has reviewed 40 mini-projects, used the review to select four case studies and subjected the most prospective case study to a full impact assessment. The full impact assessment has shown that even when the costs from linked project investments are considered, forecast returns are sufficient to provide an overall positive return on total research cost.

1 Introduction

1.1 Background

This impact assessment study (IAS) is of a cluster of ACIAR-funded aquaculture-based livelihood projects completed in PICs and tropical Australia.

ACIAR has placed significant emphasis on assessing the impact of the research it funds, with particular focus on measuring both adoption and impact. ACIAR uses IASs to refine its priorities, to learn the lessons of current and past projects and to be accountable to the Minister, the Parliament, the wider Australian public and partner country stakeholders.

ACIAR has provided support for aquaculture-based livelihood projects in PICs since the early 1990s. Aquaculture in PICs is a diverse and expanding sector, well suited to the needs of small island communities for which it can provide a valuable source of livelihoods and income flows.

Aquaculture provides livelihood opportunities for women and youths who might otherwise be under-represented in village economic activity. Small-scale community-based aquaculture can be delivered with few, if any, environmental impacts.

Central to this cluster of ACIAR-funded aquaculture-based livelihood projects are FIS/2001/075 (*Sustainable aquaculture development in the Pacific islands region and northern Australia*) and FIS/2006/138 (*Developing aquaculture-based livelihoods in the Pacific islands region and tropical Australia*). These two projects developed and implemented a novel approach to research and development delivery.

To give effect to this approach, project leaders from FIS/2001/075 and FIS/2006/138 worked with stakeholders from PICs to identify 40 mini-projects that targeted specific aquaculture bottlenecks and opportunities.

Mini-projects looked at various aquaculture species (such as prawn, finfish, pearl oyster, sandfish) and activity types (such as feed production, farming systems, disease testing, spat collection, business skills, academic training). Mini-projects were completed in Fiji, Vanuatu, Wallis and Futuna, Papua New Guinea (PNG), Tonga, Samoa, Kiribati, Solomon Islands, Nauru and in Indigenous communities in tropical northern Australia.

The mini-project concept was novel in that it targeted short-term and specific bottlenecks to regional aquaculture development, and provided bridges to sustain research activity and fledgling industries between larger and more complex ACIAR investments.

To assess the impact of these two central projects, two key steps were required. Firstly, a preliminary assessment of all 40 mini-projects was completed to identify prospective case studies for detailed assessment. Secondly, an analysis of linked projects was needed to ensure that case study impacts were correctly ascribed to the total ACIAR investment.

1.2 Impact assessment requirements

Impact assessment requirements were to:

1. analyse 40 mini-projects completed as part of FIS/2001/075 and FIS/2006/138 and select four case studies for more detailed consideration
2. prepare a narrative for each of the selected case studies, to address:
 - details of the adoption pathway
 - impacts through the supply chain
 - impacts on women and youth
 - impacts on the environment
 - capacity built
 - scientific knowledge created
 - contribution to policy development
3. consider linked projects and the investment required to create case study impacts
4. for the most prospective case study detail:
 - research and development and extension inputs
 - the impact pathway
 - outputs
 - capacity development
 - outcomes
 - uptake of research and development
 - articulation of the counterfactual, social, environmental and economic impacts
 - valuation of impacts and lessons learned.

1.3 Impact assessment methods and activities

The IAS was delivered through four major tasks (Figure 1). The first task was a review of FIS/2001/075 and FIS/2006/138 literature and frameworks used by Australian rural research and development corporations and others for rapid project appraisal.

From this material, a preliminary assessment framework was developed. The framework addressed:

- mini-project type
- cost
- whether the mini-project would have been funded in the absence of ACIAR support
- level of success achieved (outputs delivered)
- community economic, social and environmental impacts realised
- scientific knowledge created
- capacity built
- contributions to policy development and adoption path (outcomes realised).

The framework was populated with data on 40 mini-projects assembled from the project literature and a limited number of stakeholder interviews.

The preliminary assessment was used to identify four case studies for detailed impact assessment. Case studies were not randomly selected. They were chosen where it was hoped that returns from the case study sample would more than compensate for whole project investment, where there was clear evidence of outcomes and to avoid an impact assessment with no measured benefits to report (Davis et al. 2008).

The second task was a qualitative analysis of three case studies completed after considering ACIAR's adoption framework detailed in the *Guidelines for assessing the impacts of ACIAR's research activities* (Davis et al. 2008). The case study analysis framework addressed research outputs—what was discovered, capacity development, uptake of the research and development, progress along adoption pathways, factors contributing to adoption of project outputs and lessons learned.

The three qualitative case studies focused on native prawn aquaculture in Vanuatu and Wallis and Futuna, the suitability of locally produced rainbow trout feed in PNG and live rock production in Australia. Each case study was a composite of up to three mini-projects.

The third IAS task was a qualitative and quantitative analysis of the fourth case study, which was completed using ACIAR's impact assessment guidelines (Davis et al. 2008). The fourth case study addressed winged pearl oyster (*P. penguin*) hatchery, nursery culture, oyster farming, mabé and handicraft production in Fiji and Tonga.

To quantify the return on investment, project literature was reviewed, and semi-structured interviews were completed with the relevant ACIAR Research Program Manager, team leaders and project collaborators in Australia. Interviews were also completed with government officials, researchers, industry members and farmers in Fiji. Linked project investments were considered.

The fourth IAS, completed by Dr Katja Mikhailovich task, was an analysis of benefits for women involved in ACIAR projects addressing spat collection, mabé production and pearl handicrafts in Fiji. The framework for analysis of benefits for women was adapted from a women's economic empowerment assessment tool developed by Golla et al. (2011) and a modified version of the International Food Policy Research Institute Women's Empowerment in Agriculture Index (IFRI 2012). Social impacts were considered, where possible, and incorporated into small vignettes about communities involved in ACIAR projects.

The analysis involved literature reviews, qualitative individual and group interviews and document analysis to identify how women have benefited in key areas recognised as indicators of women's empowerment:

- skills and knowledge
- access and control of assets and resources
- changes to income and control over income
- involvement in decision-making
- time and workload
- changes to family and community relationships
- leadership and social capital.

1.4 Project summaries

Table 1 summarises the key ACIAR projects considered in this IAS. Summaries were obtained from ACIAR project records and the ACIAR website.

<p>Preliminary assessment of ACIAR investment in aquaculture-based livelihoods in PICs and Australia:</p> <ul style="list-style-type: none"> • Rapid appraisal techniques • ACIAR projects FIS/2001/075 and FIS/2006/138 • Preliminary assessment of 40 mini-projects • Selection of four case studies 	<p>Qualitative analysis of three case studies to profile impacts:</p> <ul style="list-style-type: none"> • ACIAR adoption framework • Case study 1: native prawn, Vanuatu • Case study 2: rainbow trout, PNG • Case study 3: live rock, Australia
<p>Impact assessment, qualitative and quantitative analysis of mabé production in Fiji and Tonga:</p> <ul style="list-style-type: none"> • ACIAR impact assessment guidelines • Case study 4: winged pearl oyster hatchery, nursery culture, oyster farming, mabé and handicraft production in Fiji and Tonga <p>Consideration of linked projects:</p> <ul style="list-style-type: none"> • FIS/2006/172 Winged pearl oyster industry development in Tonga • FIS/2009/057 Pearl industry development in the western Pacific, in Tonga, Fiji and PNG • PARDI/PRA/2010.01 Cultured pearl production capacity and improved quality, Fiji and Tonga • PARDI/PRA/2013.01 Assessing potential of the mother-of-pearl handicraft sector in Fiji • FIS/2014/103 Pearl livelihood development in Fiji • FIS/2014/060 Developing pearl-based livelihoods in the western Pacific • FIS/2016/126 Half-pearl (mabé) industry development in Tonga and Vietnam. 	
<p>Assessment of impacts on women involved in mabé and the pearl industry in Fiji, including:</p> <ul style="list-style-type: none"> • women's economic empowerment index and the framework for the measurement of women's economic empowerment • gender, culture and aquaculture in Fiji • benefits of spat collection and mabé production for women in Fiji • knowledge and skill development • access and control of productive assets and income • income distribution • decision-making and leadership • time and workload • broader social benefits • benefits of jewellery and shell handicrafts 	

Figure 1: Conceptual framework for the impact assessment study

1.5 Report structure

The IAS report has the following structure:

- Section 2 summarises preliminary assessment findings, methods used to review the 40 mini-projects, commentary on the usefulness of the mini-project approach and rationale for case study selection.
- Section 3 provides a qualitative analysis of three case studies. It addresses the analysis approach adopted, what was discovered, capacity development, uptake of research and development outputs, factors contributing to adoption, project success and lessons learned.
- Section 4 provides a qualitative and quantitative analysis of the mabé case study. It includes an assessment of research and extension investments, impact mapping, project outputs, capacity developed, research uptake, articulation of the counterfactual (i.e. what would have happened in the absence of ACIAR's investment), impacts along the supply chain, social impacts, environmental impacts, economic impacts and lessons learned.
- Section 5 is the assessment of women's empowerment as a result of the development of a mabé industry in Fiji. It focuses on the impact on women as a result of the development of spat collection, oyster farming and jewellery and handicraft production enterprises.
- Section 6 details IAS conclusions.

Table 1: Summary of ACIAR projects considered in this IAS

Project number	Title	Objectives	Associated reviews and materials
FIS/2001/075	Sustainable aquaculture development in the Pacific islands region and northern Australia	<ul style="list-style-type: none"> Identify and implement targeted research activities and technology transfer in response to issues identified by PICs through the Secretariat of the Pacific Community, where possible by drawing on results and expertise developed through completed and ongoing aquaculture research and development activities, particularly ACIAR and WorldFish projects. Extend the outcomes of existing ACIAR and WorldFish projects to other communities/countries in the Pacific islands and in northern Australia. Two areas of research identified were post-larval fish capture and culture, and sea cucumber production and reseedling. Enhance technical and research skills in aquaculture within partner institutions at national and regional level through: on the job training during projects; specialised training courses; student projects; use of specialised personnel from partner institutions in outreach research activities; and technology transfer. 	<ul style="list-style-type: none"> Project proposal (Rimmer 2003) Final report (Rimmer 2006) Project summary (Anon. 2007) Project review (Mackay & Wani 2006)
FIS/2006/138	Developing aquaculture-based livelihoods in the Pacific islands region and tropical Australia	<ul style="list-style-type: none"> Identify and implement targeted research activities and technology transfer in response to priority issues identified by PICs, where possible by drawing on results and expertise developed through completed and ongoing ACIAR, WorldFish and other aquaculture projects. Increase institutional capacity among PICs to support and manage research, particularly in PNG. Provide technical support for Indigenous Australian aquaculture ventures. 	<ul style="list-style-type: none"> Project proposal (Southgate 2007) Final report (Hair & Southgate 2007) Capture-based culture techniques for <i>Mar</i> Vanuatu (Pickering & Gereva 2011) Live rock stars (Bowen 2015)
FIS/2006/172	Winged pearl oyster industry development in Tonga	<ul style="list-style-type: none"> Develop appropriate hatchery culture techniques for <i>P. penguin</i>. Develop appropriate nursery culture and grow-out techniques (in partnership with mini-projects MS0803 Fiji and MS0807 Tonga). Better understand half-pearl production and aspects affecting pearl quality (for example, seed position, culture techniques, location and time). Investigate round pearl production from <i>P. penguin</i>. Train Tonga fisheries staff in culture methods/pearl production. Train farmers and members of the Pearl Growers Association. 	<ul style="list-style-type: none"> Final report (Southgate & Ngaluafé 2010)

Project number	Title	Objectives	Associated reviews and materials
FIS/2009/057	Pearl industry development in the western Pacific, in Tonga, Fiji and PNG	<ul style="list-style-type: none"> Develop more effective hatchery culture methods for black-lip pearl oyster (<i>Pinctada margaritifera</i>) and the winged pearl oyster (<i>P. penguin</i>). Enhance sustainable development of the cultured pearl industries in Fiji and Tonga. Undertake baseline studies for the development of pearl culture in Kavieng, PNG. 	<ul style="list-style-type: none"> Project proposal (Southgate 2010) Project review (Beyer & Pickering 2017)
PARDI/PRA/2010.01	Cultured pearl production capacity and improved quality in the Fiji and Tongan cultured pearl industries	<ul style="list-style-type: none"> Increase cultured pearl production capacity, and improve the quality of life of Fijian and Tongan coastal communities with opportunity to participate in cultured pearl production. Explore the potential of mother-of-pearl handicraft and jewellery production to create economic opportunity for women in Fijian and Tongan coastal communities. 	<ul style="list-style-type: none"> PARDI final report (Underhill 2015) Cultured pearl final report (Southgate 2015) A craft of their own for Fiji women (Crab 2015) Pearls are the business (Moorhead 2015) PARDI capacity building publication (PARDI 2014)
PARDI/PRA/2013.01	Assessing potential for developing the mother-of-pearl handicraft sector in Fiji	<ul style="list-style-type: none"> Assess the potential for developing the mother-of-pearl handicraft sector in Fiji to support livelihood and income generating opportunities for women, economic growth and import replacement. 	<ul style="list-style-type: none"> Project proposal (Simos 2013) PARDI final report (Underhill 2015)
FIS/2014/103	Pearl livelihood development in Fiji	<ul style="list-style-type: none"> Maintain momentum in pearl shell handicraft enterprise development in Fiji through the end of PARDI/PRA/2010.01 and the start of the follow-on project FIS/2014/060. 	<ul style="list-style-type: none"> Project profile on ACIAR website
FIS/2014/060	Developing pearl-based livelihoods in the western Pacific	<ul style="list-style-type: none"> Expand the community-based spat collection program in Fiji. Expand community-based mabé production in Fiji and Tonga. Expand pearl and mother-of-pearl handicraft production by community and women's groups in Fiji and Tonga. Expand pearl and mother-of-pearl handicraft production by community and women's groups in PNG. Evaluate the economic and socioeconomic impacts of pearl-based livelihood development in partner communities. 	<ul style="list-style-type: none"> Project proposal (Southgate 2016)
FIS/2016/126	Half-pearl (mabé) industry development in Tonga and Vietnam	<ul style="list-style-type: none"> Improve husbandry methods to support increased oyster production for sustainable industry expansion. Assess the potential of half-pearl farming in Vietnam. Evaluate the socioeconomic aspects of mabé culture Tonga, Vietnam. 	<ul style="list-style-type: none"> Project proposal (Southgate 2017)

2 Preliminary assessment

2.1 Methods for preliminary assessment of mini-projects

A framework to complete preliminary assessment of mini-projects was developed, after considering the portfolio evaluation framework used by Australian rural research and development corporations (such as the Rural Industries Research and Development Corporation and

Australian Egg Corporation Limited), as well as published papers on rapid appraisal techniques (such as USAID 2010). Population of the framework relied on literature review, limited stakeholder interviews and rapid appraisal techniques.

The framework, and what is required to populate it, is summarised in Table 2.

Table 2: Framework to determine preliminary assessment of mini-projects

Criteria	Information required on mini-projects and its source
Project number and name	<ul style="list-style-type: none"> • Provided by the project leader for FIS/2001/075 and FIS/2006/138.
Synopsis	<ul style="list-style-type: none"> • Developed for FIS/2001/075 and provided for FIS/2006/138.
Type	<ul style="list-style-type: none"> • Project type identified both aquaculture species targeted (for example, prawn) and the type of activity investigated (for example, feed production, farming system, disease testing, spat collection, business skills).
Country/geography	<ul style="list-style-type: none"> • Notes multiple countries where this is relevant.
Project partners	<ul style="list-style-type: none"> • Government agencies, research organisations, non-government organisations, and anyone else involved.
Aquaculture bottleneck addressed	<ul style="list-style-type: none"> • Adapted from the mini-project's statement of objectives.
Size	<ul style="list-style-type: none"> • FIS/2006/138 defined as: small (\$15,000 or less) and medium (\$15,000-\$50,000).
Cost	<ul style="list-style-type: none"> • ACIAR plus co-funding agencies and implementation. • Non-ACIAR costs to be determined for case study 4 during the IAS.
Funding without ACIAR support	<ul style="list-style-type: none"> • To provide an indication of whether ACIAR is adding to research knowledge or 'crowding out' other sources of research funding. • Determined by referencing the capacity of partner organisations. • Confirmed for case study 4 as part of the IAS.
Level of success achieved	<ul style="list-style-type: none"> • Explanation of whether the identified aquaculture bottleneck was successfully addressed, partially delivered, or not delivered at all.
ACIAR and other project linkages	<ul style="list-style-type: none"> • Statement of whether the mini-project provided a foundation for development of further ACIAR or other agency research projects or partnerships including government-private partnerships.
Community economic impact	<ul style="list-style-type: none"> • Smallholder enterprise opportunity. • Job creation and income generation. • Enhanced productivity and profit from existing aquaculture systems • New options for established commercial aquaculture ventures. • Diversification of aquaculture commodities. • Tourism development opportunities.
Community social impact	<ul style="list-style-type: none"> • Food security, which is increasingly important due to population growth and potential protein shortages in PICs. • Women in development and opportunity for families in PICs. • Youth opportunities and potential reduction in urban drift. • Creation of income and livelihood alternatives. • An overall increase in income earning opportunity.

Criteria	Information required on mini-projects and its source
Community environmental impact	<ul style="list-style-type: none"> • Decrease in pressure on fishing stocks and reefs • Increased pressure on the environment, such as collecting of fish stocks for aquaculture ventures, or unsustainable harvesting of a new species to produce fishmeal and aquaculture feed.
Scientific knowledge created	<ul style="list-style-type: none"> • Determine whether new scientific knowledge was created or existing knowledge was simply transferred to the PICs as a result of the project.
Capacity built	<ul style="list-style-type: none"> • Aquaculture capacity, such as additional smallholder ability to farm. • Human capacity, such as scholarships and training opportunities provided to students (for example, John Allwright PhD scholarship and farmer training). • Institutional capacity, such as capacity to support and manage research. • Extension capacity, such as public or private agency ability to transfer technology. • Enduring life of the capacity created, such as whether skills developed or transferred remained available beyond the life of the project.
Policy development contribution	<ul style="list-style-type: none"> • Statement on whether mini-project outcomes have been useful in informing Pacific island country policy including policy on export of marine species, exploitation of local resources, importation of exotic species, etc.
Adoption pathway and tools	<ul style="list-style-type: none"> • A description of how research outputs were communicated to potential users of the information, and any publications produced. Users targeted included other researchers, fish farmers and government agencies.
Case study suitability	<ul style="list-style-type: none"> • Criteria for consideration as a case study included positive responses to the criteria developed in this framework, the likely availability of data to inform an IAS, whether the project was in some way representative of the population and the degree of success achieved bearing in mind that much can be learned from project failures.

2.2 Preliminary assessment findings

FIS/2001/175 and FIS/2006/138 supported 40 mini-projects, with 16 focusing on freshwater aquaculture, 23 addressing mariculture and a single project to design a new hatchery in Samoa had both freshwater and mariculture dimensions.

Aquaculture research questions that received the most attention were aquaculture feed supply, shrimp/prawn farming, oyster farming, especially for pearl production, finfish production including tilapia and sandfish production (sea cucumber). Each of these had five to seven mini-projects.

Mini-projects were carried out in eight countries and one territory, and included all ACIAR Pacific priority countries. Half the projects were completed in the larger 'high island' countries of Fiji and PNG. Project budgets were less than \$15,000 for more than half (57%) of mini-projects. The others were \$50,000 or less. There were more of the larger mini-projects in FIS/2006/138.

Criteria for completing the preliminary assessment were developed after consideration of the literature. A simple 'yes' or 'no' was applied to questions such as the following:

- Would the mini-project have proceeded without ACIAR funding support?
- Did the mini-project lead to other research projects?
- Is the mini-project suitable for a detailed case study?

A 1-3 scale rating was applied to other preliminary assessment questions, where a more nuanced response added to the quality of the assessment. These questions included the following:

- Were community economic, social, or environmental benefits generated?
- Was new scientific knowledge created?
- Was individual and/or institutional capacity built and sustained?
- Did the mini-project contribute to policy development?
- Was the adoption path clear?

A mini-project with three 'ticks' for a preliminary assessment question indicated a strong performance against the criteria; two ticks indicated a moderate performance; and a single tick indicated some achievement. When no outcome was realised for the criteria, this was recorded as a 'no'.

Results from the preliminary assessment are summarised in tables 4–12. The review of these summaries shown in Table 3 shows that most mini-projects were successful—adoption pathways were clear, capacity was built, scientific knowledge was created and community economic, social and environmental benefits were generated.

Adoption pathways used for communication of mini-project outputs included publishing in relevant scientific journals, preparing and delivering conference presentations, documentation in regional and Secretariat of the Pacific Community newsletters and producing relevant aquaculture production manuals.

A review of FIS/2001/075 (Mackay & Wani 2006) noted that, while an impressive number of publications had been produced, in some cases reporting of project results within countries had been much weaker. This was addressed in FIS/2006/138 with additional effort placed on direct communication and extension activities with current and potential aquaculture producers.

Mini-projects resulted in a substantial increase in knowledge and technical skills in research and development and extension among participating organisations in the PICs and Australia. But limited capacity was built in the target Aboriginal communities of northern Australia.

The scientific quality of the mini-projects was assured by technical reviews of projects FIS/2001/175 and FIS/2006/138. In spite of limited funding and a short time frame, some of the mini-projects achieved significant science results. For example, mini-project MS0806 achieved a world first in captive breeding of the native freshwater prawn *M.lar*.

Significant community benefits were generated in 10 out of 40 mini-projects (tables 4 to 12).

- A village-scale sponge aquaculture enterprise model was transferred from the Federated States of Micronesia to a successful pilot in the Solomon Islands (MS0506).
- Improved feed and stocking efficiencies were developed for smallholder tilapia farmers, using caged culture techniques (MS0601).
- An assessment of Fly River herring for fishmeal and as an aquaculture feed ingredient in PNG resulted in a lower-cost and locally sourced and sustainable replacement for imported ingredients (MS0808).
- Locally produced feed for rainbow trout (*Onchorynchus mykiss*) proved to be effective, easier to source and of much lower cost than standard imported feeds (MS1001).
- Improved access to credit and grant funding was provided to freshwater fish farmers in PNG through a training workshop that introduced fish farmers and extension officers to bookkeeping and business management skills. Credit providers were also introduced to the economics of fish farming (MS0905).
- In Fiji, significant community benefits were generated from mabé pearl oyster culture (MS0803). Socioeconomic research showed that the average income earned by Cakaudrove Province villagers was low, and living costs were high. Economic modelling revealed that mabé pearl culture could generate significant revenue for local coastal communities. Communities were familiar with the species (*Pteria penguin*), and its role in village food production could be supplemented with a cash income from a new aquaculture industry.

Table 3: Mini-project summary statistics—preliminary assessment

Criteria	Percentage of mini-projects
Would not have proceeded without ACIAR funding support	78
Success level realised (2 or more ✓)	83
Led to other research projects (ACIAR or other)	50
Community economic benefits generated (2 or more ✓)	55
Community social benefits generated (2 or more ✓)	45
Community environmental benefits generated (2 or more ✓)	18
Scientific knowledge created (2 or more ✓)	63
Capacity built (2 or more ✓)	90
Policy development contribution (2 or more ✓)	25
Adoption pathway clear (2 or more ✓)	88

- Mabé production had been a successful village industry in Tonga that had become hamstrung by a shortage of juvenile pearl oysters. Mini-project MS0807 and MS1002 rejuvenated the industry through successful hatchery and juvenile oyster culture techniques, which provided community benefits to the remote Vava'u Island Group.
- Community benefits in Vanuatu included assessment of capture and culture-based aquaculture using the native freshwater prawn *M. lar*. The mini-project showed that with improved capture techniques, low-cost local feeds, improved pond/cage design and a better understanding of wild stock dynamics, a profitable business could be developed for remote and impoverished communities (ML0901).
- In Samoa, sea grape (*Caulerpa spp.*) aquaculture yields were improved through the adoption of Australian tray grow-out methods. Sea grape production is primarily done by women, and any growth in the industry is most likely to benefit women and their families (MS1009).
- In Australia, only three mini-projects were completed, each with limited community benefits. Live rock culture for the aquarium industry (MS1008) was successful, and research completed for the preliminary assessment showed that benefits had been realised by two Aboriginal Australians with a business based in Geraldton, Western Australia.

ACIAR minimised the additional administrative burden of managing 40 mini-projects by integrating mini-project management with other ACIAR projects. There was a high degree of collaboration among the technical teams. Regional and Australian experts contributed to project success.

2.3 Usefulness of mini-project approach

Positive features of the mini-project approach included strong support from stakeholders from PICs, who saw immediate and tangible benefits from mini-projects that addressed specific aquaculture bottlenecks. This included confirmatory testing of the viral status of *Penaeus monodon* (black tiger shrimp) to inform Fiji Government biosecurity policy (MS0401).

Mini-projects were able to act as a 'bridge' while larger ACIAR initiatives were being planned and executed. For example, resurrected confidence in the Tonga mabé industry would once again have been dashed if spat supply to smallholders had been interrupted between the end of FIS/2006/172 in 2009 and the start of FIS/2009/057 in 2011. Mini-project MS1002 provided juvenile oysters to farmers for the 2010 season.

Mini-projects developed solutions to aquaculture bottlenecks that can be applied to other PICs. For example, livelihood solutions developed in the Federated States of Micronesia for small-scale sponge farming were simply transferred to the Solomon Islands using a low cost \$7,000 mini-project. Mini-projects also allowed cost-effective completion of research questions in different environmental conditions at the same time—local researchers were engaged to identify best practice culture techniques for winged pearl oyster in both Fiji (MS0803) and Tonga (MS0807) at the same time.

The major problem with the mini-project model has been high transaction costs. Mini-projects require more time in development, monitoring, mentoring and implementation than one large project. Project teams worked before the start of the mini-projects to ensure their effectiveness through consultation on concept, design, implementation and assessment of in-country collaboration.

Contributions from a competent and trustworthy in-country mini-project manager were essential. The technical team was critical in reviewing and revising submissions. The Secretariat of the Pacific Community, project staff and ACIAR staff carried out field visits that paved the way for effective mini-projects. However, all these necessary activities add to project transaction costs.

Mini-projects might successfully address a single research question, but answers to multiple research questions might be required before impacts are realised. Mini-project MS1001 successfully addressed the supply of low-cost local feed sources for rainbow trout (*Onchorynchus mykiss*), but additional research will be required to establish a longer and more robust supply chain. Mini-projects might require a more comprehensive understanding of context and impact pathway before additional scientific knowledge translates into lasting end-user impacts.

Other project-specific negatives associated with mini-projects reported to this assessment included incidences of an overly ambitious research agenda, a lack of resources and enthusiasm from local researchers and/or smallholders, a lack of awareness of grant opportunities, no follow up from previous success and a lack of strategic focus in the mini-projects that were funded.

For example, mini-project MS0505 for the experimental release and monitoring of cultured juvenile white teatfish (*Holothuria fuscogilva*) in Kiribati, had some impact on increasing the capacity of Kiribati Fishery Division technicians, and contributed to the development of a national sea cucumber plan. However, the ACIAR Project Review Report (Mackay & Wani 2006) found that the mini-project attempted too much for the limited funds available, broodstock were difficult to find and research staff showed little enthusiasm for the endeavour. Research staff were engaged in other projects when the mini-project began. The review recommended that the mini-project be terminated, and the funds returned to ACIAR.

Mini-projects were more effective when delivered on an established 'farm', and were particularly successful when integrated into an established commercial enterprise. For example, mini-project MS0803 provided research capacity to an established and commercial round pearl farm in Fiji, and worked to develop an additional enterprise based on half-pearl (mabé) production. The commercial farm already had trained technicians and oyster farmers in place, as well as a supply chain linked to European pearl markets.

Factors contributing to mini-project success included research and smallholder commitment, mini-project delivery on an established 'farm', targeting of a very specific and manageable bottleneck and regular and sustained visits to mini-project research sites by the ACIAR project team and other professionals.

Given that factors leading to mini-project success are equally applicable to other ACIAR geographies and investment priorities, the preliminary assessment found that the mini-project approach was a useful model for wider ACIAR application.

2.4 Case study selection

On completion of the preliminary assessment, 10 mini-projects were shortlisted for possible inclusion in case studies. Criteria used to shortlist mini-projects for further analysis was:

1. the availability of mini-project data (for example, information on the value of outputs created, the number of families engaged, area of reef protected)
2. whether the mini-project was in some way representative of the population (for example, type of aquaculture-related activity, geographic setting)
3. success (recognising that as much can be learned from research failures as from research success).

Criteria 1 (availability of data for further analysis) resulted in the shortlisting of mini-projects addressing native freshwater prawn (*M. lar*) capture and culture aquaculture in Vanuatu and Wallis and Futuna, rainbow trout (*Onchorynchus mykiss*) growth using locally formulated feeds in PNG, and hatchery, nursery culture and mabé production using the winged pearl oyster (*P. penguin*) in Fiji and Tonga.

Criteria 2 (representative of the mini-project population) skewed mini-project selection toward projects completed in PNG and Fiji—the larger 'high island' countries—and reaffirmed the importance of the rainbow trout case study and winged pearl oyster investigation.

Criteria 3 (success recognising that much can be learned from failure) suggested expansion of the case study shortlist to include Australian live rock production. Australian live rock production was not as successful, as some mini-projects and balanced the portfolio toward consideration of impacts on Aboriginal Australia, a key objective of both FIS/2001/175 and FIS/2006/138.

After consultation with ACIAR the final case studies were agreed:

- Case study 1 was native freshwater prawn (*M. lar*) capture and culture in Vanuatu and Wallis and Futuna. It included:
 - MS0402 (Monoculture of the freshwater prawn (*M. lar*) in Vanuatu and integrated prawn-taro farming in Wallis and Futuna)
 - ML0901 (Study of *M. lar* capture and culture techniques in Vanuatu).
- Case study 2 was rainbow trout (*Onchorynchus mykiss*) growth rates on locally produced feed, in PNG. It was the single mini-project MS1001 (*Growth of rainbow trout (Onchorynchus mykiss) on locally produced feed*) in PNG Highland ponds.

- Case study 3 was the transfer of Pacific experience to indigenous Australia. It was the single mini-project MS1008 (*Transfer of Pacific experience to Indigenous Australian sustainable aquaculture: live rock culture, from Tonga to Western Australia*).
- Case study 4 was winged pearl oyster (*P. penguin*) hatchery, culture and mabé production, in Fiji & Tonga. It included:
 - MS0803 (Improving winged pearl oyster (*P. penguin*) juvenile culture and mabé production techniques in the Fiji Islands)
 - MS0807 (Improved husbandry methods for the culture of juvenile winged pearl oysters (*P. penguin*) in Tonga)
 - MS1002 (Support of pearl oyster (*P. penguin*) hatchery production in Tonga).

Case studies 1-3 were analysed qualitatively, while case study 4 was analysed both qualitatively and quantitatively as part of an impact assessment study.

Table 4: Summary of preliminary assessment results for FIS/2001/075 mini-projects

No.	Name	Cost	Funded in absence of ACIAR investment	Success level	Led other projects	Community economic impacts	Community social impacts	Community environment impacts	Scientific knowledge created	Capacity built	Policy developed	Adoption pathway clear	Case study potential
MSO401 Fiji	Pathogen-free shrimp stock	\$10,290	No	√√√	Yes	No	No	No	√√√	√√√	√√√	√√	No
MSO402 Vanuatu	Freshwater prawn and taro	\$17,070	No	√√√	Yes	No	No	No	√√√	√√√	No	√√√	Yes
MSO403 PNG	Aquaculture facility	\$5,250	Yes	√	No	No	No	No	No	√	No	√√	No
ML0401 Fiji, PNG	Aquaculture feed	\$50,000	No	√√√	Yes	No	No	No	No	√√√	No	√√	No
MSO502 Tonga	Microalgae feed training	\$1,050	Yes	√	Yes	No	No	No	No	√	No	√√	No
MSO503 Samoa	Microalgae feed training	\$5,012	Yes	√	Yes	No	No	No	No	√	No	√√	No
MSO504 Kiribati	Mabé pearl oyster culture	\$12,326	No	√√√	Yes	√	No	No	√√√	√√√	No	√√√	No
MSO505 Kiribati	Cultured teatfish	\$13,400	No	√	Yes	No	No	No	√√√	√√√	No	√√	No
MSO506 S. Islands	Sponge aquaculture	\$6,984	No	√√√	Yes	√√√	√√	No	No	No	No	√√√	Yes
MSO507 Fiji	Aquaculture profitability	\$5,900	Yes	√	No	No	No	No	No	No	No	No	No
MSO601 PNG	Tilapia cage culture	\$20,380	No	√√√	Yes	√√√	√√	No	√√√	√√√	No	√√√	No
MSO602 Fiji	Eel aquaculture	\$11,500	No	√	No	No	No	√	√√√	√√√	No	√√√	No
MSO603 Nauru	Nile tilapia aquaculture	\$15,750	Yes	√√√	No	√√	√√	No	√	√√√	√√	√	No
MSO604 Samoa	Nile tilapia aquaculture	\$8,600	No	√	No	√	√√	No	No	√√√	No	√√√	No

Table 5: Summary of preliminary assessment results for FIS/2006/138 PNG mini-projects

No.	Name	Cost	Funded in absence of ACIAR investment	Success level	Led other projects	Community economic impacts	Community social impacts	Community environment impacts	Scientific knowledge created	Capacity built	Policy developed	Adoption pathway clear	Case study potential
MS0805	Pathogen free shrimp stocks	\$15,420	No	√√	No	No	No	No	√√√	√√	√√√	√√	No
MS0808	Herring for fishmeal	\$7,550	Yes	√√√	Yes	√√√	√√√	√√√	√√√	√√√	√√	√√√	No
MS0903	Molluscs on spat collectors	\$21,120	No	√√√	Yes	No	No	No	√√√	√√√	√√√	√√	No
MS0905	Credit access for fish farmers	\$11,000	No	√√	No	√√√	√√√	No	No	√√√	√√	√√√	No
MS1001	Local feed for rainbow trout	\$4,200	No	√√√	Yes	√√√	√√√	No	√√√	√√√	No	√√√	Yes
MS1005	Pen culture mud crab	\$20,000	No	√	No	√	√	No	No	√√√	No	√√√	No
MS1007	Aquaculture feed inventory	\$30,100	No	√√√	No	√√	√√	√	√√	√√√	No	√√√	No

Table 6: Summary of preliminary assessment results for FIS/2006/138 Fiji mini-projects

No.	Name	Cost	Funded in absence of ACIAR investment	Success level	Led other projects	Community economic impacts	Community social impacts	Community environment impacts	Scientific knowledge created	Capacity built	Policy developed	Adoption pathway clear	Case study potential
ML0801	Juvenile sand-fish culture	\$42,000	No	√√	Yes	√√	√√	√√√	√√√	√√√	No	√√√	No
MS0803	Mabé pearl oyster culture	\$8,300	No	√√	No	√√	√√	No	√√	√√√	√√	√√√	Yes
MS0804	Pearl oyster spat collectors	\$9,700	No	√√	No	√√	√√	No	√√	√√√	√	√√√	No
MS0806	Freshwater prawn breeding	\$7,000	No	√√	Yes	No	No	√√	√√	√√	√	√√	Yes
MS1003	Substrata for prawns	\$6,500	No	√√	No	√√	No	No	√√	√√	No	√	No
MS1006	Sandfish sea ranching	\$7,000	No	√√	No	√√	√√	√√√	√√	√√	√	√√	No

Table 7: Summary of preliminary assessment results for FIS/2006/138 Vanuatu mini-projects

No.	Name	Cost	Funded in absence of ACIAR investment	Success level	Led other projects	Community economic impacts	Community social impacts	Community environment impacts	Scientific knowledge created	Capacity built	Policy developed	Adoption pathway clear	Case study potential
MS0801	Clown fish culture	\$15,000	No	√	No	No	No	No	No	√√	No	√	No
ML0901	Freshwater prawn aquaculture	\$28,800	No	√√	Yes	√√	√√	No	√√	√√	No	√√	Yes

Table 8: Summary of preliminary assessment results for FIS/2006/138 Tonga mini-projects

No.	Name	Cost	Funded in absence of ACIAR investment	Success level	Led other projects	Community economic impacts	Community social impacts	Community environment impacts	Scientific knowledge created	Capacity built	Policy developed	Adoption pathway clear	Case study potential
MS0807	Mabé pearl oyster culture	\$18,300	No	√√	Yes	√√	√√	No	√√	√√	No	√√	Yes
MS0902	Live rock culture	\$21,000	No	√√	No	√√	√√	√√	√√	√√	√√	√√	No
MS1002	Mabé pearl hatchery	\$25,080	No	√√	Yes	√√	√√	√√	√√	√√	No	√√	Yes

Table 9: Summary of preliminary assessment results for FIS/2006/138 Solomon Islands mini-projects

No.	Name	Cost	Funded in absence of ACIAR investment	Success level	Led other projects	Community economic impacts	Community social impacts	Community environment impacts	Scientific knowledge created	Capacity built	Policy developed	Adoption pathway clear	Case study potential
MS0802	Rabbitfish culture	\$20,000	Yes	√√	No	√	√	No	No	√√	No	√√	No
MS0901	Mozambique tilapia	\$14,488	No	√√√	Yes	No	No	No	No	√√√	√√√	√√	No

Table 10: Summary of preliminary assessment results for FIS/2006/138 Samoa mini-projects

No.	Name	Cost	Funded in absence of ACIAR investment	Success level	Led other projects	Community economic impacts	Community social impacts	Community environment impacts	Scientific knowledge created	Capacity built	Policy developed	Adoption pathway clear	Case study potential
MS1009	Sea grape aquaculture	\$13,200	No	√√√	Yes	√√√	√√	√√	√√	√√	No	√√	No
MS1010	Hatchery design	\$6,500	Yes	√√	No	No	No	No	No	√	√	√√	No

Table 11: Summary of preliminary assessment results for FIS/2006/138 Kiribati mini-projects

No.	Name	Cost	Funded in absence of ACIAR investment	Success level	Led other projects	Community economic impacts	Community social impacts	Community environment impacts	Scientific knowledge created	Capacity built	Policy developed	Adoption pathway clear	Case study potential
MS0904	White teatfish release	\$15,200	Yes	√	No	No	No	No	No	√	No	√	No

Table 12: Summary of preliminary assessment results for FIS/2006/138 Australia mini-projects

No.	Name	Cost	Funded in absence of ACIAR investment	Success level	Led other projects	Community economic impacts	Community social impacts	Community environment impacts	Scientific knowledge created	Capacity built	Policy developed	Adoption pathway clear	Case study potential
MS0906	Sandfish Goulburn Island	\$2,500	No	√√	Yes	No	No	No	No	No	No	√√	No
MS1004	Sponge culture, Qld	\$9,500	No	√√	No	√	√	No	No	√√	No	√√	Yes
MS1008	Live rock culture, WA	\$15,000	No	√√	No	√	No	No	No	√√	No	√√	Yes

3 Qualitative analysis of three case studies

3.1 Methods used for qualitative analysis of three case studies

The framework for analysing the qualitative impact of three case studies was developed after considering ACIAR's adoption framework detailed in the *Guidelines for assessing the impacts of ACIAR's research activities* (Davis et al. 2008).

The framework addressed case study description and mini-project achievements. It classified research outputs into the three broad categories of:

- new technologies or practical approaches for particular problems or issues
- new scientific knowledge of basic understanding
- knowledge models and frameworks for policymakers.

Capacity development was analysed in terms of research and end-user capacity built, research infrastructure developed and the continued use of both types of capacity.

A six-level classification scheme used by ACIAR adoption studies (see Pearce & Alford 2015) has been employed in case study analysis to judge progress along adoption pathways (Table 13).

Table 13: ACIAR categories for judging progress along adoption pathways

Category	Description
NF	Demonstrated and considerable use of the results by the next and final users.
Nf	Demonstrated and considerable use of the results by the next user, but only minimal uptake by the final users.
NI	Intermediate outputs with considerable use by the next users, and has led to further outputs that have a final user.
Ni	Intermediate outputs with considerable use by the next users, and yet to lead to further outputs that have a final user.
N	Some of the results adopted by the next users, but no uptake by the final users.
O	No uptake by either next or final users.

Source: Davis et al. 2008.

Factors underlying adoption of mini-project outputs are grouped into knowledge, incentives and barriers, and are addressed through a series of impact assessment questions. Knowledge questions include the following:

- Did the final users know about the project outputs?
- Is there continuity of staff in organisations associated with adoption, leading to ongoing transfer of knowledge?
- Are the outputs complex compared with the capacity of users to absorb them?
- Do users have a sufficient knowledge base to support adoption?

Questions pertaining to incentive to adopt research outputs include the following:

- Do users have sufficient incentives to adopt outputs?
- Does adoption of the outputs increase risk or uncertainty for the users, thus reducing incentives to adopt?
- Is adoption either compulsory or indirectly prohibited?
- Are there extreme forms of incentives or barriers?

Barriers to adoption are tested with the following questions:

- Do potential users face capital or infrastructure constraints limiting their ability to fund adoption of the outputs?
- Do potential users of the outputs face cultural or social constraints on adoption?

Case study analysis was concluded with a statement on overall impact, lessons learned, reasons for success and initiatives that might contribute to further adoption by final users.

3.2 Native freshwater prawn capture and culture

3.2.1 Case study description

Case study 1 is a qualitative analysis of two mini-projects addressing native freshwater prawn (*Macrobrachium lar*) capture and culture in Vanuatu and Wallis and Futuna.

The first mini-project, MS0402 (*Monoculture of the freshwater prawn (M. lar) in Vanuatu and integrated prawn-taro farming in Wallis and Futuna*), demonstrated that the native freshwater prawn can be successfully cultured in ponds in PICs as an alternative to the introduced giant Malaysian freshwater prawn *M. rosenbergii*.

The second mini-project, ML0901 (*M. lar capture and culture techniques in Vanuatu*), concluded that capture and culture of *M. lar* is technically and economically suitable for low-tech, smallscale aquaculture.

Macrobrachium lar-based aquaculture enterprises resulting from the mini-projects relied on wild-capture of freshwater prawn juveniles and their farming in small ponds or cages set in streams and creeks. Hatchery production of *M. lar* to increase the volume and reliability of freshwater prawn juveniles was addressed in a separate mini-project (MS0806).

3.2.2 What was discovered —project outputs

New technologies and practical approaches developed from the case study mini-projects included:

- identification of *M. lar* as a potential new aquaculture species for PICs
- improved identification and capture techniques for *M. lar*
- development of new low-cost local feeds using household and village waste
- low-cost pond and cage design for small-scale freshwater prawn aquaculture
- growing systems for prawn monoculture and integrated prawn-taro production.

New scientific knowledge and basic understanding generated by the mini-projects included an understanding of wild *M. lar* population dynamics to better manage wild stocks, and maintain a sustainable source of prawns for aquaculture production. Culture techniques were

developed using both ponds and cages suitable for production of prawn as either a monoculture or integrated with swamp taro production.

New scientific knowledge was generated on how to achieve acceptable survival and growth rates for *M. lar* in captivity. Knowledge that *M. lar* can grow and survive at rates comparable to *M. rosenbergii* at higher stocking densities using low-cost, plant-based feed was potentially transformational. Demonstration that the native freshwater prawn *M. lar* is potentially a successful aquaculture species might, it was argued, avoid the need to import *M. rosenbergii*.

An understanding of the socioeconomic impacts of introducing *M. lar* aquaculture as a smallholder enterprise in Vanuatu and Wallis and Futuna was developed.

Smallholder enterprise analysis showed that an average 'farm-gate' sale price of US\$10.55 per kilogram for *M. lar* in remote areas of Vanuatu and production of up to 7 tonnes per hectare per year was possible. Village enterprises consisting of two to three ponds or bamboo cages are typically much smaller than 1 hectare.

Small-scale enterprise returns were assessed through the mini-projects as being sufficient for both an owner and employee to earn a supplementary income from the enterprise. Buoyant *M. lar* markets operate in both Luganville and Port Vila, Vanuatu, where *M. lar* is marketed and sold as a delicacy.

Positive findings from the mini-projects included the potential for prawn sales to contribute US\$155 per year or 15% of average household income in impoverished parts of Efate Island and Santo Island, Vanuatu.

Less positive findings included the geographical disconnect between waterways with wild juvenile prawn populations and pond and cage sites suitable for aquaculture development, as well as subsequent land disputes between owners of waterways and aquaculture sites. There was also widespread theft of *M. lar* aquaculture stock during mini-project delivery.

Knowledge, models and frameworks for policymakers and broad-level decision-makers included preliminary indications that planned imports of *M. rosenbergii* might be substituted with a local native prawn. Use of a local native prawn would, it was reasoned, reduce the biosecurity risk associated with farming an imported species.

Unfortunately, linked research has shown that it is difficult to breed *M. Lar* in a hatchery (mini-project MS0806), and until this can be achieved, the size of the freshwater prawn farming industry in Vanuatu and Wallis and Futuna, based on wild-caught *M. lar* juveniles, will be limited.

Capture of wild juvenile *M. lar* and their culture is time consuming and physically demanding. *Macrobrachium. lar* farming based on wild-capture will only appeal to the most impoverished communities with few alternative income sources. As a consequence, it will only be relevant to remote parts of Vanuatu and Wallis and Futuna, and its small scale will help limit any adverse environmental impact, such as depletion of wild *M. lar* stocks.

3.2.3 Capacity development

Research and end-user capacity built included the training of research staff, incorporation of mini-project outputs into tertiary training materials and the training of smallholder prawn farmers.

Training of research staff from Vanuatu Department of Fisheries and the Service de L'Economie Rurale et de la Peche in Wallis et Futuna included wild population assessment methods, *M. lar* identification and freshwater prawn culture techniques. The project leader of mini-project ML0901, Sompert Gereva from the Vanuatu Department of Fisheries, continued his studies in *M.lar* after the mini-project ended, undertaking a Master of Science at the Queensland University of Technology.

Mini-project research outputs were incorporated into Certificate of Agriculture training in Vanuatu. Subsequently, agriculture students were required to build and manage a freshwater prawn pond or cage production system in a remote village as part of their studies.

Smallholders in remote Vanuatu and Wallis and Futuna were trained during the mini-projects in improved freshwater prawn capture techniques, pond design and management, feed production, prawn husbandry, harvest and marketing.

The mini-projects did not create research infrastructure, as they were field based and did not make use of hatcheries, centrally located experimental farms or trials. As a consequence, no lasting research infrastructure was developed through the mini-projects in either Vanuatu or Wallis and Futuna.

Research capacity developed as part of the mini-projects is in continued use. Fisheries staff from Vanuatu and Wallis and Futuna trained as part of the mini-projects have continued to be involved in fisheries research. After the project, Sompert Gereva from the Vanuatu Department of Fisheries was funded by the Secretariat of the Pacific Community to go to Samoa as a consultant, where he conducted a site survey and demonstrated *M. lar* capture-culture aquaculture techniques. As a result of this consultancy, two tilapia farmers have adopted *M. lar* aquaculture in Samoa, and their operations are ongoing. Tertiary Certificate of Agriculture students trained using research outputs have accepted and retained graduate positions in the Vanuatu Department of Fisheries (Dr Tim Pickering, Aquaculture Lecturer, University of the South Pacific, Fiji, pers. comm., 2017).

3.2.4 Uptake of R&D outputs—progress along adoption pathways

Uptake of new technologies and practical approaches achieved an 'NF' in Vanuatu (demonstrated and considerable use of the research results by both the next and final users). Improved capture techniques, pond and cage design, growing system, feed production, prawn husbandry, harvesting and marketing techniques were all adopted by smallholder prawn farmers in Vanuatu (Dr Tim Pickering, Aquaculture Lecturer, University of the South Pacific, Fiji, pers. comm., 2017).

In Wallis and Futuna, uptake of new technologies and practical approaches was '0'. There was no sustained uptake in prawn farming activity after the completion of the mini-project, apart from the continued traditional practice of harvesting *M. lar* when taro swamps are drained for harvest (Dr Tim Pickering, Aquaculture Lecturer, University of the South Pacific, Fiji, pers. comm., 2017).

Farms producing *M. lar* increased from none in Vanuatu prior to the two mini-projects to 12 in 2010 and 16 in 2011, before declining to three to four in 2017. The main cause of the contraction in farm numbers was the geographic disconnect between suitable capture areas and suitable culture areas. The surviving successful farms were ones where both capture and culture can occur at the same place (Dr Tim Pickering, Aquaculture Lecturer, University of the South Pacific, Fiji, pers. comm., 2017).

Freshwater prawns produced using mini-project techniques have been sold in regional markets in Luganville and Port Vila, Vanuatu, and locally within and between remote villages. Prawns have provided both a cash income and a unit of exchange for barter for remote villagers.

In addition to providing a source of income, farmed *M. lar* was also an important supplement to the prawn farmers' diet and was consumed at harvest by the farm family.

Mini-project research established that dietary protein was in short supply in remote Vanuatu – on average, protein consumption before the mini-project was limited to a single 1 kg can of fish shared between four adults 2–3 days per week.

Uptake of new scientific knowledge and basic understanding also achieved an 'NF' in Vanuatu (demonstrated and considerable use of the research results by both the next and final users). Scientific knowledge on population dynamics, culture techniques to maximise survival and growth rates, and an improved understanding of socioeconomic status have been used to establish freshwater prawn farms in Vanuatu.

In Wallis and Futuna, uptake of new scientific knowledge achieved an 'Nf' (demonstrated and considerable use of the research results by the next user, but only minimal uptake by the final users). Final user uptake in Wallis and Futuna was not sustained.

Encouragingly new scientific knowledge developed as part of these mini-projects has also been applied in other settings. For example, low-cost plant-based feeds developed during MS0402 were used during research into hatchery production of *M. lar* in Fiji (mini-project MS0806).

Knowledge, models and frameworks for policymakers and broad-level decision-makers achieved a 'Nf' in Vanuatu (demonstrated and considerable use of the research results by the next user, but only minimal uptake by the final users). Mini-project results have not led to the substitution of *M. rosenbergii* for *M. lar*, which is a sound outcome, given current limits on *M. lar* supply. However, mini-project outputs have been incorporated into government-funded Certificate of Agriculture training in Vanuatu.

In Wallis and Futuna, there was no uptake of research by policymakers or decision-makers.

3.2.5 Factors contributing to the adoption of project outputs

Factors underlying adoption of mini-project outputs are grouped into knowledge, incentives and barriers, and assessed through a series of impact assessment questions.

Did the final users know about the project outputs?

The ACIAR and local research teams used a participatory action approach to engage potential prawn farmers in research site villages in Vanuatu and Wallis and Futuna. Following completion of the mini-projects, staff from fisheries departments held field days to promote prawn aquaculture and additional funding for technical vocational education training was provided by AUSAid. For example, the Vanuatu Department of Fisheries held field days to promote prawn capture-culture techniques in remote areas of north-west Santo, Malekula Island and Tanna Island. Agriculture students in Vanuatu built and demonstrated prawn capture-culture farms in additional remote villages as part of their studies.

Is there continuity of staff in organisations associated with adoption, leading to transfer of knowledge?

Fisheries department staff from both Vanuatu and Wallis and Futuna trained through the project have remained with their departments, filling both research and extension roles. These roles include transfer of knowledge relating to pond and cage production systems. In addition, agriculture graduates trained in research outputs have accepted positions in extension at the Vanuatu Department of Fisheries.

Are the outputs complex compared with the capacity of users to absorb them? Do users have a sufficient knowledge base to support adoption?

Simple and appropriate aquaculture technologies have been developed and extended to remote village communities. Prawn capture relies on readily available materials (such as shade cloth and bamboo poles), ponds require simple plastic sheeting, cages are made from split bamboo and marketing makes use of cool damp hessian sacks. Aquaculture feed is produced simply from household and village waste.

Do users have sufficient incentives to adopt outputs?

The mini-projects collected socioeconomic data showing high levels of poverty on remote islands in Vanuatu. The survey showed that people did not have a radio, gas stove, flush toilet, canoe or outboard motor. The mini-project also showed that prawn capture–culture aquaculture could contribute US\$155 per year, the equivalent of a 15% increase in impoverished household income.

Capital costs to generate this increase in income were manageable (US\$72 to construct a pond or US\$20 to construct a cage). Smallholders in remote villages in Vanuatu have both incentive and the means to adopt mini-project outputs. The situation is understood to be similar in Wallis and Futuna.

Does adoption of the outputs increase risk or uncertainty for the users, thus reducing incentives to adopt?

Risks associated with prawn capture–culture aquaculture include reliance on wild capture supply, theft of stock and a disconnect between control of waterways and suitable aquaculture sites. These risks are substantial, and act as a disincentive to adopt prawn farming.

Is adoption either compulsory or indirectly prohibited? Are there extreme forms of incentives or barriers?

Adoption was neither compulsory nor indirectly prohibited. There were no extreme incentives or barriers in place.

Do potential users face capital or infrastructure constraints, limiting their ability to fund adoption of the outputs?

No. Capital requirements are manageable and infrastructure is in place for farmers in remote locations to supply either markets in regional centres or via local sales and exchanges within or between villages.

Do potential users of the outputs face cultural or social constraints on adoption?

Yes. There is an important disconnect between sites suitable for the capture of *M. lar* and sites suitable for farm ponds and cages. The inability to co-locate ponds/cages with the source of juvenile stocks is a reason for the decrease in prawn farms in Vanuatu.

Land disputes can also arise when communally owned tribal land is used by individuals for cash income. Disputes can arise over access

to river sites favourable for collection of juvenile prawns. Wild stock left in place turn into a food staple and community members might be reluctant to see them harvested as juveniles. Addressing the shortage of juveniles available for prawn farming through hatchery production is a priority.

3.2.6 Lessons learned

Despite mini-project technical success and early adoption, overall impacts on final users have been modest. The total number of farms adopting project technology has declined from a peak of 16 in Vanuatu in 2011 to three to four in 2017. There was no sustained adoption in Wallis and Futuna.

Lessons learned are relevant to other ACIAR projects, as well as to achieving further success with prawn farming in PICs. Outputs from case study mini-projects have achieved adoption by final users, and this is attributable to various replicable techniques. Replicable techniques employed include participatory action approaches and strong engagement by the research team with potential prawn farmers.

Research teams used simple and appropriate aquaculture technologies that were suitable for inland communities on small remote islands with limited land and aquaculture enterprise potential. The mini-projects focused on a product considered to be a delicacy in both Vanuatu and Wallis and Futuna with an already established high-value market. The product was easily transported to market in a fresh state.

Research included a larger mini-project (\$40,000 rather than the project average of \$10,000) that allocated a budget for socioeconomic, supply chain and market research. Economic and market data collected in the field ensured that the mini-projects had a compelling case to make to impoverished smallholders.

Mini-projects were part of a continuum that built on and extended research foundations. MSO402 demonstrated that wild-caught *M. lar* can be cultured in ponds while MLO901 showed capture and culture is technically and economically feasible. Mini-project research was then built upon with technical vocational education training to extend findings to other communities.

The mini-projects had acceptable environmental risks, noting that the risk of excessive removal of wild *M. lar* juveniles was manageable and unlikely, given the hard labour required to populate an aquaculture enterprise.

Finally, mini-project research was transferable to other PICs with wild populations of *M. lar* that might be domesticated. For example Fiji has an established annual market for 200 tonnes of *M. lar* and wild stocks have suffered from overfishing and habitat destruction. Samoa has established *M. lar* capture culture enterprises, and the Solomon Islands (Malaita) and New Caledonia (Province Nord) have expressed interest in *M. lar* farming following completion of the mini-projects.

Initiatives that might contribute to further adoption of prawn farming techniques by final users include further scientific, social and supply chain research. Additional scientific research is required to raise survival rates for *M. lar* bred in a hatchery. Mini-project MS0806 showed that *M. lar* can be bred in a hatchery (a world first research achievement), but survival rates are low and certainly less than *M. rosenbergii*.

Further social research is required to understand how the geographical and cultural disconnect between waterways, pond and cage sites, and those wishing to establish prawn farms in rural Vanuatu and Wallis and Futuna might be bridged. Ongoing extension is needed for those considering prawn farming, and those who have established farms and are experiencing production difficulties or require 'refresher' training.

An understanding of gender issues in prawn farming and of whether small-scale aquaculture might be best managed through women and their gardens is also suggested as a social research issue worthy of further investigation.

Research is suggested on whether engagement of a commercial supply chain partner may be beneficial and assist with the sustainability of enterprises. A commercial supply chain partner might create 'pull' through the value chain, as well as an additional incentive to source juvenile stock and remain in production.

With ongoing investment, there is scope to further shift *M. lar* from opportunistic catch to self-sustaining smallholder enterprises in multiple PICs.

3.3 Rainbow trout growth rates on locally produced feed

3.3.1 Case study description

Case study 2 is a qualitative analysis of a single mini-project addressing the growth of rainbow trout (*Onchorynchus mykiss*) on locally produced feed in PNG highland ponds (MS1001).

Research completed as part of the mini-project compared the effectiveness of a rainbow trout diet produced from local ingredients in Goroka, in PNG's Eastern Highlands Province, with an imported diet. The research found that the imported diet led to better growth, but that the local diet was satisfactory, lower cost and more accessible to highland fish farmers.

3.3.2 What was discovered –project outputs

New technologies or practical approaches developed from the case study mini-project included an understanding of the suitability of locally produced feed, and knowledge that a diet based on pelletised local feed can be produced for K5 per kilogram compared with imported feed, which is difficult to secure and costs K12.50 per kilogram.

The mini-project showed that while the imported feed led to better growth, the local diet produced a satisfactory outcome. Unfortunately, the mini-project did not collect data on feed conversion ratios, so it was not possible to conclude whether rainbow trout reached the same size on a smaller amount of imported feed.

Consumer taste tests revealed that rainbow trout fed locally produced pellets were comparable in taste to wild caught fish, which was important for the marketing of farm raised fish.

The mini-project was a feeding trial on a well-studied species. Consequently, it did not target the creation of new scientific knowledge on *O. mykiss*. However, it did show that rainbow trout could be produced at lower altitudes (1,600 m) than previously thought (1,800 m), which would enable higher-value rainbow trout to compete with, and possibly displace, lower-value tilapia. There are a large number of smallholder tilapia ponds in the Goroka District.

Current protocols make it extremely difficult to import livestock feeds in PNG. The mini-project showed that this is not necessarily a policy problem, as suitable local alternatives can be produced cost effectively. Mini-project results were made available to both local agricultural and national agencies responsible for aquaculture and trade policy.

3.3.3 Capacity development

Research and end-user capacity built included the training of researchers and fish farmers. The mini-project team leaders, Wally Solato and Cathy Hair, worked to develop staff capacity in both the PNG National Fisheries Authority (NFA) and the National Department of Agriculture and Livestock (NDAL).

Capacity developed included skills in aquaculture feed preparation, data management, experimental protocols and husbandry for rainbow trout. Capacity was also built in planning and running experimental feed trials and data recording.

Fish farmers participating in the feeding trial developed skills in sampling, data collection, fish husbandry (in particular, feeding strategies) and handling fish.

The mini-project did not develop research infrastructure. Feed was already being produced locally in Goroka and the mini-project simply tested the product on existing farms using existing equipment.

Research capacity developed as part of this mini-project continues to be used. Skills developed during the mini-project by the NFA and NDAL on data management and experimental protocols have been applied to tilapia research.

Several fish farmers who trialed rainbow trout production are now producing tilapia in their ponds and applying skills learned through the mini-project to the production of this species (Ms Cathy Hair, Project Leader, FIS/2006/138, University of the Sunshine Coast, pers. comm., 2017).

3.3.4 Uptake of R&D outputs—progress along adoption pathways

Uptake of new technologies and practical approaches achieved an 'Nf' (demonstrated and considerable use of the results by the next user, but only minimal uptake by the final users). Locally produced feed was prepared before the mini-project, used during the mini-project by initial users (research staff) and provided to both the re-opened Kutuni Trout Farm and Hatchery and the A1 Trout Farm at Goroka (final users).

After the end of the mini-project in 2012, Kutuni had rainbow trout production of 10 tonnes per year, and supplied rainbow trout fingerlings to four smaller-scale tilapia farms that each produced 5 tonnes per year. Collectively, annual rainbow trout

production in the Eastern Highlands Province was 30 tonnes per year, at a 'farm gate' value of K16.67 per kilogram. Industry gross value of production was about K500,000 (A\$200,000).

The profitability of rainbow trout production was enhanced by gifted, locally produced and easily sourced feed. It was NFA's intention to produce trout feed on a routine basis, and sell the product to farmers at cost price.

In 2017, all farms associated with the mini-project had stopped producing rainbow trout. While interest in rainbow trout aquaculture remained strong among farmers, the NFA reported some significant constraints to the industry (Mr Joe Alois and Mr Havini Vira, Fisheries Officers, NFA, pers. comm., 2017).

These included:

- seasonal and possibly longer-term changes in water temperature, rendering fingerling production at Kutuni non-viable, as there is no alternative source of rainbow trout fingerlings in the Eastern Highlands Province
- lack of critical mass in trout production that is required to make local feed production sustainable—locally sourced feed was produced by NFA and distributed at no cost to farmers during the feeding trial, and there was insufficient demand from farmers to continue production post-trial
- lack of a reliable market outlet for rainbow trout—when production dramatically increased in 2012, the local ad hoc market was flooded, and prices fell. Difficulty with distribution and marketing of rainbow trout grown in the PNG highlands was noted as far back as the early 1980s (Brown 1983).

Uptake of new scientific knowledge and basic understanding achieved a '0'. New scientific knowledge was limited to the possibility of producing rainbow trout at lower altitudes (1,600 m), and subsequent practical experience has cast doubt on the validity of this finding.

Failure of the Kutuni hatchery to produce fingerlings has been linked, at least in part, to seasonal and possibly longer-term changes in to water temperature (heating).

Knowledge, models and frameworks for policymakers or broad-level decision-makers achieved a 'Nf' (demonstrated and considerable use of the research results by the next user, but only minimal uptake by the final user).

The literature on rainbow trout farming in PNG notes the high cost of feed and marketing as the major barriers to industry development. Review of this mini-project shows that supply of suitable feed at no cost to farmers is not enough to sustain the industry. Any future public investment in rainbow trout farming must also include market and value-chain development. This information has been communicated to PNG policymakers and will shape future investments in rainbow trout and other aquaculture species.

3.3.5 Factors contributing to the adoption of project outputs

Factors underlying adoption of mini-project outputs can be grouped into knowledge, incentives and barriers, and assessed through a series of impact assessment questions.

Did the final users know about the project outputs?

The feed trial was completed on two commercial farms, one of which was the primary source of rainbow trout fingerlings in the Eastern Highlands Province. Other rainbow trout farms would have been made aware of the trial and the success of the locally produced feed when they came to buy their fingerling stock.

In addition, fisheries officers running the trial are responsible for advising local fish farmers, and providing support to freshwater aquaculture in the Eastern Highlands Province (and beyond). Further extension of the results was achieved during the normal course of fishery officer duties, including farm visits and when farmers visit the NDAL office in Goroka for advice.

Is there continuity of staff in organisations associated with adoption, leading to ongoing transfer of knowledge?

Key members of the mini-project research team remain in place, and are familiar with research outcomes. For example, Joe Alois, of the NFA, who manufactured the feed used in the trial in 2011 and was involved in mini-project extension, was able to provide an update of the status of trout production and feed use in 2017.

Are the outputs complex compared with the capacity of users to absorb them? Do users have a sufficient knowledge base to support adoption?

No. The single research output—knowledge that locally produced lower-cost feed was acceptable when compared to the hard-to-obtain and more

expensive alternative—was an easy message to absorb. Other factors, including fingerling supply and lack of markets, have limited the ongoing adoption of mini-project outputs.

Do users have sufficient incentives to adopt outputs?

No. While the availability of low-cost high-quality trout feed directly addresses a major barrier to production, the absence of established premium-paying markets prevents the necessary supply chain 'pull through' that would keep fish farmers and fingerling producers in rainbow trout production. In the absence of this 'pull through' fish farmers have reverted to other enterprises, including low-price/low-risk tilapia production.

Does adoption of the outputs increase risk or uncertainty for the users, thus reducing incentives to adopt?

Yes. Rainbow trout are expensive to produce compared with other freshwater aquaculture species. They are demanding with respect to water quality, and require a high protein diet that was not readily available before NFA's intervention. Rainbow trout farming is not a low-risk smallholder activity, and requires a measure of skill for success (FAO n.d.). Rainbow trout production using mini-project outputs, in the absence of close, careful and ongoing extension increases farmer production risk.

Is adoption either compulsory or indirectly prohibited? Are there extreme forms of incentives or barriers?

Adoption was neither compulsory nor indirectly prohibited. There were no extreme incentives or barriers in place.

Do potential users face capital or infrastructure constraints, limiting their ability to fund adoption of the outputs?

Yes. Adoption requires access to clean fast-flowing water that can be diverted into farm ponds. Ponds are of concrete construction, and need to be located above 1,600 m (Goroka is 1,550 m). Capital costs required to establish a commercial trout farm would be many thousands of kina, and beyond the capacity of individual highland farmers.

Do potential users of the outputs face cultural or social constraints on adoption?

No cultural or social constraints identified.

3.3.6 Lessons learned

Investment of a modest sum (A\$4,200) in the trial of a local diet for the farming of rainbow trout in the PNG highlands has produced modest outcomes. A community trout farm closed since 1991 was temporarily reopened when locally manufactured feed became available, and four tilapia farms converted to trout production for a single season. New skills in aquaculture research were developed by NFA and NDAL, and fish farmers improved their husbandry techniques.

The Food and Agriculture Organization of the United Nations (FAO n.d.) noted that rainbow trout farming is not a smallholder activity. The fish are demanding with respect to water quality, and the feed is expensive. The FAO noted the chequered history of rainbow trout production in PNG stretching back to the first attempt at the Kutuni Trout Farm in Goroka in 1970. Brown (1983) concluded that distribution and marketing are a challenge for rainbow trout farming in PNG.

The activity is also capital intensive, and beyond the financial capacity of individual highland farmers. It is also high risk when compared with low-cost/low-sale price tilapia farming. Rainbow trout farming, with its reliance on higher altitudes, has limited applicability to other PICs.

Outputs from the mini-project were initially adopted by final users, and this was attributable to a clear research objective, sound project design, a close working relationship with the relevant trout farms, and an encouraging initial sale price for the fish.

The mini-project had a single objective (does locally produced rainbow trout feed produce acceptable growth rates?), which was delivered by the researchers. Sound project design included field trial completion in partnership with the largest potential user of locally sourced feed and the major supplier of rainbow trout fingerlings—Kutuni Trout Farm and Hatchery. The close working relationship with the farm established during the feeding trial resulted in the simultaneous training of NFA and NDAL staff and farm employees. Initial sale prices for small numbers of rainbow trout to guest houses, restaurants and individuals at 32 kina (K) per kilogram were encouraging, before farmers found that prices fell to between K16 and K22 per kilogram for larger harvest volumes.

Initiatives that might contribute to the sustained revival of a rainbow trout industry in the

Eastern Highlands Province include value-chain and market development, as well as finding a commercial partner interested in a larger volume sustainable supply.

Value-chain and market development research might include investigating the feasibility of airfreighting fresh fish to the larger population centre of Port Moresby or to mining industry centres with capacity to pay for a premium product. Identification of a commercial partner, such as one of the emerging Western-style supermarkets based in Port Moresby, could provide a sustained market, demand and 'product pull' for rainbow trout.

Rainbow trout production in the Eastern Highlands Province has been aided by the availability of low-cost locally produced feed. The mini-project was able to demonstrate that locally produced feed produced satisfactory rates of fish growth. However, on its own, low-cost feed was not enough to sustain an industry, and future investment would need to address market development.

The mini-project could only address one issue, so could not account for the need to develop a value chain. There is advantage in having the mini-project associated with a more holistic program.

3.4 Transfer of experience—live rock production

3.4.1 Case study description

Case study 3 is a qualitative analysis of a single mini-project (MS1008—*Transfer of Pacific experience to Indigenous Australian sustainable aquaculture: live rock culture from Tonga to tropical Australia*). The mini-project facilitated the development of live rock culture enterprises in Indigenous communities through a 4-day course on production of artificial live rock. This resulted in enhanced capacity, and a successful licence application by an Aboriginal corporation.

Live rock is the term given to either natural or artificial rock that has spent time in the sea and developed a covering of marine bacteria, plants and animals, and is used in home and commercial aquariums for aesthetic effect, fish hides and biofiltration. More recently, the technology has been applied at a larger scale to reef construction and restoration.

Wild live rock is removed from a reef, shipped to market and sold through an aquarium supplier or pet shop. Harvesting of wild live rock has the potential to deplete reef systems, so it is illegal in Australia and is being phased out in PICs. Linked mini-project MS0902 (*Live rock and coral culture for the ornamental industry, Tonga*) helped the industry in that country to transition from wild to artificial live rock production.

Artificial live rock is made on land using materials such as cement, sand, pumice and shells. It is placed in the sea or seawater tank for a period to build up growth, before being removed and placed in sea water-filled containers and transported to market. Artificial live rock now dominates aquarium supplier and pet shop sales, and is being used in largescale, experimental, reef restoration projects (Mr John Wheatland, Baba Marda Abrolhos Live Rock Pty Ltd, pers. comm., 2017).

3.4.2 What was discovered —project outputs

The mini-project did not develop any new technologies or practical approaches, but was concerned with the extension of live rock production techniques developed in Tonga to Indigenous Australians through the design and delivery of a 4-day training course. Live rock production is considered to be a culturally appropriate, sustainable business opportunity for Indigenous Australians.

No new scientific knowledge or base understanding was generated by the mini-project. Knowledge developed and tested in Tonga as part of MS0902 was transferred to Indigenous Australians.

In terms of knowledge, models and frameworks for policymakers or broad-level decision-makers, the mini-project did provide an evidence base to support the development of a new industry. It showed that live rock production could be a source of economic opportunity for Indigenous communities in northern Australia, and that artificial live rock production can be accomplished without environmental damage. The training workshop completed as part of the mini-project demonstrated to Western Australian fisheries officers that artificial live rock could be tagged during construction to differentiate it from poached wild live rocks.

3.4.3 Capacity development

The project team of Cathy Hair (James Cook University), Scott Mactier (James Cook University and Tonga Fisheries Division) and Bart Penny (Kimberley TAFE, Broome Aquaculture Centre) developed and delivered a training course for 15 Indigenous Australians at the One Arm Point Hatchery, 250 km north east of Broome, Western Australia.

Indigenous students were taught a small amount of theory about the biology of live rocks, as well as insights into live rock transport, marketing and economics. Students spent most of the time making rocks from cement and other aggregates, tagging their products and placing them in the sea to attract accretions.

Training targeted three Indigenous interest groups:

- Baba Marda Abrolhos Live Rock Pty Ltd of Geraldton WA—a venture proposed by retired fisherman John Wheatland and Yamitji men Eugene Witby and Shane Bonney
- Ardyaloon Bardi Aboriginal Community representatives local to One Arm Point, Western Australia
- Dominic Maymuru, Laynhapuy Homelands Association Inc., Nhulunbuy, Northern Territory—the recipient of a Fisheries Research and Development Corporation scholarship aimed at developing skills in aquaculture suitable for remote Indigenous communities in the Northern Territory.

Extension and licensing officers from the Western Australian Department of Primary Industries and Regional Development were also trained in the same artificial live rock production techniques, so they could support Indigenous students trained during the mini-project and conduct similar courses in the future. A representative from the Darwin Aquaculture Centre was also trained to provide extension support for Indigenous communities in the Northern Territory.

In becoming familiar with artificial live rock production techniques, Western Australian fisheries licensing officers were better able to understand that live rock production could be environmentally benign, and were subsequently able to approve the Baba Marda Abrolhos Live Rock Pty Ltd production enterprise. The enterprise had been under consideration by Western Australian fisheries licensing officers for 6 years before the training course and its subsequent approval.

The mini-project resulted in the development and documentation of a training course for the Kimberley College of TAFE, Broome Aquaculture Centre. It also produced simple pieces of infrastructure, including a rock making table, capable of holding materials and supporting rock moulds, that could be used for training purposes in the future.

Skills developed by Western Australian fisheries extension and licensing officers can be used to introduce other Indigenous communities to artificial live rock production, and are available for consideration of any subsequent licensing applications. It is understood that no additional applications for live rock production have been received by the department.

Skills developed during the 4-day training course have been employed by Eugene Witby and Shane Bonney of Baba Marda Abrolhos Live Rock Pty Ltd to produce trial artificial live rocks to test both the domestic and export aquarium market, and produce larger artificial live rocks for use in overseas reef restoration assignments. Eugene and Shane's Baba Marda Abrolhos Live Rock Pty Ltd has used skills developed through the mini-project to advance their own intellectual property, which they hope to export as live rock 'know-how'. Export of intellectual property, rather than large live rocks, is expected to overcome cost barriers associated with live rock long distance freight (Mr Eugene Witby, Buba Marda Abrolhos Live Rock Pty Ltd, pers. comm., 2017).

3.4.4 Uptake of R&D outputs—progress along adoption pathways

Uptake of new technologies and practical approaches achieved an 'NF' (demonstrated and considerable use of the research results by both the next and final users). The presence of Western Australian fisheries staff at the training course, along with the provision of information on the live rock production process, rock tagging and the market for live rocks, resulted in the approval of the Baba Marda Abrolhos Live Rock Pty Ltd application to place artificial rocks in the environment off the coast of Geraldton, Western Australia.

Skills transferred to Shane Bonney and Eugene Witby from Baba Marda Abrolhos Live Rock Pty Ltd via mini-project training have allowed their company to better understand the live rock market, and develop new live rock products,

including use of limestone substrata and moulds for the production of artificial live rock (Mr John Wheatland, Buba Marda Abrolhos Live Rock Pty Ltd, pers. comm., 2017).

The Buba Marda Abrolhos Live Rock Pty Ltd combined limestone with cement, sand, water and 'a few secret ingredients' to create what it believes are unique live rocks that, after filtration to remove toxins, are placed in the ocean. John Wheatland explained that 'after a short time, coralline algae begins to grow on the substrata, forming a perfect landing pad for the coral spawn to settle'. 'Within two years, a scientist would be hard pressed to identify the artificial live rock as being man-made' (Bowen 2015).

Subsequently the Buba Marda Abrolhos Live Rock Pty Ltd has explored sales opportunities for live rock produced off Geraldton, but has found that the need to transport live rocks and sea water, makes them expensive and uneconomic compared with product produced closer to market (Professor Paul Southgate, Project Leader FIS/2006/138, pers. comm., 2017).

Consequently, the company has diversified into coral breeding and reef restoration work, using live rocks with sales and ongoing interest in Mauritius, India (Chennai), Thailand (Phuket) and the United Arab Emirates (Dubai).

The Company has switched from provision of coral-encrusted live rocks to the sale of intellectual property and training. John Wheatland said that 'airfreighting heavy rocks around the globe isn't very efficient, so the plan is to license the intellectual property to others so they can manufacture their own live rocks' (Bowen 2015).

Mr. Eugene Witby of Buba Marda Abrolhos Live Rock Pty Ltd explained that the basic training received through mini-project MS1008 in live rock production, biology and marketing has assisted the company to develop its new IP-focused business (Mr Eugene Witby, Buba Marda Abrolhos Live Rock Pty Ltd, pers. comm., 2017).

Uptake of new scientific knowledge or basic understanding achieved an 'NF' (demonstrated and considerable use of the results by the next and final users). New technology developed and tested in Tonga was transferred to Indigenous Australia. The technology has been used to develop additional IP in coral regeneration and live rock production in partnership with the Batavia Coast Maritime Institute, Geraldton, and Curtin University,

Perth (Bowen 2015). The result is an IP-based product that has achieved preliminary export sales, and has scope for further international success.

Knowledge, models and frameworks for policymakers or broad-level decision-makers were assessed as 'Nf' (demonstrated and considerable use of the results by the next user, but only minimal uptake by the final users). Live rock technologies transferred to the Indigenous Australian-owned Buba Marda Abrolhos Live Rock Pty Ltd have been further developed and sold as an IP based export product. The product is under consideration by the Minister of Fisheries in Chennai for marine park restoration around the Andaman Islands, and interest has been expressed in the technology by Dubai-based resorts planning to use live rock to line a break wall (Bowen 2015).

Mini-project training has demonstrated to policymakers and decision-makers that live rock production can be done without damage to the environment, artificial live rocks can be distinguished from the natural product with tags and there is potential to create enterprise and employment opportunity.

3.4.5 Factors contributing to the adoption of project outputs

Factors underlying adoption of mini-project outputs can be grouped into knowledge, incentives and barriers, and assessed through a series of impact assessment questions.

Did the final users know about the project outputs?

A total of 15 Indigenous Australians from three different parts of Australia (Geraldton and Broome, Western Australia, and Nhulunbuy, Northern Territory) participated in training as part of the mini-project. One group from Geraldton has built an enterprise around live rock technology. No further training or extension work on live rocks has been completed.

Is there continuity of staff in organisations associated with adoption, leading to ongoing transfer of knowledge?

Western Australian fisheries staff who participated in mini-project live rock training remain with the Western Australian Department of Primary Industries and Regional Development, and are able to contribute to extension and the licensing of live rock enterprises should there be a demand for these activities.

Are the outputs complex compared with the capacity of users to absorb them? Do users have a sufficient knowledge base to support adoption?

No. Live rock production uses simple technologies based around the mixing of cement and inert materials, and the placement of rocks in the marine environment. Other factors, including distance to market and the cost of transporting live rocks and seawater, have limited wider adoption of mini-project outputs.

Do users have sufficient incentives to adopt outputs?

No. Distance to market and the cost of transporting live rocks limit profitability and act as a disincentive to Indigenous communities adopting live rock production.

Does adoption of the outputs increase risk or uncertainty for the users, thus reducing incentives to adopt?

Live rock production is a low risk activity—capital and construction costs are minor, and rocks can be made and placed in the marine environment during non-work hours. Once licensed, there is very little opportunity cost in live rock production. The enterprise is limited by access to profitable markets.

Is adoption either compulsory or indirectly prohibited? Are there extreme forms of incentives or barriers?

Before the mini-project, difficulties with securing a licence to place artificial live rocks in the Western Australian marine environment functioned as an indirect prohibition on adoption. Post mini-project, it has been possible to secure an aquaculture licence for this purpose.

Do potential users face capital or infrastructure constraints, limiting their ability to fund adoption of the outputs?

No. Capital and infrastructure requirements for live rock production are minor.

Do potential users of the outputs face cultural or social constraints on adoption?

No cultural or social constraints have been identified. Participants in mini-project training noted that live rock making is considered to be a culturally appropriate for Indigenous Australians.

3.4.6 Lessons learned

The investment of \$15,000 to introduce three groups of Indigenous Australians to live rock production techniques developed in Tonga as part of another ACIAR funded mini-project has produced a sustained outcome.

The Buba Abrolhos Live Rock Pty Ltd has secured licensing approval for live rock production in Western Australia, has further developed the technology for reef reconstruction and has achieved some initial export sales.

Future growth in live rock production enterprises run by Indigenous Australians in northern Australia will be limited by licensing and the proximity of profitable markets.

Live rock production will continue to be relevant to PICs, such as Fiji and Tonga, which are active in the international aquarium live fish trade.

Outputs from the mini-project have been adopted, and this was attributable to appropriate approaches, inclusion of aquaculture licensing officers in mini-project training and the further commercial development of the technology.

A practical, hands-on approach to training was adopted through the mini-project, which engaged Aboriginal Australians. Theory was kept to a minimum, and most of the time was allocated to making and perfecting live rocks. The technology was simple and already proven through its application in Tonga.

Inclusion of Western Australian fisheries aquaculture licensing officers in mini-project training also assisted with adoption of mini-project outputs. Through mini-project training, these officers developed a better understanding of artificial live rock's environmental impacts and enterprise potential.

Finally, the ability of the Buba Abrolhos Live Rock Pty Ltd to further develop artificial live rock production technology, turn live rock production into IP and overcome the distance from market barrier assisted with the sustained uptake of research outputs. Cost-effective access to markets was critical to the development of a small live rock industry.

Initiatives that might contribute to further adoption of artificial live rock production by final users include working with Indigenous communities closer to market and further research to develop lighter substrata and water-free live rock transport techniques.

Working with Indigenous communities in northern Australia that are relatively close to population centres, such as Darwin and Cairns, would help reduce the cost of freight required to transport live rocks to market. Research on the product to develop lighter substrata would also assist with freight cost. In addition, it might be possible to develop techniques to keep rocks alive for short periods without the need to transport heavy and therefore costly sea water.

Artificial live rock production using training provided by mini-project MS1008 has proved successful in Australia for a single Indigenous enterprise that is now selling IP in the form of live rock 'know how'. Further growth in this opportunity for Indigenous Australians, with existing technology, will be modest.

3.5 Conclusions on qualitative case studies

Detailed qualitative analysis of three case studies comprising four mini-projects showed mixed success.

Case study 1 mini-projects were technically successful, and immediately adopted by smallholders, but adoption then dropped off.

Case study 2 was also technically successful, but needed to be part of a multi-faceted approach to industry establishment.

Case study 3 provided a sustained success for a single Aboriginal-owned enterprise.

Unquantified benefits from case study mini-projects spanning scientific knowledge, capacity development and policy development, as well as unquantified economic, social and environmental benefits are, on balance, likely to exceed modest direct investment.

However, on their own, returns from these three case studies were sufficient to justify total investment in ACIAR projects FIS/2001/075 and FIS/2006/138.

Case study 4 was the qualitative and quantitative analysis of mabé production in Fiji and Tonga linked to three additional mini-projects. Mini-projects completed as part of this case study, when combined with other investments, were highly successful.

4 Impact assessment of mabé production, Fiji and Tonga

4.1 Methods used for impact assessment

The IAS was completed using ACIAR's impact assessment guidelines (Davis et al. 2008) and ACIAR's impact assessment framework.

An understanding of the framework was developed via best practice (e.g. impact pathway analysis of ACIAR's investment in rodent control in Vietnam, Lao and Cambodia; Palis et al. 2013) and journal articles (e.g. Douthwaite et al. 2013).

4.2 Mabé project background

Mini-projects addressing winged pearl oyster (*P. penguin*) hatchery, nursery culture, training and mabé production were essential foundations for the development of a new industry in Fiji, and industry revival in Tonga.

This impact assessment study includes the ACIAR projects described in Section 1 and the three mini-projects completed as part of FIS/2006/138. Mini-projects are described in Table 14.

Mabé (pronounced 'mar-bay') are half-pearls or blister pearls. They are made by gluing several hemispherical nuclei to the inside surface of live winged pearl or black-lip pearl (*Pinctada margaritifera*) oyster shells.

Black-lip pearl oysters are used for mabé production when they are too old to carry a round pearl and have been seeded for round pearl production up to four times. Over 6–9 months, the hemispherical nuclei glued to the inside of the shell are covered with nacre (mother-of-pearl) by the oyster and form mabé. Mabé pearls vary in size from 12 to 20 mm in diameter (PARDI 2014).

Mabé are lower cost, quicker and easier to produce than round pearls, but are less valuable. However, unlike round pearl production, multiple mabé (up to 5) can be made from a single oyster and their collective value may be greater than that of a single round pearl (Professor Paul Southgate, Project Leader, FIS/2006/138, pers. comm., 2017).

Handicrafts are also manufactured from the mother-of-pearl lining of the winged pearl and black-lip oyster shell. Handicrafts include necklaces,

macramé, pendants, broaches, hair ties, shell bowls and framed mother-of-pearl pictures. In Fiji the sector has an annual retail value for pearl items of F\$8.1 million plus F\$4 million for mother-of-pearl handicrafts. Sales are dominated by low-cost imports from South-East Asia (Chand 2012).

Mabé and mother-of-pearl handicraft production is compatible with traditional Pacific lifestyles, and provides opportunities for income generation various levels. Individuals might catch spat (juvenile oysters) to sell to pearl farms, grow pearl oysters to produce mabé or mother-of-pearl, be directly employed by pearl farms or associated ventures, or be involved in mabé/pearl shell jewellery and handicraft production.

Oyster meat is a useful by-product and is consumed as part of the Pacific diet. Pearl culture is environmentally benign, and the product is lightweight, non-perishable and of high value. Mabé is an ideal export commodity or high-value souvenir from PICs (ACIAR 2017).

Before ACIAR investment in this cluster of projects, there was no production of mabé in Fiji from winged pearl or black-lip oyster (Professor Paul Southgate, Project Leader, FIS/2006/138, pers. comm., 2017).

In Tonga, *P. penguin* cultivation for mabé production had been introduced by the Tasaki Pearl Co. of Japan in 1975.

By 2007, there were 25 small oyster farms in Tonga, only three of which were stocked and actively engaged in mabé production. Mabé was sold onto both domestic and export markets.

The industry was constrained by a reliable supply of juvenile oysters, oyster culturing was not well understood and wild populations of *P. penguin* had been depleted in an effort to stock oyster farms.

Halfway through implementation of this cluster of ACIAR projects in 2013, the Tongan industry produced 2,000 pieces of mabé valued at US\$100,000. By 2016, the industry had increased to 12,000 pieces valued at US\$600,000. By 2020, mabé is forecast to become Tonga's second largest industry after tourism, and have a value of US\$3.3 million (Beyer & Pickering 2017).

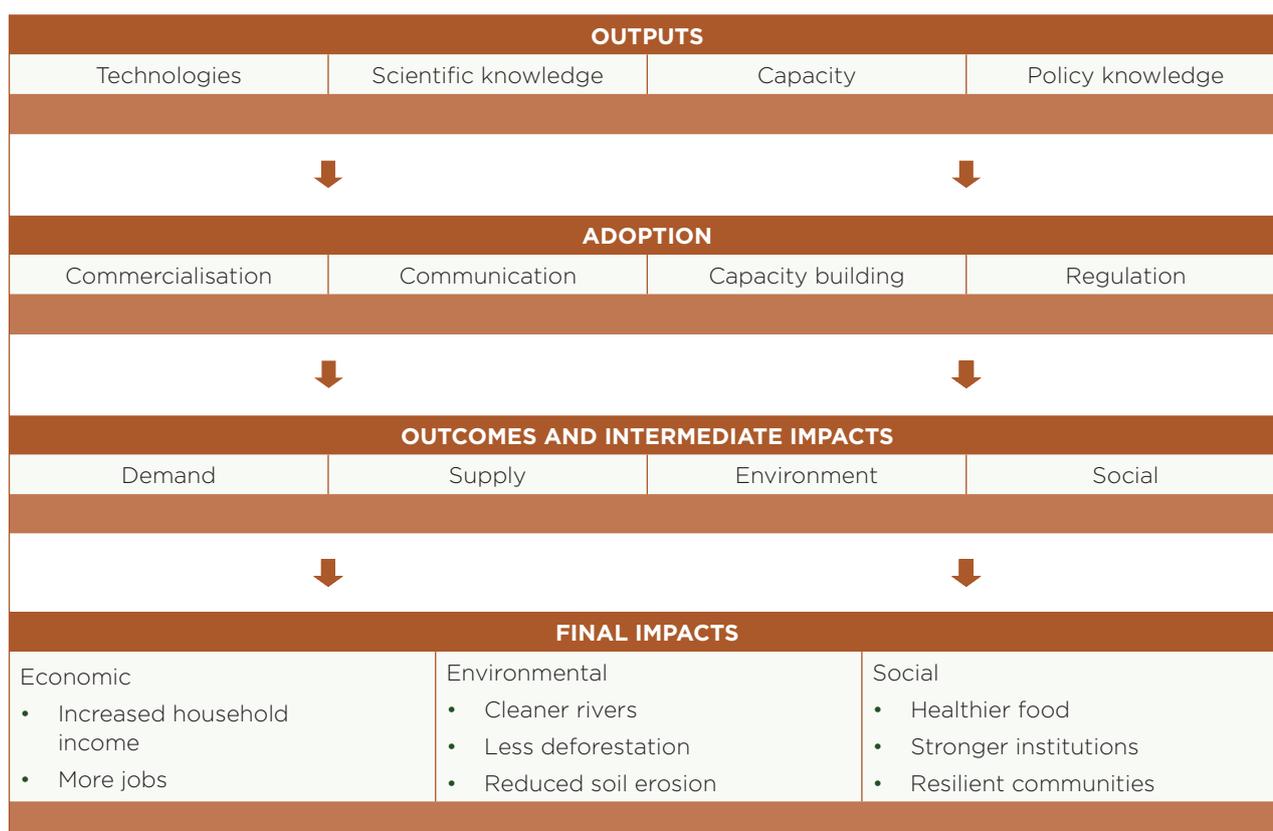


Figure 2: ACIAR impact assessment framework

Source: ACIAR 2014.

Table 14: Mini-projects included in the impact assessment study

Mini-project title	Mini-project objectives
MS0803: Improving <i>P. penguin</i> (winged pearl oyster) juvenile culture and mabé production techniques in the Fiji Islands	<ul style="list-style-type: none"> Through completion of a Masters at the University of the South Pacific (USP), using an ACIAR/USP scholarship, develop improved methods to produce quality mabé from <i>P. penguin</i> with emphasis on 'seeding' and culture requirements. Determine the best culture practices for grow-out of juvenile <i>P. penguin</i> in Savusavu Bay, Cakaudrove Province, Vanua Levu. Using socioeconomic assessment tools, determine the potential benefits from, and main constraints to, uptake of mabé production by coastal communities in Cakaudrove Province, Fiji.
MS0807: Improved husbandry methods for the culture of juvenile winged pearl oysters (<i>P. penguin</i>) in Tonga	<ul style="list-style-type: none"> Through completion of a Masters at the USP, using an ACIAR/USP scholarship, determine the effect of various culture units on growth and survival of winged pearl oysters, and identify the best culture unit for nursery culture and juvenile culture in Vava'u, Tonga. Optimise culture methods by determining the effects of depth, stocking density and cleaning frequency on growth and survival.
MS1002: Support for winged pearl oyster (<i>P. penguin</i>) hatchery production in Tonga	<ul style="list-style-type: none"> Bridge the gap in spat supply to Tongan oyster farmers for the 2010 season. FIS/2006/172 provided hatchery stock to farmers in 2008 and 2009, and FIS/2009/057 provided hatchery stock from 2011 to 2015.

Source: ACIAR project records.

4.3 Project locations

Project locations, Fiji and Tonga are shown in figures 3 and 4.



Figure 3: Map of Fiji
 Source: ANU n.d.



Figure 4: Map of Tonga with detail of Tongatapu
 Source: ANU n.d.

4.4 Research and extension investment

ACIAR investment in projects relevant to winged pearl oyster spat collection, hatchery, culture and mabé production in Fiji and Tonga are shown in Table 15.

MS0803

Mini-project MS0803 included a Masters scholarship for Fiji national Pranesh Kishore to the value of \$18,300. The balance of the project, \$8,300, covered socioeconomic investigations. Pranesh Kishore subsequently completed a PhD, on which the PhD scholarship focused only on round pearls, and its cost has been excluded from the impact assessment. There were no cash or in-kind contributions made to mini-project MS0803.

FIS/2006/172

Project FIS/2006/172 had an ACIAR investment of \$204,574 from 1 June 2007 to 30 November 2009 with an extension to 30 June 2011. In addition to this budget, an allowance of \$20,000 per year for 4 years has been made for the use of government hatchery facilities in Tonga.

MS0807

Mini-project MS0807 was an ACIAR/USP Masters scholarship for Tonga national Martin Finau to the value of \$18,300. The scholarship addressed nursery production of the winged pearl oyster.

MS1002

Mini-project MS1002 was a single year ACIAR investment of \$25,080 to maintain winged pearl oyster hatchery production in Tonga. There were no cash or in-kind contributions made to this mini-project other than the use of the government hatchery facilities in Tonga, which were costed as part of FIS/2006/172.

FIS/2009/057

Project FIS/2009/057 had an ACIAR investment of \$1.2 million from April 2013 to June 2017. Cash and in-kind contributions made to this project are summarised in Table 16.

In addition, a New Zealand Voluntary Service Abroad officer worked with FIS/2009/057, providing marketing and business development support in Tonga, at an estimated total cost of \$280,000 over the life of the project. FIS/2009/057 addressed both round pearl and mabé production. Half of total investment was directed toward mabé research, and this was included in the impact assessment.

PRA/2010.01

Project PRA/2010.01 supported the development of cultured pearl industries in Fiji and Tonga, and was jointly funded by ACIAR and the European Union via its Increasing Agricultural Commodity Trade program. European Union contributions totalled \$120,000 over the project's 3-year life. Other partner contributions to PRA/2010.01 are summarised in Table 17. Half of total PRA/2010.01 budget is attributable to round pearl development, and is not relevant to the impact analysis.

PRA/2013.01

Project PRA/2013.01 assessed the potential for development of the mother-of-pearl handicraft sector in Fiji, and was funded by ACIAR. There were no partner agency cash or in-kind investments. A single year investment of \$80,000 was made by ACIAR, and all of these funds were relevant to development of the mabé industry.

FIS/2014/103

Project FIS/2014/103 had an ACIAR investment of \$135,600 from March 2015 to February 2016, with an extension to December 2016. The project was a small research activity completed in collaboration with Ba Town Council and Ba Women's Forum, Fiji. Ba Town Council contributed the financial equivalent of \$20,000 per year for use of its workshop facilities.

FIS/2014/060

Project FIS/2014/060 included expansion of the spat, mabé and handicraft sectors in Fiji, Tonga and PNG, as well as socioeconomic impact investigations.

Cash and in-kind contributions pledged to this project are summarised in Table 18. Twothirds of total budget is included in the impact assessment, and onethird, relevant to PNG, has been excluded.

Table 15: ACIAR investment in projects that include mabé production in Fiji and Tonga (A\$)

Year	MS0803	FIS/ 2006/ 172	Tonga	MS0807	Tonga	MS1002	FIS/ 2009/ 057	Fiji, Tonga	PRA/ 2010.01	Fiji, Tonga	PRA/ 2013.01	Fiji	FIS/ 2014/ 103	Fiji, Tonga	FIS/ 2014/ 060	Fiji, Tonga	FIS/ 2016/ 126	Tonga	Total	
2007	0	93,479	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93,479	
2008	13,600	47,388	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60,988	
2009	13,000	8,707	18,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40,007	
2010	0	55,000	0	25,080	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80,080	
2011	0	0	0	0	0	0	0	433,979	0	433,979	0	0	0	0	0	0	0	0	433,979	
2012	0	0	0	0	0	0	0	239,705	0	239,705	0	0	0	0	0	0	0	0	239,705	
2013	0	0	0	0	0	0	112,862	294,969	0	294,969	0	0	0	0	0	0	0	0	407,831	
2014	0	0	0	0	0	0	307,043	0	80,000	0	0	0	0	0	0	0	0	0	387,043	
2015	0	0	0	0	0	0	263,669	0	0	0	35,600	0	0	0	0	0	0	0	299,269	
2016	0	0	0	0	0	0	254,245	0	0	100,000	393,076	0	0	0	0	0	0	0	747,321	
2017	0	0	0	0	0	0	216,231	0	0	0	460,694	0	0	0	0	0	0	0	676,925	
2018	0	0	0	0	0	0	0	0	0	0	499,062	0	0	0	0	0	325,762	0	824,824	
2019	0	0	0	0	0	0	0	0	0	0	511,858	0	0	0	0	0	329,014	0	840,872	
2020	0	0	0	0	0	0	0	0	0	0	399,930	0	0	0	0	0	329,475	0	729,405	
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	246,263	0	246,263	
Total	26,600	204,574	18,300	25,080	1,154,050	968,653	80,000	80,000	135,600	2,264,620	1,230,514	6,107,991	1,242,314	220,523	66,035	40,424	95,188	18,708	17,970	1,850

Source: ACIAR project records.

Note: Totals include allowances for expenditure in PNG and Vietnam, and round pearl investment.

Table 16: Cash and in-kind contributions to FIS/2009/057 (A\$)

	2013	2014	2015	2016	2017	Total
James Cook University	110,696	334,684	292,384	284,027	220,523	1,242,314
Tonga Government	37,184	90,694	89,694	88,694	66,035	372,301
Fiji Government	20,934	55,358	55,358	55,358	40,424	227,432
PNG Government	45,452	130,290	128,290	128,290	95,188	527,510
Secretariat Pacific Community	8,491	19,359	19,285	19,218	18,708	85,061
J Hunter Pearls, Fiji	2,030	14,700	21,000	21,000	17,970	76,700
Hainan University, China	0	0	0	1,850	0	1,850
Total	224,787	645,085	606,011	598,437	458,848	2,533,168

Source: ACIAR project records

FIS/2016/126

The focus of project FIS/2016/126 will be on scale-up of smallholder mabé enterprises in Tonga and Vietnam. Two-thirds of project effort will be expended in Tonga.

Tonga in-kind contributions are estimated at \$20,000 per year, and include use of Tonga Government hatchery facilities and a share of the salary cost of the newly appointed Pearl Industry Development Officer. This project will also link with the Australian Government Department of Foreign Affairs and Trade Tonga Skills Development Program which planned to hold three pearl handicraft workshops in Tonga in 2017, as well as the Australian Volunteer for International Development and Australian Business Volunteer programs and their New Zealand equivalents. This will total an estimated investment of \$280,000 over the life of the project.

This project is due to start in 2018, and will be completed in 2021.

Professor Paul Southgate, team leader for all IAS projects, estimates that half of total mabé investment in Fiji has been made by ACIAR. Other major contributors are the Fiji Government (35%), the private sector in Fiji (10%), and other Australian and international agencies (5%). In Tonga, Professor Southgate and Mr Max Wingfield estimate that 55% of total mabé investment has been made by ACIAR, 5% by both the private sector and international agencies, and the balance from the Tonga Government.

The IAS projects are a subset of total investment in Fiji and Tonga pearl production. They were chosen because together they form a rational cluster of investments—that is, spat collection, hatchery operations, nursery culture, oyster farming, mabé production, handicraft and business training.

Table 17: Cash and in-kind contributions to PRA/2010.01 (A\$)

	2011	2012	2013	Total
James Cook University	76,000	76,000	76,000	228,000
University of the South Pacific	54,000	24,000	50,000	128,000
Tonga Government	40,000	40,000	40,000	120,000
Fiji Government	40,000	40,000	40,000	120,000
Tonga Pearl Industry	10,000	10,000	10,000	30,000
J Hunter Pearls, Fiji	15,500	15,000	15,000	45,500
Total	235,500	205,000	231,000	671,500

Source: ACIAR project records

Table 18: Cash and in-kind contributions to FIS/2014/060 (A\$)

	2016	2017	2018	2019	2020	Total
University of the Sunshine Coast	146,466	178,466	178,466	178,466	113,143	795,007
James Cook University	44,324	63,324	63,324	63,324	27,604	261,900
Tonga Government	32,000	32,000	32,000	32,000	26,174	154,174
Fiji Government	38,176	38,176	38,176	38,176	37,814	190,518
PNG Government	68,896	68,896	68,896	68,896	57,678	333,262
New Caledonia Government	8,750	8,750	8,750	8,750	7,709	42,709
Ba Women's Forum	60,000	60,000	60,000	60,000	60,000	300,000
Ba Town Council	26,400	26,400	26,400	26,400	26,400	132,000
Total	425,012	476,012	476,012	476,012	356,522	2,209,570

Source: ACIAR project records

4.5 Impact pathway

An impact pathway was developed with Professor Southgate, and ratified with researchers and fisheries officers. The final impact pathway incorporating insight from fieldwork is shown in Figure 5.

ACIAR projects are grouped into foundational technologies, capacity building, refinement of technologies and scale-up. A long-term commitment to the development of mabé industries in Fiji and Tonga is expected to result in widespread research adoption.

4.6 Output, outcome and impact mapping

ACIAR impact mapping teases out the important distinctions between project outputs, adoption, outcomes, intermediate impacts and final impacts. The impact map is presented in Figure 6.

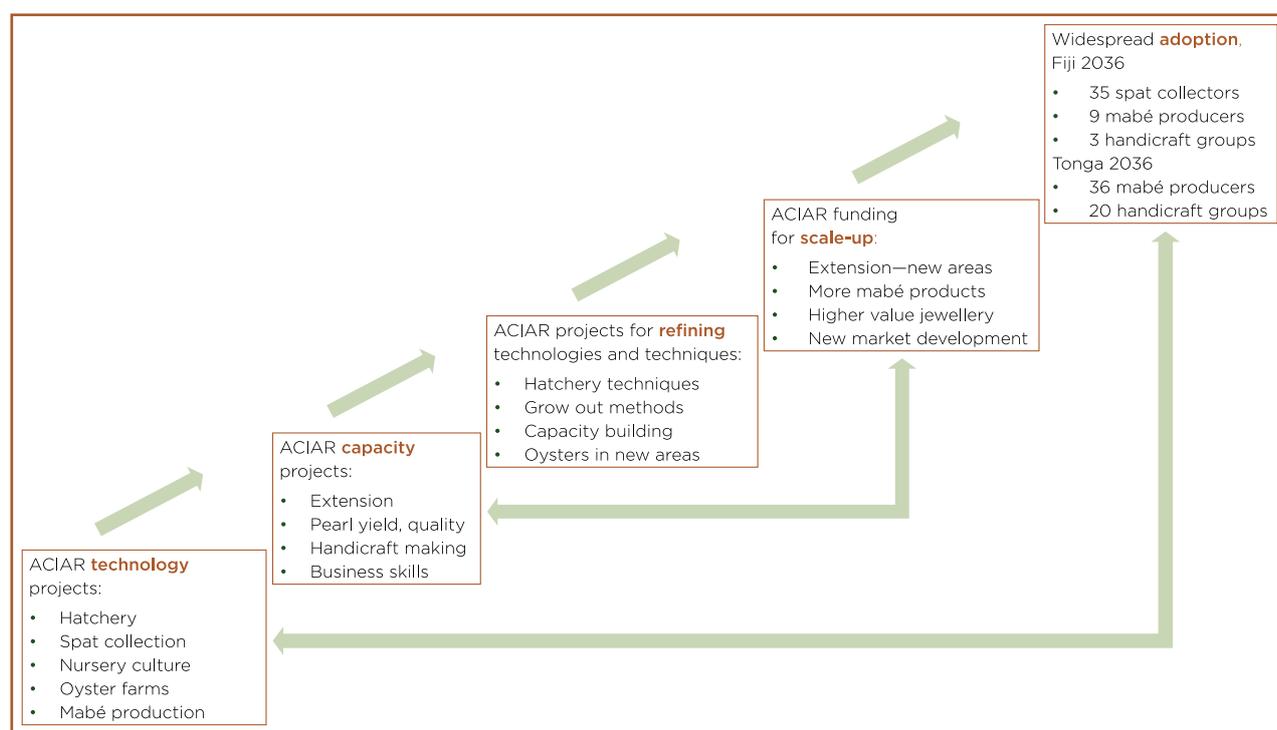


Figure 5: Impact pathway for mabé projects in Fiji and Tonga





Figure 6: Impact map for mabé projects in Fiji and Tonga

4.7 What was discovered —project outputs

New technologies and practical approaches developed as a result of ACIAR investment included protocols for ocean capture of spat, techniques for hatchery spawning the winged pearl oyster and nursery protocols to increase juvenile oyster survival and shorten the non-productive maturation phase.

New oyster farming techniques developed included information on optimal oyster placement in the water column, winged pearl oyster stocking rates, cleaning frequency and anti-fouling procedures.

Improved mabé production techniques developed through the ACIAR projects include new knowledge on anaesthetising the winged pearl oyster and the location of seed material in the oyster. Both production techniques improved the survival and productivity of the winged pearl oyster. Tools for assessing mabé quality were developed through research investment such as the experimental use of x-ray technology to forecast harvest window and the quality of the subsequent mabé crop.

Jewellery and handicraft production techniques were developed with local and international artists, and resultant mabé and mother-of-pearl pieces incorporated both Fijian and Tongan culture into their design.

Business analysis tools were developed that showed that mabé-based smallholder enterprises focusing on spat collection, oyster farming and jewellery/handicraft production are all able to support village employment and generate an income.

New scientific knowledge created by the research cluster showed that high-quality and well-coloured mabé can be produced in Fiji.

New scientific knowledge was also generated on how to adapt hatchery culture techniques developed for other oyster species to winged pearl oyster production. Successful experiments were done in Tonga to induce winged pearl oyster spawning outside of the species' natural May window. Scientific knowledge was developed to determine the optimal larval density in a hatchery and food ration requirements for the different ages of winged pearl oyster larvae.

Successful trialling of commercially available micro-algae concentrates has supported the development of a simplified hatchery protocol for *P. penguin* that does not require live micro-algae culture. It has also eliminated the need for specialised algae culture skills and infrastructure and reduced hatchery operating costs (Southgate et al. 2016). This output has favourable skill and cost reduction implications for bivalve hatchery operation worldwide (Chris Barlow, Research Program Manager, Fisheries, ACIAR, 2017).

Genetic mapping was done to understand the winged pearl oyster genetic resource and prevent contamination of wild stocks. Without this knowledge aquaculture activity risked losing unique strains and traits, and impoverishing both the ecosystem and future mabé production. Research outputs pertaining to winged pearl oyster genetic diversity also informed oyster translocation policy in Fiji and Tonga.

Knowledge models and frameworks for policymakers and broad-level decision-makers included business analysis tools used to inform government policy. Information generated from these tools was used to set government investment priorities in Fiji and Tonga.

Subsequently, the pearl industry in Fiji was repositioned within the government policy priority matrix—from a commercial export activity to a community development endeavour. A Mother-of-pearl Industry Development Strategy for Fiji was produced with ACIAR, with a solid emphasis on women's empowerment. Tax policy changes are forecast in light of demonstrated mabé industry economic value and lobbying by commercial farms. Import tariffs on low-cost mother-of-pearl handicrafts imported from South-East Asia are anticipated.

In Tonga, a Pearl Industry Development Plan was produced with ACIAR funding. The plan outlined how a revitalised industry could be developed on remote and impoverished island groups. Subsequently the industry has expanded from its diminished base in Vava'u and now includes the Ha'apai group of islands and Tongatapu. Implementation of the industry development plan has also included establishing an industry information centre and training facility for handicraft production, and employing a full-time Pearl Industry Development Officer within MAFFF (Beyer & Pickering 2017).

Geographic information system information and economic data on pearl farming produced as part of FIS/2016/126 are expected to inform ongoing pearl industry planning and development in Tonga.

4.8 Capacity development

Capacity development can be thought of in terms of both individual and institutional capacity. Review of capacity developed includes an assessment of both types of capacity and their ongoing role in Fiji and Tonga.

Team leader Professor Paul Southgate has developed a deep understanding of project delivery in the Pacific. He has superior capacity in project development, managing incountry culture, seeking out additional funding opportunities, incorporating PhDs into the work program and achieving project publications. Project publications ensure career progression for academic staff engaged in ACIAR projects, and ongoing Australian university support for ACIAR projects.

Professor Southgate continues to apply the skills he has developed to other ACIAR projects, and will be the team leader for FIS/2016/126 between 2018 and 2021.

Senior Project Scientist Mr Max Wingfield has developed biology and extension skills in Tonga through the IAS projects. These skills are being applied to mabé pearl seeding in PNG as part of FIS/2014/060.

Senior Project Scientist Ms Cathy Hair has transferred knowledge developed in Fiji and Tonga through design and delivery of mini-projects to current assignments, including FIS/2014/061 (*Improving technical and institutional capacity to support development of mariculture-based livelihoods and industry in New Ireland, PNG*).

Ms Sophie Gordon is an Australian Volunteer for International Development and is based in Tonga. In 2017, she started her PhD in winged pearl oyster and mabé production while building mabé production capacity in Tonga. She will work to understand the relationship between environmental conditions and mabé quality, and map suitable oyster farm sites in Tonga to support industry expansion. This work will be done as part of FIS/2014/060.

In Fiji, Dr Pranesh Kishore completed initial aquaculture research training and a Master of Science at the USP as part of mini-project MS0803,

supported by the ACIAR/USP Scholarship scheme. Dr Kishore went on to complete his PhD in factors affecting the quality of round pearls at James Cook University with an ACIAR John Allwright Fellowship under the ACIAR-PARDI pearl project.

Round pearl producer J Hunter Pearls Fiji estimates that changed farming practices resulting from adoption of Dr Kishore's work has added 30% to the value of its round pearl crop. Dr Kishore is now based at USP Fiji as a University of the Sunshine Coast Project Scientist on ACIAR project FIS/2014/060 (post-doctorate scientist). Dr Kishore is currently working on this project, advising the mabé industry in Tonga, establishing a spat collection sector and mabé industry in PNG and communicating his knowledge to the industry in Fiji. He has used the skills developed through IAS projects to benefit the people of the western Pacific.

Dr Kishore is supervising three Master of Science ACIAR/USP/USC scholarship recipients as part of his postdoctoral work and FIS/2014/060. The Master of Science students are John Carreon, Kristina Sankar and Charlene Erasaito, who are all working on mabé research.

Dr Monal Lal completed a Master of Science on mini-project MS0402, and a pearl genetics PhD as part of FIS/2009/057. Dr Lal's work on the genetic connectivity of pearl stocks is allowing pearl spat collection and distribution to proceed without contamination of the genetic resource.

Dr Lal is now based at USP where he is engaged as the project postdoctoral scientist for FIS/2016/122 and will oversee research (particularly genetic research) within this project and its extension and application in the Pacific. Dr Lal has used the skills developed through IAS projects to continue to benefit the people of the western Pacific.

Employees of private sector round pearl producer J Hunter Pearls Fiji were taught skills in winged pearl oyster cultivation and mabé production as part of mini-project MS0803. They are now able to capture winged pearl oyster spat, grow out oysters until they are suitable for implanting with seed, seed the oyster and produce high-quality mabé. These same employees worked with village-based groups to kick start spat collection and mabé production enterprises. J Hunter Pearls Fiji employees no longer fulfil this role on behalf of the industry.

Fiji Ministry of Fisheries extension staff have become proficient in spat collection, mabé production and community engagement. Extension staff received on-the-job training as part of PARDI/PRA/2010.01 and continue to roll out community capacity building as part of FIS/2014/060 and the Fiji Government's National Spat Collection Program.

The Ministry of Fisheries Pearl Oyster Project team, part of the National Spat Collection Project, consists of Fisheries Assistant Mr Garry Bingnald, Team Leader Ms Nanise Kundrain Tuqiri and 10 extension officers.

Training of individuals participating in village-based enterprises was completed as part of the IAS projects. Training through PARDI/PRA/2010.1 included the development of skills in infrastructure set-up, deployment of spat collectors, system monitoring, float replacement, oyster husbandry, cleaning frequency and techniques, mabé production, handicraft and jewellery making, business management, marketing and retail.

For example, women from the Ba Women's Forum, Viti Levu were trained in winged pearl oyster shell cutting and polishing, jewellery and handicraft production. These same women were also trained in business management, marketing and retail. In 2018, women from Taveuni Island, Vanua Levu will participate in a similar training program.

A Fiji Pearl Farmers Association with membership from spat collectors and smallholder farmers is under consideration as a forum to practice and enhance industry skills and sustain industry capacity.

In Tonga, Mr Martin Finau completed a Master of Science at USP in winged pearl oyster cultivation as part of mini-project MS0807. Mr Finau then went on to serve as deputy project leader for FIS/2009/057, contributing hatchery operation and field supervision. Mr Finau fulfilled these roles with distinction between 2013 and 2017. His career in the Tongan Government has included roles as Section Head of Aquaculture, MAFFF, and Section Head of Compliance, MAFFF. Martin currently manages MAFFF's Offshore Fisheries Section.

Fijian student Mr Jerome Taio completed a Master of Science at USP as part of FIS/2006/172. Mr Taio's Master of Science addressed the use of commercially available micro-algae as a feed source for winged pearl oyster produced under intensive hatchery conditions in Tonga and Fiji. Mr Taio has since joined the Fijian military.

Mr Poasi Ngaluafe, has developed outstanding leadership and project management qualities through his contributions to ACIAR projects. Mr Ngaluafe managed partner agency contributions and outputs for three ACIAR projects, becoming an effective project manager (FIS/2006/172, FIS/2009/057 and PARDI/PRA/2010.1).

Mr Ngaluafe has served as Section Head Aquaculture, MAFFF, before being promoted to Head of Fisheries Licencing, MAFFF. In this new role Mr Ngaluafe is applying the skills developed through management of ACIAR projects to more effective fisheries licensing, improved ministry outcomes and the training of junior colleagues. Capacity developed with ACIAR has been applied for the benefit of the Tongan people.

Ms Tracy Aisea is a Tongan science graduate from USP and was Mr Ngaluafe's second in charge in Aquaculture, MAFFF, and in the administration of ACIAR projects. In 2016, she was promoted to become the first female Section Head of Aquaculture, MAFFF. In 2017, Ms Aisea was completing a Master of Science in Japan and had left MAFF for a shortterm gap, where it is hoped she will return.

Dr Siosa'a Malimali has also served as Section Head of Aquaculture, MAFFF, and is now a senior manager in MAFFF. Dr Malimali trained through ACIAR mini-project MS0502 in micro-algae culture for use in hatcheries at the University of Tasmania, and went on to complete a PhD at the University of Newcastle, Australia.

Tonga MAFFF extension officers have been trained in the hatchery production of winged pearl oysters and farming techniques suitable for community-based oyster farms (FIS/2006/172). In 2017, MAFFF appointed its first full-time Pearl Industry Development Officer, Mr Siaosi Vi, who will work towards the efficient operation of the Tonga Government's aquaculture hatchery in the absence of overseas expertise.

Training workshops for artisans have addressed Tongan handicraft design, production skills and quality control. Local mentors in design and shell carving assist with training activities and provide an ongoing leadership role (FIS/2014/060).

Members of the Tonga Pearl Farmers Association developed new skills in field trial delivery and peer-to-peer extension during delivery of ACIAR projects. Tongan oyster farmers are now proficient in infrastructure set-up, field culture,

oyster handling and husbandry, pearl production and harvest (FIS/2016/060). Membership increased from seven in 2007, to 15 in 2009 and 18 in 2017. With encouragement from MAFFF and ACIAR, all village-based pearl farmers are now active members of the association.

In Fiji, legacy training infrastructure built as part of IAS projects includes the Fiji Handicraft Training Centre, Ba Viti Levu. The training centre was developed and initially equipped in Ba as part of PARDI/PRA/2010.01, and this infrastructure and facility was upgraded in 2017 as part of FIS/2014/060. The facility is routinely used for handicraft and jewellery making. A new training centre will be developed and equipped in Taveuni in 2018 as part of FIS/2014/060.

In Tonga, the government-owned oyster hatchery at Sopu, Tongatapu was upgraded as part of FIS/2006/172. The hatchery now routinely produces 500,000 winged pearl oyster spat per year, and is the essential source of juvenile oysters for mabé production. All 18 village-based winged pearl oyster farms source juvenile oysters from the hatchery without drawing from the marine environment.

To encourage mabé production outside of Vava'u, Tonga, four winged pearl oyster demonstration farms were established on the main island of Tongatapu, and a fifth was established on the Ha'apai Island Group, as part of FIS/2009/057. Over time, these farms will be handed over to the village in which they are housed. In 2017, all five demonstration farms were fully stocked, are closely supported by ACIAR and MAFFF staff, providing training and income-earning opportunities for villagers.

A new Pearl Information and Training Centre has been established in Vava'u, Tonga, in collaboration with the Ministry of Labour and Commerce. The facility will function as an industry showpiece and information centre and hub for handicraft skills training. The centre will be supplied with oyster shell cutting and polishing equipment of the type provided to the Ba Women's Forum in Fiji as part of FIS/2014/060.

4.8.1 Capacity development lessons learned

Development of individual and institutional capacity has been a major achievement for the projects considered in the IAS. The majority of individuals trained to Masters and PhD level have been retained in the aquaculture and fisheries sectors in their countries, boosting institutional capacity.

Team leader Professor Paul Southgate reports that his personal preference for ACIAR scholarship recipients completing 50% of their project research in-country has contributed to this outcome. He also notes the need to maintain contact with MAFFF managers and to keep training new people, as a successful industry requires ongoing individual and institutional capacity building.

Beyer and Pickering (2017) report the need for careful monitoring of staff movements, especially in the hatchery at Sopu, to avoid loss of industry momentum.

4.9 Uptake of R&D outputs

Adoption of R&D outputs includes uptake of new technologies, new scientific knowledge and new knowledge models and frameworks for policymakers and broad-level decision-makers. It considers R&D uptake by both initial users (e.g. researchers) and final users (e.g. oyster farmers).

Fiji

An uptake timeline for R&D outputs in Fiji is shown in Table 19. Key events include:

- the 2008 demonstration that quality mabé can be produced in Fiji
- trial production of mabé on round pearl farms
- the training of women in villages in spat collection techniques
- the training of women's groups in pearl husbandry, seeding techniques and business skills.

By 2013, several villages were earning worthwhile income from the sale of winged pearl oysters, and, in 2014, women were trained to produce high-quality jewellery from mabé grown in winged pearl oysters.

In 2016, sales of handicrafts and jewellery made by ACIAR-trained women were trialled in major department stores. In that same year, the mabé industry was identified as being particularly suitable as an income generator for disenfranchised communities in remote areas. The training of additional jewellery-making groups is proposed in 2018, along with market research to identify additional profitable outlets for handicrafts and jewellery.

Table 19: Uptake of new technology, science and policy knowledge in Fiji

Date	Research output and its uptake
2008	Dr Pranesh Kishore works with round pearl producer J Hunter Pearls, Savusavu Bay, Cakaudrove Province, to demonstrate that quality mabé can be produced in Fiji. New spat collection and pearl oyster farming knowledge is developed. The commercial farming of winged pearl oysters begins (MS0803).
2009	<p>Civa Pearls, Taveuni Island, starts collecting spat and farming black-lip pearl oysters for round pearl production.</p> <p>Other commercial operations include chief Ratu Jone in Savusavu Bay, Vanua Levu, whose village collects spat and produces round pearls and mabé, and Namarari Pearls (Tokito Pearls), Viti Levu, who produce a small volume of mostly round pearls and trial mabé production, in partnership with J Hunter Pearls.</p> <p>In total, four commercial players produce round pearls and trial mabé with black-lip pear oysters. Mabé from black-lip pearl oysters augments these businesses' main enterprise of round pearl sales.</p>
2009	<p>Women in villages are trained and equipped to collect spat and supply juvenile winged pearl and black-lip pearl oysters to farms producing round pearls and mabé (such as Yaroi Village, Savusavu Bay).</p> <p>Ms Taniela Nayasi of Yaroi Village explains that 'we were given 13 line collectors each 100-metres long in 2009, seven were destroyed by Cyclone Thomas in 2010, six were harvested in 2011 and earned more than F\$4,000 (A\$2,490). With the profit the village bought more lines in 2012, and we deployed 20 lines, and harvested nine, earning F\$7,000 (A\$4,360). We still have 11 lines to harvest. The village also bought a further 20 lines (40 in total) and plan to deploy them in September 2015'. In 2017 the village is an active and successful supplier of juvenile winged pearl and black-lip oysters to J Hunter Pearls (Moorhead 2015).</p>
2009	Within two years of the project's start, an integrated supply chain was emerging—spat collection, oyster farming and round pearl and mabé marketing by commercial pearl producers. At that point, round pearls are exported and mabé is sold exclusively on the domestic market.
2010	<p>Raviravi Ladies Group, Macuata Province, Vanua Levu, moves from spat collection to become the first village-based farmer of winged pearl oysters for mabé and mother-of-pearl production.</p> <p>Group members are taught pearl husbandry, seeding techniques and business skills. In 2016, the group celebrated the financial success of their enterprise by holding their first mabé harvest festival.</p> <p>The Raviravi Ladies Group sell their harvest in 2017 to the Ba Women's Forum for F\$44 (A\$26.50).</p>
2012	Mabé production workshops are held for farmers. Training involves teaching farmers how to handle and prepare oysters for seeding, techniques required to produce the highest-quality mabé and the husbandry of oysters seeded for mabé production.
2013	<p>Business skills training is provided to mabé industry participants. Participants are trained in the use of whole-farm economic models (decision support tools), and models are customised for farms, spat collection and value adding (handicraft) activities.</p> <p>Local financial representatives attend training sessions to help farmers establish relationships with lenders, and enable both parties to understand and satisfy capital lending requirements (PARDI/PRA/2010.01).</p>
2013	<p>Following business training workshops, Novunieva Village, Cakaudrove Province, double capture of spat by setting five additional line collectors.</p> <p>The village's first harvest of 2,000 oysters sells for F\$4,000 (A\$2,300) in 2013.</p> <p>The village has since built a shop from the proceeds, and aimed to double their income in 2014 and buy a boat.</p> <p>Based on Novunieva village's success, a neighbouring village takes up spat collection. Tavulumo village sell their first spat harvest to J Hunter Pearls, but expand into mabé and mother-of-pearl handicrafts targeting the tourist trade.</p> <p>Novunieva and Tavulumo villages previously relied on minimal income from fish sales, a livelihood which is inherently difficult to produce and trade due to the region's rugged terrain (Moorhead 2015).</p> <p>In 2017, both villages continue to collect spat and sell them to J Hunter Pearls and Civa Pearls.</p>

Date	Research output and its uptake
2014	As a result of demand for black-lip and winged pearl oyster spat for farming, 17 village communities are provided with training and supported with simple capital items (such as 100 m ropes/line collectors, plastic spat collectors), so that they can engage in spat supply to oyster farms. All oyster farms were stocked in 2014 as a result of their spat collection efforts.
2014	<p>Nine women and one man from the Ba Women's Forum, Viti Levu, are trained in jewellery and handicraft production using mother-of-pearl from black-lip and winged pearl oysters.</p> <p>The women are taught business, marketing and retailing skills (PARDI/PRA/2010.01). Handicraft production skills are taught by Ms IlseMarie Erl, a New Zealand traditional jewellery designer and trainer, with input from Mr Robert Kennedy, a Fiji fashion designer. Ms Neke Moa, an esteemed Fijian jewellery-maker, also joined Ms Erl training the ladies from the Ba Women's Forum.</p> <p>Subsequently, the Ba women have marketed their product under the Marama Shell-craft brand, and have achieved Fiji country-of-origin labelling status.</p> <p>Dr Maria Doton, Chair of Ba Women's Forum says that 'in the 12 months since the training started, the mindset of the trainees has changed. The women have become more independent, confident, enthusiastic and business-minded. They look forward to the day they will have a stable source of income and improve their financial status' (Moorhead 2015).</p>
2014	<p>The importance the Government of Fiji places on mabé is illustrated through official attendance at the graduation of nine Ba women and one man in mother-of-pearl handicraft production.</p> <p>The graduation was attended by Fiji's Attorney-General, the Minister and Permanent Secretary for the Ministry of Industry and Trade, and senior representatives from the Ministry of Social Welfare, Women and Poverty Alleviation (Moorhead 2015).</p>
2014	<p>Associate Professor Anand Chand, USP, reports broad interest among other villages, as well as increasing availability of mother-of-pearl, which means there is potential for similar training throughout Fiji.</p> <p>'For the first time in Fiji, there is a structured and effective spat collection program, and more oysters are becoming available to pearl farmers and communities throughout Fiji. This is supporting growth in mother-of-pearl handicraft production,' he said (Moorhead 2015).</p>
2014	<p>Director of Fisheries Mr Suresh Chand announces that the Fiji Government's focus on the pearl industry has shifted from one defined as a reasonable export earner to an industry achieving community engagement through strong employment and income generation.</p> <p>As a consequence, the national budget to assist communities to enter the spat collection industry in northern Fiji was doubled, and the National Spat Collection project was rolled out as part of the Fiji Government's commitment to FIS/2014/060.</p>
2016	<p>Further training on product distribution, jewellery making, business and marketing is provided to women from the Ba Women's Forum.</p> <p>Tappoo Department Stores, Suva and Sigatoka (which service high-end tourist sales, especially cruise ships) provided the women from the Ba Women's Forum with a trial stocking opportunity for their jewellery.</p> <p>Sales through Tappoo Department Stores provided the women with insights on customer needs, customer education, sales, operating in a competitive market, merchandising, product placement, point-of-sale promotion, pricing and trading margins (FIS/2014/060).</p>
2016	<p>Mabé industry is identified as being particularly suitable for disenfranchised communities in the maritime islands of the eastern Fiji province of Lau. Lau has an indigenous population of winged pearl oysters with unique colours, and the people of Lau are skilled shell carvers.</p> <p>Further industry expansion into this area is forecast (Beyer & Pickering 2017). Roll-out of the handicraft/jewellery training program used with the Ba Women's Forum is planned for two other Fiji regions—possibly Taveuni and Lau (FIS/2016/040 project proposal and confirmed during field work).</p>
2017	<p>Women from the Raviravi Ladies Group, Macuata Province complete their transition along the supply chain, moving from spat collection to oyster farming for mabé production, and finally to jewellery and handicraft making. A Ministry of Fisheries representative, the local chief and Dr Pranesh Kishore are present as Fijian Ms Kini receives payment for sale of her raw mabé to Ba Women's Forum for processing into handicraft and jewellery.</p>

Date	Research output and its uptake
2017	Five of the 17 villages engaged in spat collection are trained and actively involved in producing their own mabé (Raviravi, Natuvi, Ratu Joni, Ravita and Qamea). Namarai and Nacoubau will also be trained.
2018	<p>Taveuni is chosen as the second women's jewellery and handicraft group. This initiative results from a partnership created through FIS/2014/060 with Taveuni Rotary Club, a local pearl farm (Civa Pearls) and a local spat/pearl producing community.</p> <p>The Taveuni facility will be supplied with jewellery and handicraft making equipment, a formal training program will be rolled out and students will be selected in consultation with stakeholders.</p> <p>A third women's jewellery and handicraft group will be selected following consultation with Fiji Ministry of Fisheries—possibly Raviravi Vanua Levu, Namarai Viti Levu or Lau (noting that Lau is remote and very difficult to service).</p>
2018	<p>Market research is planned to expand profitable outlets for jewellery and handicrafts, including major retailers (e.g. Tappoo, Jacks, Prouds), specialist tourist handicraft outlets, resorts, hotels, airlines, tourist operators and government agencies.</p> <p>Overseas market research will include Oxfam, Trade Aid and other ethical market retailers (FIS/2014/060 proposal). Consumer (cruise ship) surveys will be carried out in 2018 in Fiji and Tonga to inform product development and training needs.</p>

Table 20: Uptake of new technology, science and policy knowledge in Tonga

Date	Research output and its uptake
2007	Three small winged pearl oyster farms producing mabé are undersupplied with spat, and barely operating. Winged pearl oyster farms in Tonga are based on an extended family, with work shared between family members, including handicraft production.
2008	Hatchery cultured juvenile oysters are provided to winged pearl oyster farms to alleviate their oyster shortage in 2008 and 2009 (FIS/2006/172).
2009	New farming and culture techniques are developed as part of MS0807. These techniques are taken up by Tonga pearl farmers who modify their previous farming practices (MS0807).
2010	Hatchery cultured juvenile oysters provided to farms in Vava'u in 2010. Vava'u was the centre of mabé production in Tonga before industry contraction (MS1002).
2010	New hatchery techniques are developed for winged pearl oyster. Techniques improve hatchery efficiency and lower the cost of spat production. Successful use of commercial bivalve feed has positive implications for hatchery culture of other species.
2013	Disaffected pearl farmers in Vava'u return to the industry, and new farmers express interest in establishing pearl farms. Interest in establishing pearl farms is also received from new areas, such as the main island of Tongatapu and the remote and impoverished Ha'apai Group (FIS/2009/057).
2013	The Pearl Industry Development Plan produced as part of PARDI/PRA/2010.01 is endorsed by the Tongan Fisheries Minister in November 2013.
2014	Pearl farmers from Tongatapu produce high-quality mabé, and in so doing suggest the potential for industry expansion into many different island groups (FIS/2009/057).
2014	Mabé production workshops are held for all farmers in Tonga to improve pearl yield and quality. Workshop materials are prepared in local languages, and distributed as part of a training course (PARDI/PRA/2010.01).
2015	Hatchery cultured juvenile oysters are provided to farms from 2011 to 2015. At the end of 2015, all 16 operational pearl farms were, for the first time, fully stocked with winged pearl oyster juveniles (FIS/2009/057).
2015	<p>Technical, business and handicraft skills provided to Tongan pearl farmers enable the creation of stratified income-generating opportunities, including pearl farming, handicraft production and retailing.</p> <p>Farm enterprise returns and business skills are taught to farmers using a decision support model in 2015 (Vava'u) and 2016 (Tongatapu) (FIS/2009/057).</p>

Date	Research output and its uptake
2015	Manuals and farm logbooks for mabé production are prepared and distributed to pioneer winged pearl oyster farmers in the Ha'apai Island group. A mabé and pearl jewellery competition is established at the Tonga Royal Agricultural Show (FIS/2014/060).
2016	Jewellery design workshops are held in Tonga by Australian-Tongan artist Ms Debora Allen (FIS/2014/060). Handicraft and jewellery production is done by women in Tonga. Typically, it is a family-based activity where women and young people complete pearl grinding and polishing, handicraft production and retail activities (FIS/2016/126).
2018	Training programs developed in Fiji and executed with the Ba Women's Forum will be provided to Tongan women artisans through a series of short training courses. Training will include jewellery and handicraft making, business skills and enterprise development. Training will take place in the new Vava'u pearl training facility using jewellery and handicraft making equipment supplied by ACIAR (FIS/2014/060).
2018	Training will also target oyster farmers who have little awareness of what constitutes good-quality mabé. Farmers have a tendency to sell mabé only on the basis of size. As a result, relatively poor-quality pearls are often overpriced and high-quality pearls often are under-priced. Quality control and accurate grading and valuation of Tongan pearls are important steps for the industry as it looks to develop export markets. (FIS/2014/060 proposal).
2019	Market research is planned to expand profitable outlets for jewellery and handicrafts, including major retailers, specialist tourist handicraft outlets, resorts, hotels, airlines, tourist operators and government agencies. Overseas market research will include Oxfam, Trade Aid and other ethical market retailers (FIS/2014/060).

As a consequence of ACIAR investment, first with a mini-project and subsequently with larger investments, a new mabé industry has been developed.

Tonga

An uptake timeline for R&D outputs in Tonga is shown in Table 20. In 2007, the Tonga mabé industry was constrained by a shortage of winged pearl oyster spat.

In 2008, the shortage of spat was addressed, with hatchery produced supply generated as part of FIS/2006/172.

By 2013, disaffected winged pearl oyster farmers were returning to the mabé industry, and new farmers were expressing interest in winged pearl oyster production.

A Pearl Industry Development Plan was produced as part of PARDI/PRA/2010.01, and was endorsed by the Tongan Fisheries Minister in November 2013.

Mabé production workshops were held for all Tongan pearl farmers to improve pearl yield and quality. Training programs in 2015 and 2016 addressed technical, business, handicraft and jewellery design skills.

Further training is planned for 2018, and market research is proposed for 2019 to identify additional profitable outlets for handicrafts and jewellery.

As a consequence of ACIAR investment, the Tonga mabé industry—which was in decline due to a shortage of juvenile oyster stock in 2007—has been revived and has experienced sustained growth and industry value adding.

4.10 Factors contributing to the adoption of project outputs

Factors underlying adoption of investment cluster outputs can be grouped into knowledge, incentives and barriers, and assessed through a series of impact assessment questions.

4.10.1 Factors contributing to adoption, Fiji

Did the final users know about the project outputs?

Final user awareness in Fiji was created through:

- a dialogue with village chiefs to understand needs, and explain the potential project benefits before research began
- completion of project research with the community
- training end-users in the use of research outputs
- sustained extension by both IAS project researchers and Ministry of Fisheries extension officers.

Before research started, researchers met with village chiefs in their villages to explain what was involved with spat collection, how basic capital equipment would be provided as part of the project and that there would be opportunity for the village to sell black-lip pearl oysters and produce and sell mabé.

Research was completed in the community, preliminary sales were made and neighbouring villages asked to be part of the IAS projects.

Completion of the research within villages meant that community members were aware of the research as outputs were generated. Community members provided labour and learned pearl oyster production techniques on the job. Following initial research success, researchers and Ministry of Fisheries extension officers provided additional community training via PARDI/PRA/2010.01.

Is there continuity of staff in organisations associated with adoption, leading to ongoing transfer of knowledge?

Key researcher Dr Pranesh Kishore has been working with Fiji village communities engaged in spat collection, oyster sale and mabé production since MS0803—the first of the IAS projects. Dr Kishore's engagement with the community is programmed to continue through to 2021 when FIS/2016/126 is completed. FIS/2016/126 is led by Professor Paul Southgate who has been responsible for all IAS projects. Ms Nanise Kundrain Tuqiri and Mr Garry Bingnald have led the Fiji Ministry of Fisheries extension team, providing ongoing advice and access to resources since the National Spat Collection Program began in 2014.

Are the outputs complex compared with the capacity of users to absorb them? Do users have a sufficient knowledge base to support adoption?

Research outputs are not complex. Spat collection and winged pearl oyster production rely on simple technologies—anchored rope lines, chaplets and collectors.

Cleaning and harvest are both straightforward mechanical exercises that are already well understood by coastal communities.

Some skill and manual dexterity is required for the seeding of winged pearl oysters for mabé production, but with basic training this can be accomplished by most community members. Over time, superior seeders are identified by the village and they assume responsibility for this task.

Do users have sufficient incentives to adopt outputs?

Final users are highly incentivised when it comes to adoption of IAS project outputs. Incentives are economic but also include addition to the villages food supply. Economic incentives are created via pull-through demand for juvenile oysters and mabé.

Round pearl production in Fiji is constrained by a shortage of juvenile black-lip pearl oysters. Commercial pearl farms are keen to secure additional supply and village-grown juveniles are readily purchased for A\$1.20 each.

Jewellery and handicraft makers at the Ba Women's Forum continue to look for suitable markets for their products, but their sales are constrained by the absence of appropriate enterprise management. The Ba Women's Forum buy raw mabé for about A\$26.50 per shell. Juvenile oyster and mabé production also adds to the village's food supply.

Harvested winged pearl oysters whose shell is destined for mabé production may be consumed in the village, and Ministry of Fisheries extension officers report that after Cyclone Winston in 2016, lost fishing from destroyed ocean reefs was partially replaced by fish attracted to spat lines (Mr Rasiade, Senior Fisheries Officer, Ministry of Fisheries, Namari Government Station pers. comm., 2017).

Villages adopting juvenile oyster and mabé production are also incentivised by Fiji Government programs. Most villages have a community development plan that identifies investment priorities, and funds suitable for increasing juvenile oyster and mabé production can be sourced from several government ministries, including the Ministry for Community Development, the Ministry for Women and the Ministry for Youth.

Does adoption of the outputs increase risk or uncertainty for the users, thus reducing incentives to adopt?

Spat collection is a low-risk activity. It relies on simple technologies and mechanical processes. Mabé production requires more skill, but is not high risk. Mabé seeding may produce variable results, but lower-quality outputs do not create significant economic loss. Seeded mabé survival rates are acceptable.

Jewellery and handicraft manufacture and sale are low-risk economic activities accomplished after training. Input costs (mabé implanted winged pearl oyster shells) are modest, capital equipment including grinders and polishers can be purchased as a group or village using a Fiji Government grant targeting implementation of community development plans, the activity can be completed around other tasks and sale is accomplished through joint marketing initiatives.

Adoption of outputs does not increase risk for smallholders engaged in spat collection, mabé production and the manufacture and sale of handicrafts. Risk has not reduced the incentive to adopt among the targeted demographic—remote villages with limited sources of income and women’s groups looking to provide for their communities.

Is adoption either compulsory or indirectly prohibited? Are there extreme forms of incentives or barriers?

Adoption was neither compulsory nor indirectly prohibited in Fiji. There were no extreme incentives or barriers in place.

Do potential users face capital or infrastructure constraints, limiting their ability to fund adoption of the outputs?

Outside assistance is required to fund spat collection, mabé production and jewellery/handicraft enterprises. Capital is required to buy collector lines, grow-out lines and jewellery-making equipment.

Enterprises have been launched with ACIAR project and Fiji Government assistance providing a capital base for ongoing infrastructure investment.

Commercial finance is not generally available to smallholders interested in developing mariculture enterprises. But most villages have community development plans that are supported with ongoing government grants targeting the purchase of capital items, and assistance is available through the Australian Government Department of Foreign Affairs and Trade (DFAT) and others for ongoing training.

A shortage of capital can be addressed and need not be an insurmountable barrier to research output adoption. Kishore et al. (2018) reported that income generation from spat collection in Fiji was often invested in additional spat collection infrastructure or in community infrastructure.

Do potential users of the outputs face cultural or social constraints on adoption?

Spat collection, mabé production and jewellery and handicraft making are consistent with cultural practice in coastal communities in Fiji.

Spat and mabé lines can be set, monitored, cleaned and harvested around other village activities, and are not time consuming nor time critical. The work is consistent with a group approach adopted for other similar activities, and surplus labour is available for these tasks. Jewellery and handicraft are also completed as a group activity, with women artists sharing work tasks and working around other community and family commitments.

4.10.2 Factors contributing to adoption, Tonga

Did the final users know about the project outputs?

In Tonga, researchers worked with families in Vava’u to rekindle interest in winged pearl oyster farming and jewellery and handicraft production that had become dormant due to a lack of spat supply.

In 2007, the FIS/2006/172 research team held meetings with locals involved in making pearl handicrafts to encourage their ongoing commitment to the industry.

In 2011, four demonstration farms were established in the main island of Tongatapu, with a fifth in the Ha’apai Island Group. The farms provided hands-on training for new and potential pearl farmers, and facilitated the gradual handover of management and husbandry to the community (FIS/2009/057).

Demonstration farms were supported by Australian and New Zealand volunteers who assisted with nursery culture operations, handicraft skills and business marketing (FIS/2009/057).

High-quality training materials were produced including:

- A guide to *P. penguin* oysters, Tonga
- Hatchery manual: working draft
- Grow-out manual
- A husbandry guide to *P. penguin* oysters, Tonga
- Seeding manual, English
- Mabé grading guide, English (Beyer & Pickering 2017).

Is there continuity of staff in organisations associated with adoption, leading to ongoing transfer of knowledge?

Professor Paul Southgate has been project leader for all ACIAR mabé investments made in Tonga. Mr Max Wingfield, Senior Project Scientist, USC, has delivered research on the ground in Tonga.

All IAS projects have been delivered in partnership with the Government of Tonga MAFFF Aquaculture Section. Mr Poasi Ngaluafe headed the MAFFF Aquaculture Section from the start of FIS/2006/172 in 2007 through to FIS/2014/060 in 2016.

Mr Martin Finau, MAFFF Aquaculture, was deputy project leader for FIS/2009/057 and remains in the MAFFF Aquaculture Section and active in FIS/2014/060 and FIS/2016/126.

FIS/2009/057 project reviewers (Beyer & Pickering 2017) warn about the need to monitor movements in Tonga hatchery staff to ensure that spat supply is not interrupted in the event of anticipated staff turnover.

Are the outputs complex compared with the capacity of users to absorb them? Do users have a sufficient knowledge base to support adoption?

Hatchery operation in Tonga is a sophisticated operation requiring skilled technicians. Suitable staff have been trained, and hatchery operation has been successful. Spat collection is a simple procedure accomplished after basic training. Nursery production, oyster farming and mabé production are more complex than spat collection, but are achievable by farm families with training.

Oyster and mabé production procedures are well documented in own language materials, and communicated via ACIAR project and MAFFF staff. Jewellery-making and handicraft can be accomplished following training. End-users have a sufficient knowledge base to support adoption.

Do users have sufficient incentives to adopt outputs?

Traditionally mabé production has been done by families on the remote Vava'u island group. Mabé are high-value, portable and non-perishable products that can be stored and shipped to market.

Income levels in Vava'u are lower than the national per capita average of US\$2,900 per year, and an additional cash income source is valued. IAS projects have been used to introduce mabé production to the even more remote Ha'apai group

of islands, and provide an alternative income source on Tongatapu. There is economic incentive to adopt research outputs in each of these areas.

Does adoption of the outputs increase risk or uncertainty for the users, thus reducing incentives to adopt?

Hatchery production of spat is a high-risk operation requiring skilled technicians and substantive infrastructure. For these reasons, it is best accomplished in a public institution, such as the government operated hatchery in Tonga.

Spat collection, nursery operations, mabé production and jewellery/handicraft making are lower-risk activities whose capital and operating costs and economic impact in the event of loss are manageable. Adoption of research outputs does not increase risk or uncertainty to an unacceptable level.

Is adoption either compulsory or indirectly prohibited? Are there extreme forms of incentives or barriers?

Adoption was neither compulsory nor indirectly prohibited in Tonga. There were no extreme incentives or barriers in place.

Do potential users face capital or infrastructure constraints, limiting their ability to fund adoption of the outputs?

As with Fiji, outside assistance is required for initial funding of mabé economic activity. Initial success provides the capital base for capital renewal and expansion. Noncommercial domestic and aid-based sources of funding are available for families interested in mabé-based enterprises that fall outside IAS project scope.

Do potential users of the outputs face cultural or social constraints on adoption?

Mabé production is consistent with cultural practice in Tonga. Oysters are gathered and harvested from the wild as a source of food and as a raw material for use in traditional ornamentation and jewellery.

Spat collection, oyster farming and handicraft manufacture for sale simply formalises and increases the scale of a traditional practice.

The production system is flexible. Activities are not time critical, and harvested shell can be stored at low cost and worked into jewellery and handicraft at any time.

There are no cultural or social constraints associated with the adoption of research outputs.

4.11 Mabé supply chain and market

The current mabé supply chain for Fiji and Tonga is shown in figures 7 and 8.

The supply chain in Fiji is more complex than shown in the simplified figure. Individual villages have become vertically integrated producing and selling juvenile oysters, farming oysters for mabé production and undertaking their own handicraft operations.

Not all individuals or villages are good at all three tasks, and this affects production volume and quality. Researchers and extension officers forecast further specialisation and industry stratification, and are working with industry to achieve this outcome.

To this end, the Raviravi Village Women’s Group and Natuvu Village, both of which are in Vanua Levu have started sale of unworked whole mabé shells to the Ba Women’s Forum, Viti Levu, which specialises in handicraft and jewellery production. Professor Paul Southgate also noted the emergence of dedicated specialists, including contract cleaners and harvesters who will maintain the health of spat collection lines and manage juvenile oyster harvest on behalf of a village.

In 2017, trial sales of Fiji mabé into Australian ethical markets are encouraging, with demand exceeding supply. Industry growth is currently constrained by small volumes of raw mabé shell (Dr Pranesh Kishore, Project Scientist, Fiji, pers. comm. 2017).

In Tonga, the supply chain is poorly developed. In 2017, oyster farmers carved their own shells. Oyster farmers are artists of varying skills, and product is simple, low-value handicraft. At the time of writing, any finely worked product is purchased by wealthy Tongans. Simple handicraft items are

bought by tourists, and unworked mabé may be carried to New Zealand or Hawaii in hand luggage, and sold to fund travel expenses.

ACIAR project FIS/2016/126—which is budgeted to run from 2018 to 2021—will address market development, and will work toward creating specialists, farmers, artists and retailers through targeted training.

Retail development will include traditional sales in Tonga, as well as international web sales. Planned market development includes sales via Oxfam (who have developed their own mabé designs), Fair Trade Australia, the Australian Museum’s commercial arm and auctions of raw shells/mabé to test the market with jewellery makers in Sydney, Fiji and Auckland.

ACIAR project FIS/2016/126 will commission jewellery makers to work with mabé and produce high-value products. The focus will be on lifting product quality and the price mabé can command. For example, new products will incorporate worked gold fittings. Mabé will be repositioned as an item worth thousands of dollars rather than its current retail of up to A\$200.

Product competition for mabé produced in Fiji and Tonga comes from low-cost South-East Asian shell and mabé items. China supplies low-cost freshwater pearls, which also compete with mabé. Some Cook Island mabé reaches the market place Fiji and Tonga.

The mabé industry in Fiji is starting to understand how to supply and attract the top end of the international market. Tonga needs to lift the quality of its products if it is to be successful in international markets. Repositioning mabé in the market place is important industry development work, which will ensure the sustainability of current social, environmental and economic impacts.

Community spat collection	Mabe production on Community oyster farms	Jewellery and handicraft makers	Jewellery and handicraft makers
<ul style="list-style-type: none"> village based 60% women sell black-lip oysters to round pearl farms start oyster farms with juvenile winged pearl oysters some handicraft production. 	<ul style="list-style-type: none"> village based men complete boat-based work, women seed and clean oysters produce shells for mabe and mother-of-pearl sell shells to jewellery and handicraft makers. 	<ul style="list-style-type: none"> mabé and mother-of-pearl handicraft jewellery design culture incorporated into handicrafts work with retailers to ensure products meet tourist needs training in jewellery design, business and marketing. 	<ul style="list-style-type: none"> mabé and mother-of-pearl handicraft jewellery design culture incorporated into handicrafts work with retailers to ensure products meet tourist needs training in jewellery design, business and marketing.

Figure 7: Supply chain in Fiji

Government hatchery	Nursery culture of spat	Mabe production on Community oyster farms	Retailing jewellery and handicrafts
<ul style="list-style-type: none"> • Tonga Government facility • large numbers of juveniles produced for nursery grow-out prior to supply to oyster farms • in 2017, the hatchery produces 500,000 juveniles for distribution to oyster farmers (some retained for research) • hatchery production will 'ramp up' as the industry expands. 	<ul style="list-style-type: none"> • Department of Fisheries grow out spat • over time it is proposed that a shift will be made to grow out on community oyster farms • training under way to ensure community farms able to manage nursery culture. 	<ul style="list-style-type: none"> • produce shells for mabé and mother-of-pearl • produce jewellery and handicrafts • training under way to increase stratification /specialisation and identify skilled mabé growers and jewellery makers. 	<ul style="list-style-type: none"> • cruise ships • retailing Tonga • strong domestic focus • certified ethical • export to Hawaii and New Zealand informally in hand luggage • trial export to Australia and New Zealand • trial ethical markets.

Figure 8: Supply chain in Tonga

4.12 Articulation of the counterfactual

Without ACIAR investment in the projects, social, environmental and economic impacts realised through the development of a mabé industry in Fiji and industry revival in Tonga would have been delayed.

In the late 20th century, Japanese research demonstrated that high-quality round pearls could be produced in Fiji, and a commercial industry was established with private United States funding.

In 2005, Professor Paul Southgate was in Fiji, following a successful research project in Tanzania that demonstrated the possibility of community-based mabé production from the black-lip pearl oyster (Southgate et al. 2006; Saidi et al., 2017). At that time, Professor Southgate suggested to ACIAR that a mini-project to examine the technical feasibility of mabé production in Fiji would be worthwhile, and that the mini-project could take place within the commercial round pearl industry. The round pearl industry had the necessary aquaculture infrastructure and route to market to realise research results.

Subsequently, ACIAR funded a mini-project, completed by Pranesh Kishore. Dr Kishore had a personal interest in oysters and the marine environment, was a Fiji national and understood the culture. Dr Kishore's research work demonstrated that high-quality mabé could be produced in Fiji. Subsequent ACIAR research (PRA/2010.01) showed an annual F\$4 million market for Fiji mabé and mother-of-pearl products.

Without Dr Kishore's initial ACIAR-funded research and the serendipity of Professor Southgate being on hand in Fiji, it is likely that the development of a mabé industry in Fiji would have been delayed. Government, industry and aid agencies were all focused on round pearl production, and mabé was not under consideration.

In Tonga, a mabé industry had been established by Japan in 1975, but by 2007, the 20 small farms dependent on wild caught spat had exhausted their supplies, and the industry had contracted to three barely operating units. ACIAR project FIS/2006/172 provided spat for the remaining oyster farms in 2008. Without this investment, most of the industry would have collapsed.

In 2008, no other organisations were interested in reviving the Tonga mabé industry. Japan, through the Japanese International Cooperation Agency, had switched its interest to round pearl production. New Zealand, through its aid program, was active in Tonga, but lacked expertise and insight into pearl and oyster aquaculture. The Tonga Government had not identified mabé as a development priority.

Consequently, under the counterfactual, the social, environmental and economic impacts created from ACIAR's mabé investment would have been delayed. It is suggested that a full 5-year planning cycle would have been required before mabé would have been identified as an industry able to deliver developmental goals in Fiji and Tonga.

4.13 Social impacts

Social impacts attributable to the development of a mabé industry in Fiji and Tonga result from the additional income generated from spat collection, oyster farming and jewellery and handicraft production.

In Fiji, spat collection generates about A\$120 per participant per year (F\$4,000 or A\$2,400 divided by 20 people). This represents about 10% of household income.¹

Income earned by villagers in rural Fiji is low, and living costs are high. Hair & Southgate (2012) report household surpluses in the villages of Vatulele and Nacodreudreu, both considered for spat collection, to be as low as A\$960 per year.

In Tonga, pearl farms are owned and operated by an extended family, and typically generate 35% of that family's income, taking 1 day per week to operate. Each person earns A\$7,500 per person, which is greater than the average fulltime wage in Tonga (Mr Max Wingfield, Senior Project Scientist, USC, pers. comm., 2017).

Additional income results in opportunities to buy community assets and lift living standards. In Fiji, this might include a boat and outboard motor or materials for a new village hall. In Tonga, the additional income earned might be used for health care and school-related costs.

Additional income might be earned by women, and mabé is a growing employer of women in both countries. Mabé industry employment and gender equality in the mabé industry is shown in Tables 21 and 22.

In Fiji, spat collection and oyster farming activities completed in a boat tends to be done by men. Women complete onshore activities, including oyster seeding and harvest.

Mr Max Wingfield (Senior Project Scientist, USC pers. comm., 2017) notes that the low percentage of women in oyster farming in Tonga is not intractable. There is no 'solid barrier' to women working on boats. Fishing, a somewhat similar economic activity, is done by both males and females. Through ongoing project work, a higher percentage of women engaged in oyster farming in Tonga is expected in the future.

Likewise, the percentage of women working as jewellery and handicraft makers is currently 38%, and Mr Wingfield aims for more than half the jewellery and handicraft work to be completed by women by the end of FIS/2016/126 in 2021. Female engagement in jewellery and handicraft work is viewed by both researchers and village communities as a better option than current alternative income-generating opportunities.

Table 21: Mabé industry employment and gender equality in Fiji

Employment Sector	2008 (A\$)	2017 (A\$)	Gender balance 2017	
			Male (%)	Female (%)
Spat collection/mabé production	0	340*	40	60
Jewellery/handicraft	0	10	10	90
Retail	0	0	0	0
Total	0	350	33	67

* The FIS/2014/060 proposal notes that 20 people per village are employed in spat collection, 17 villages are engaged and 60% of those engaged are women in 5 villages.

Table 22: Mabé industry employment and gender equality in Tonga

Employment Sector	2007 (A\$)	2017 (A\$)	Gender balance 2017	
			Male (%)	Female (%)
Oyster farming	3	41	88	12
Jewellery/handicraft production	4	19	62	38
Retail	4	32	16	84
Total	11	92	57	43

Source: Mr Max Wingfield, Senior Project Scientist, USC, pers. comm., 2017.

¹ Household income in rural Fiji is estimated by Garry Bingnald, Fisheries Assistant, Pearl Oyster Project, Ministry of Fisheries to be F\$200 per month, and achieved through the sale of agricultural produce and fish.

Spat collection, oyster farming and jewellery and handicraft production provides income in remote communities, and supports employment on outer islands. This can have significant benefits in reducing depopulation in these communities. Income earned in community on outer islands helps to offset a declining remittance rate from expat employment. Providing income opportunities in remote communities is a high priority for the governments of both Fiji and Tonga.

Jewellery and handicraft production provides a mechanism for the maintenance and sharing of cultural traditions. Carved winged pearl oyster shells include traditional Fijian and Tongan designs. Trainers employed as part of PARDI/PRA/2010.01 worked with the Fiji Arts Council to increase the integrity of pearl shell products.

Carving traditional designs revitalises traditions and provides a conduit for passing culture onto younger family members. Trainees at the Ba Women's Forum were from three religions and two ethnic groups.

No social costs were identified from the development and growth of a mabé industry.

4.14 Environmental impacts

The environment is considered through spat collection, juvenile oyster supply, oyster farming, marine conservation and jewellery and handicraft production. Most impacts on the environment are either neutral or positive.

Spat collection provides additional opportunity for winged pearl oyster spawn to find substrate on which to settle, establish and grow. Artificial substrata are positioned in areas where there is an abundant winged pearl oyster population. Spat collection is environmentally neutral.

Harvest of juvenile winged pearl oyster depletes an already established wild population, and has a negative impact on the environment. The substitution of this source of supply with the purchase of juveniles grown out by spat collectors or raised in a hatchery results in a gain for the environment. The gain for the environment is sustained as long as farmed juvenile supply meets total oyster farm demand. If total oyster farm demand exceeds supply, farmers will resort to the collection of wild juvenile oysters.

Oyster farming is a relatively benign form of aquaculture. Winged pearl oysters are filter feeders, and do not require food input to culture systems. Pearl farming has negligible

environmental impacts on water quality or the composition of marine sediments.

Pearl farming uses surface longlines or rafts, so has some negative aesthetic impacts. Farming infrastructure might also be a navigational hazard and affect water flow. But pearl farming infrastructure provides habitat for fish, and has been shown to positively influence local fish stocks (Cartier & Carpenter 2014). Oyster farms are known fish-attracting devices.

Oyster farming will increase the rate of recruitment of wild winged pearl oyster spat in areas where stocks are low, as spawning farm stock will add spat to the wild population. Throughout the ACIAR projects, care has been taken to ensure that any liberated spat was not of markedly different genetic make-up to wild stocks. This has been achieved through genetic mapping, and by ensuring that adequate numbers of broodstock were used in hatchery production to maximise genetic diversity.

The location of oyster farms is important. In Tonga, village-managed marine conservation areas known as Special Management Areas have been established with 'no take' policies. These areas are used to replenish marine stocks, but may also be used as sites for pearl oyster farms. Farming in the Special Management Areas and the income it generates provides additional incentive for villagers to protect marine conservation areas, and hence the broader environment.

There is no equivalent tenure aimed at marine conservation and the permitting of oyster farming in Fiji. However, Marine Protection Areas sponsored by non-government organisations are recognised in law, and pearl oyster farms are permitted in these areas.

It was noted during field investigations that villages producing spat and mabé have developed an especially keen interest in the health of the marine environment, and are quick to intervene in any activity that threatens water quality. An enhanced sense of stewardship linked to economic opportunity has been created.

The provision of a sustainable livelihood in pearl production also has the potential to reduce inshore fishing pressure. Income earned through pearl production reduces the need to harvest other species, and might, in turn, reduce total pressure on the marine environment, as communities that previously relied on the sale of wild caught fish are now able to switch to higher-value spat collection (Sims 2003).

Jewellery and handicraft production has been achieved without adverse impact on the Fijian and Tongan environment.

4.15 Economic impacts

Impact mapping has revealed various social, environmental and financial impacts, each of which has an economic dimension. This economic impact assessment concentrates on quantification of a subset of the most important final impacts. That is:

- hatchery production of spat in Tonga
- community spat collection in Fiji
- community oyster farming for mabé production in Fiji and Tonga
- community jewellery and handicraft making groups in Fiji and Tonga.

4.15.1 Hatchery production of spat in Tonga

Before ACIAR investment, techniques for hatchery spawning winged pearl oyster were not available, wild-sourced juvenile oysters were in short supply, and the Tonga mabé industry was constrained.

In 2017, the Tonga Government hatchery operated efficiently, producing spat for family-based oyster farms and research purposes. The hatchery was built at a cost of A\$32,400. Spat output between May 2013 and March 2017 is shown in Table 23.

Table 23: Spat production, Tonga Government hatchery 2013–2017

Spawning	Viable spat produced
May 2013	4,000
December 2013	40,000
February 2014	220,000
March 2014	170,000
November 2014	300,000
January 2015	350,000
January 2016	450,000
November 2016	200,000
March 2017	300,000

Source: Beyer & Pickering 2017

To date, spat spawned in the hatchery have been transferred to Tonga fisheries for a 6month nursery grow-out, before being supplied to pearl farms as advanced 5 cm juveniles.

This model was effective when the Tonga industry was small, but requires revision in light of industry growth. Under a revised model, a share of total spat production will be retained for research

purposes, and the balance will be sold to oyster farmers for grow-out and mabé production.

Spat have been provided to farmers at no cost, but under the revised model, a supply price of A\$0.50 per oyster has been suggested by research staff. With an average annual production of 500,000 spat, gross economic values of A\$250,000 per year could be generated.

The operating cost of the Tonga hatchery is relatively modest. The hatchery requires four technical staff, supervised by the Head of Aquaculture, three labourers, electricity and an allowance for capital replacement. Total annual operating cost is estimated at A\$80,000 per year.

The Tonga hatchery generates an economic surplus of A\$170,000 per year (A\$250,000 revenue less A\$80,000 in costs). The surplus will increase as the industry grows from supplying 18 farms in 2017 to a forecast 36 farms in 2036.

4.15.2 Community spat collection in Fiji

ACIAR research projects have trained and equipped villages in rural Fiji in spat collection and supply (Kishore et al. 2018). Spat are collected for harvest and sale to commercial oyster farms (black-lip pearl) or retained by the village and grown out for mabé production (winged pearl oyster).

Spat collection is a relatively 'low tech' operation, and over time most purchased inputs can be substituted with village-made alternatives. When mature, most village-based spat collection systems will consist of 10 enterprise units, each of which unit will be made up of a 100 m mainline, eight anchor lines, sea anchors, floats and collector strips (substrate).

A 100 m long, 12 mm mainline rope is required. Attached to the mainline rope are eight 30 m anchor lines. Both main and anchor lines must be bought at a cost of A\$600, and cannot be substituted with village-made alternatives.

Sea anchors can be produced in the village. Discarded animal feed sacks filled with sand are suitable anchors, as are heavy objects such as concrete-filled buckets. No capital cost is incurred for anchors. Eight floats are required per mainline, and 2-litre cordial bottles are suitable. Floats are acquired at no cost. Collector strips were made commercially in China from sheet plastic during research, but can be substituted with palm fronds or tree branches in sustainable village enterprises. No allowance is made for the capital cost of collector strips.

A total of 20 hours of labour is needed to set up each 100 m mainline, with labour costed at A\$1.50 per hour, a set-up cost of A\$30. Once set up, the mainline is left unmanaged for 12 months. Anti-fouling is not required.

Oysters ready for mabé seeding or sale to a pearl oyster farm are harvested after 12 months, and harvesting is generally completed by dragging the mainline into shallow water. Dragging may be completed using a bamboo raft or a small boat powered by an outboard motor.

This analysis allows A\$30 for hire of a small boat, and the purchase of outboard motor fuel. Harvest and packing takes 40 hours (a labour cost of A\$60). Oysters are harvested into a holding container, such as a mesh orange bag, and transferred into a woven coconut basket for transport and sale to a commercial or community oyster farm.

Oysters are robust enough to travel by public bus in a woven coconut frond basket without supplementary air or ice for up to 5 hours. Typically, oysters are picked up in the village by their buyers.

Revenue per village enterprise of 10 x 100 m mainlines is anticipated to be about A\$2,400 per year. Average sale price is A\$1.20 per oyster, and each village harvests an average of 2,000 oysters per year.

Enterprise numbers, enterprise size, capital and operating costs and enterprise returns are shown in Table 24.

Table 24: Enterprise assumptions and budget, community spat collection in Fiji

Variable	Assumption	Source/comment
Number of villages engaged in spat collection	2007 = 0 2017 = 17 2027 = 35	ACIAR project reports 2036 estimate sourced from FIS/2016/040 project proposal.
Village enterprise size	10 production units, each 100 m long	Description of the Nuvunieva village enterprise (Moorhead 2015).
Production unit capital costs		Professor Paul Southgate & Mr Max Wingfield pers. comm., 2017.
– 100 m mainline collectors	A\$100	
– eight 30 m anchor lines	A\$500	
– eight sea anchors	A\$0	
– eight plastic floats	A\$0	
– collector strips/substrata	A\$0	
Total capital cost per unit	A\$600	
Total capital cost per village	A\$6,000	
Expected life of equipment	10 years	
Annual cost of capital	A\$600	
Revenue		Beyer & Pickering 2017; Underhill 2015; Moorhead 2015.
– large juvenile oysters, not spat, ready for mabé implant	A\$2,400 (A\$1.20 each and 2,000 sold by the village each year)	
Production costs		Professor Paul Southgate & Mr Max Wingfield, pers. comm., 2017.
– annual cost of capital	A\$600	
– labour, enterprise establishment	A\$300	
– labour, anti-fouling	A\$0	
– labour, harvest and packing	A\$600	
– boat hire/fuel for outboard motor	A\$300	
Net revenue per village	A\$600	

Note: Labour has been priced at A\$1.50 per hour.

Beyer & Pickering (2017) note that 'spat can be collected by simply immersing suitable substrate in the sea in locations where there is sufficient adult winged pearl oyster population in the water. Hence it is particularly attractive to multi-tasked farmers who can earn up to an additional F\$4,000 (A\$2,400) per year by selling spat to pearl farmers'.

In 2017, 17 villages in rural Fiji were collecting spat. By 2027, an estimated 35 rural villages will be engaged in this activity.

4.15.3 Community oyster farming for mabé production

Oysters raised in a hatchery in Tonga are supplied to family-based oyster farms for mabé production. Community spat collection enterprises in Fiji retain the winged pearl oyster portion of their harvest for mabé production. Both types of enterprise have been established using the outputs of ACIAR research.

Community oyster farms managed for mabé production are set up in a similar manner to village spat collection enterprises. Typically, three 100 m longlines are required. Each longline is made up of anchor lines, sea anchors and floats. Annual capital cost is A\$180 per farm.

In areas where fish and octopus predation are not an issue, a small hole is drilled in each oyster shell, and the oyster is suspended from the mainline. In areas where predation is an issue, oysters are placed in a protective coconut frond basket, and suspended from the mainline.

Enterprise set-up, including oyster suspension, is estimated to take 20 hours per mainline by three mainlines, a total cost at A\$300 per farm (20 hours per mainline X 3 mainlines X A\$1.50 per hour). A boat might be required for this operation, so three days' hire at A\$30 per day including fuel is allowed for enterprise establishment.

Oysters enter the farm at 12 months of age, and are purchased² at a cost of A\$1.20 each. A typical community farm is stocked with 2,000 oysters, and about 55% of this stock survives to produce harvestable, first grade mabé.

Anti-fouling is required to remove predators, including a parasitic snail that is particularly problematic in Tonga. The cost of anti-fouling is estimated at 1 day's labour per week, at a cost of A\$624 (8 hours X 52 weeks X A\$1.50 per hour). Weekly boat hire might be required, at a cost of A\$1,560 (1 day per week X 52 weeks X A\$30).

When farm oysters reach 175 mm, they are large enough to seed for mabé production. Seeding is completed by a village member rather than a fly-in technician. Plastic nuclei are purchased at a cost of A\$0.10 per piece, and, in 2017, two pieces are used per oyster. Nuclei purchase cost is A\$200 (A\$0.10 per piece, two pieces per oyster and 2,000 oysters).

Seeding takes 15 minutes per oyster, including time required to retrieve and replace the oyster on the mainline. An enterprise cost of A\$1,500 is incurred (2,000 oysters X 30 minutes X A\$1.50 per hour). A single day's boat hire might also be required, at a cost of A\$30.

Labour is incurred during harvest—first to retrieve the oyster, then to open it, recover the meat and clean the shell. Five minutes per oyster is estimated at a cost of A\$250 (2,000 X 5 minutes X A\$1.50 per hour). A single day's boat hire might also be required, at a cost of A\$30.

Revenue per oyster is informed by Raviravi Village's experience selling to the Ba Women's Forum in Fiji. In 2017, Raviravi Village sold 86 oysters with mabé to the Ba Women's Forum for A\$2,280, a per-shell price of A\$26.50. Total shell revenue for a representative village enterprise is A\$29,150 (2,000 shells X 55% that survive and produce a quality mabé product X A\$26.50 per shell).

An allowance has been made for revenue resulting from sale of oyster meat. The oyster is recovered, cleaned, dried and sold by the kilogram. Nominal revenue of A\$0.50 per oyster has been allowed in this analysis.

Community oyster farm numbers, enterprise size, capital and operating costs and enterprise returns are shown in Table 25.

² An allowance has been made for the purchase of oysters for mabé production to recognise their economic value—that is oysters could be sold to other villages. In Fiji, oysters captured on spat lines are simply retained by the village for mabé production, and no exchange of cash occurs.

Table 25: Enterprise assumptions and budget, oyster farming for mabé in Fiji and Tonga

Variable	Assumption	Source/comment
Number of villages engaged in oyster farming for mabé	Fiji: 2007 = 0 2017 = 5 2036 = 9	Tonga: 2007 = 3 2017 = 18 2036 = 36
		ACIAR project reports 2036 estimate for Tonga sourced from FIS/2016/040 project proposal. Fiji estimate derived during field investigations.
Village enterprise size	Three production units, each 100 m long	Dr Pranesh Kishore, Project Scientist, Fiji, pers. Comm., 2017.
Production unit capital costs		Based on community spat collection enterprise description, adjusted for a total of three 100 m longlines rather than 10 used in spat collection.
– 100 m mainline collectors	A\$100	
– eight 30 m anchor lines	A\$500	
– eight sea anchors	A\$0	
– eight plastic floats	A\$0	
– collector strips/substrata	A\$0	
Total capital cost per unit	A\$600	
Total capital cost per enterprise	A\$1,800	
Expected life of equipment	10 years	
Annual cost of capital	A\$180	
Revenue		Professor Paul Southgate & Mr Max Wingfield, pers. comm., 2017.
– shells for mabé	A\$29,150 (2,000 shells X 55% survive X A\$26.50 per shell)	
– oyster meat	A\$550	
Production costs		Professor Paul Southgate & Mr Max Wingfield, pers. comm., 2017, with adjustments for boat use following field inspection.
– annual cost of capital	A\$180	
– labour, enterprise establishment	A\$300	
– stock purchase, oysters	A\$2,400	
– boat, enterprise establishment	A\$90	
– labour, anti-fouling, parasites	A\$624	
– boat, anti-fouling, parasites	A\$1,560	
– plastic seeds for mabé	A\$200	
– labour, seeding, retrieve, replace	A\$1,500	
– boat, retrieval, seeding, replace	A\$30	
– labour, harvesting	A\$250	
– boat, harvesting	A\$30	
Net revenue per village	A\$22,536	

FIS/2016/126 estimates Tonga mabé sales totalled A\$338,000 (T\$564,000). In 2016, there were 17 family-based farms in Tonga, averaging a gross income of about A\$19,882 per farm (A\$338,000 divided by 17 farms). In Fiji, annual revenue from three longlines, before consideration of costs, was estimated at A\$30,000 (F\$50,000) per year. These estimates are broadly consistent with the net revenue per village shown in Table 25.

In 2017, there were 5 community farms in Fiji and 18 in Tonga producing oyster shells with mabé. By 2036, an estimated 9 community farms in Fiji and 36 in Tonga will be engaged in this activity.

4.15.4 Community jewellery and handicraft making groups

Oyster shells with two mabé 'blisters' will be sold to handicraft groups in Fiji and Tonga under proposed ACIAR project investments (FIS/2014/060 and FIS/2016/126). Raviravi village's sale of oyster shell to the Ba Women's Forum is the forerunner of the proposed model.

Under this proposed model, a jewellery and handicraft making enterprise will buy 550 mabé oyster shells per year. Each mabé oyster shell will be used to create two mabébased jewellery items

with a sale price of A\$100 each, and one handicraft item from the mother-of-pearl shell lining, valued at A\$20. Total revenue for the jewellery and handicraft making group from 1,650 items will be about A\$121,000 per year.

Production of jewellery and handicrafts will require access to capital equipment, including a bandsaw, rough grinder and polisher, at a cost of A\$10,000. The enterprise will also need access to drills and diamond cutting tools, at a cost of A\$5,000.

On average, this equipment is expected to last 5 years before requiring replacement, an annual cost of A\$3,000. Replacement cost is in addition to the cost of maintenance, estimated at a further A\$3,000 per year.

Oyster shells containing mabé will need to be purchased from an oyster farm, at an estimated cost of A\$26.50 per shell, an annual cost of A\$29,150.

Each piece of jewellery is estimated to take 10 hours to complete—4 hours to grind and polish, 2 hours to cut and sand and 4 hours to weave and assemble the necklace. Each piece of handicraft will take 5 hours to complete. When trained through the ACIAR projects jewellery and handicraft makers will be skilled artists earning an hourly labour rate 3 times that achieved by, for example, a shop assistant. An hourly rate for artisans of A\$2.40 has been estimated.

Jewellery and handicraft makers will need to buy silver wire, clasps, necklace materials and other consumables. An annual allowance of A\$11,000 for jewellery and A\$1,100 for handicrafts has been made.

Jewellery and handicraft making group numbers, enterprise size, capital and operating costs and enterprise returns are shown in Table 26.

Table 26: Enterprise assumptions and budget, jewellery/handicraft making in Fiji and Tonga

Variable	Assumption	Source/comment
Number of groups making jewellery/handicrafts	Fiji:	Tonga:
	2007 = 0	2007 = 3
	2017 = 1	2017 = 10
	2036 = 3	2036 = 20
		ACIAR project reports 2036 estimate for Tonga sourced from FIS/2016/040 project proposal. Fiji estimate derived during field investigations.
Village enterprise size	10 trained artists with business and marketing skills	Description of the Women's group, Ba, Viti Levu, Fiji.
Production unit capital costs		Professor Paul Southgate & Mr Max Wingfield, pers. comm., 2017.
– bandsaw, rough grinder, polisher	A\$10,000	
– drills, diamond cutting wheels	A\$5,000	
Total capital cost per village	A\$15,000	
Expected life of equipment	5 years	
Annual cost of capital	A\$3,000	
Revenue		Professor Paul Southgate & Mr Max Wingfield, pers. comm., 2017, with adjustments following Fiji field investigations.
– jewellery (550 shells, two mabé blisters per shell, valued at A\$100 per shell)	A\$110,000	
– handicraft (550 shells, on item per shell, valued at A\$20 each)	A\$11,000	
Production costs		Professor Paul Southgate & Mr Max Wingfield, pers. comm., 2017, with adjustments following Fiji field investigations.
– annual cost of capital	A\$3,000	
– machinery maintenance	A\$3,000	
– stock purchase, mabé shells	A\$14,575	
– labour, jewellery	A\$31,680	
– labour, handicrafts	A\$6,600	
– silverware, etc—jewellery	A\$11,000	
– silverware, etc—handicraft	A\$1,100	
Net revenue for the group	A\$50,045	

Field investigations completed in Fiji as part of the IAS showed that group net revenue was currently much lower than estimated in Table 26 (A\$4,400 compared with A\$50,045). A site supervisor was required at the Ba Women's Group to lift production from part-time to full-time output. It is assumed that this staffing issue can be addressed, and the single jewellery/handicraft group in Fiji can grow to three mature functioning units by 2036. In 2017, there were 10 family-based groups producing jewellery/handicraft in Tonga, and this is forecast to increase to 20 groups by 2036.

4.15.5 Investment return

Investment return was determined over a 30-year period starting in the last year of ACIAR investment (2020–21). All benefits and costs are discounted to 2016–17 values using a discount rate of 5%.

Investment return is driven by several factors, including uptake of mabé industry activities in Fiji and Tonga. Table 27 shows forecast enterprise numbers for mabé economic activities through to 2035–36, the year in which adoption has been forecast to be mature for all mabé industry sectors.

Table 27: Forecast growth in mabé industry in Fiji and Tonga

Year	Hatchery production of spat, Tonga	Villages engaged spat collection, Fiji	Community mabé farms, Fiji	Family mabé farms, Tonga	Handicraft/jewellery groups, Fiji	Handicraft/jewellery groups, Tonga
2007	0	0	0	3	0	3
2008	40,000	0	0	3	0	3
2009	40,000	2	3	3	0	3
2010	40,000	14	3	3	1	3
2011	40,000	15	3	3	1	3
2012	40,000	16	3	3	1	3
2013	44,000	16	4	3	1	3
2014	690,000	17	4	10	1	5
2015	350,000	17	4	16	1	10
2016	650,000	17	4	17	1	10
2017	500,000	17	5	18	1	10
2018	600,000	19	6	18	2	10
2019	650,000	20	6	26	2	10
2020	700,000	21	7	34	3	15
2021	750,000	22	7	34	3	15
2022	800,000	23	7	34	3	15
2023	900,000	24	9	34	3	15
2024	950,000	25	9	36	3	15
2025	1,000,000	26	9	36	3	15
2026	1,000,000	27	9	36	3	15
2027	1,000,000	28	9	36	3	20
2028	1,000,000	29	9	36	3	20
2029	1,000,000	30	9	36	3	20
2030	1,000,000	31	9	36	3	20
2031	1,000,000	32	9	36	3	20
2032	1,000,000	33	9	36	3	20
2033	1,000,000	34	9	36	3	20
2034	1,000,000	35	9	36	3	20
2035	1,000,000	35	9	36	3	20
2036	1,000,000	35	9	36	3	20

Note: **Bold** indicates data sourced from projects and consultation, while other data are an estimate.

Total investment in impact assessment study projects of A\$9.09 million (present value terms) has been estimated to produce gross benefits of A\$10.37 million (present value terms), a net present value of A\$1.28 million and a benefit:cost ratio of 1.14:1 (over 30 years, using a 5% discount rate).

An estimated 54% of total impact assessment study project investment was funded by ACIAR. ACIAR investment in IAS projects totalled A\$4.93 million (present value terms), and produced gross benefits of A\$5.56 million (present value terms), a net present value of A\$0.63 million and a benefit:cost ratio of 1.13:1 (over 30 years, using a 5% discount rate).

Quantification of benefits does not include flow-on benefits from increased household income, import replacement, deployment of built capacity, improved environmental outcomes or positive social impacts.

With this in mind, a more detailed assessment of gender impact is done in Chapter 5, which provides a detailed assessment of the impact of mabé and pearl production on women.

This chapter is concluded with sensitivity testing of two major economic variables and comment on the risk associated with product price decrease.

4.15.6 Sensitivity analysis

Sensitivity analysis was completed on two key variables—discount rate and forecast adoption rate for spat collection, mabé and handicraft/jewellery production. Results are shown in tables 28 and 29.

Sensitivity testing shows that both a 10% discount rate and a 50% decrease in assumed adoption rate for spat collection, mabé and handicraft/jewellery production result in a benefit:cost ratio of less than 1.

Investment return is dependent on the market that handicraft makers can establish and maintain for their product. Current work on positioning handcrafted mabé jewellery as bespoke individual works of art is essential. If the market does not recognise the product as being different from mass produced and low-cost shell jewellery sourced from SouthEast Asia, prices will fall substantially as supply increases. The risk of price collapse as supply increases is significant for both the Fijian and Tongan mabé industries.

4.16 Lessons learned

The benefits from the most prospective case study—investment in winged pearl oyster hatchery, nursery culture, training and mabé production, with inclusion of linked project investments—are forecast to be sufficient to provide a positive return on ACIAR’s research investment.

Adoption of research outputs has been achieved by final users, including hatchery operators, spat collectors, mabé producers and handicraft/jewellery production groups.

Table 28: Sensitivity of IAS investment returns to discount rate (total investment, 30 years)

Criterion	Discount rate		
	0%	5% (base)	10%
Present value of benefits (A\$ million)	12.16	10.37	9.26
Present value of costs (A\$ million)	8.49	9.09	9.93
Net present value (A\$ million)	3.67	1.28	-0.67
Benefit:cost ratio	1.43	1.14	0.93

Table 29: Sensitivity of IAS investment returns to adoption rate (total investment, 30 years)

Criterion	Discount rate		
	50% decrease in assumed adoption rate	(base)	50% increase in assumed adoption rate
Present value of benefits (A\$ million)	6.08	10.37	19.49
Present value of costs (A\$ million)	9.09	9.09	9.09
Net present value (A\$ million)	-3.01	1.28	10.41
Benefit:cost ratio	0.67	1.14	2.15

Adoption has been attributed to:

- research team continuity
- in-country presence
- taking a long-term view focused on developing an industry
- partnerships with the government in Fiji and Tonga
- collaboration with the commercial sector
- an absence of negative social and environmental impacts.

Professor Paul Southgate has led mabé research in Fiji and Tonga since the design of the first case study mini-project in 2008. The first mini-project was delivered by Dr Pranesh Kishore, who has remained engaged in subsequent mabé research projects. Dr Kishore is trusted by village-based spat collectors, mabé producers and the handicraft/jewellery group. He is available in Fiji to re-establish project sites following adverse weather conditions, and to build capacity in neighbouring countries including Tonga.

ACIAR and Professor Southgate have taken a long-term view to developing an industry around mabé production in Fiji and Tonga. Case study and linked project investments have already covered 10 years of investment, with a further 4 years contracted.

A long-term commitment is required to establish a new rural industry in Australia, and this is especially the case in the Pacific where there are additional industry risks. The longterm nature of ACIAR's commitment to building an industry can be seen in the overlapping nature of project objectives in the various projects considered.

Development of an industry based around the winged pearl oyster has been accomplished in a partnership with government and the commercial pearl sector.

Government in Fiji and Tonga have made both financial contributions to ACIAR projects and policy contributions to their successful implementation. Commercial round pearl farms have provided:

- infrastructure for delivery of the first case study mini-project
- a market for juvenile oysters
- marketing opportunities for mabé
- 'cast-for-age' black-lip oysters suitable for mabé production.

Commercial partner contributions have reduced the risk associated with establishing a new industry.

Industry establishment has been facilitated by the absence of adverse social and environmental impacts. Spat collection, mabé and handicraft and jewellery production can be accomplished around other household and community responsibilities, and are compatible with traditional Pacific lifestyles. There are no substantial negative environmental impacts associated with the industry.

Recommendations arising from the impact assessment relate to the establishment of a repository for mabé and pearl industry reports, the development of an evaluation framework before project rollout and the need to complete socioeconomic research.

Currently, there is no easy repository of all reports relating to South Pacific aquaculture and mabé production. Securing even final project reports for this impact assessment was not always possible. It is recommended that an online repository be established through the Secretariat of the Pacific Community. Ready access to project reports would help avoid project duplication, and ensure each project builds on previous investments.

Consistent with best practice, budget should be set aside before the start of the project to develop an evaluation framework. Specialists should be employed for this task. Design of the evaluation framework should involve specialist inputs beyond that of the ACIAR project leader (Professor Paul Southgate, USC, pers. comm., 2017). Once developed and agreed, the evaluation framework should be populated with baseline data including socioeconomic data.

It is now a priority that socioeconomic data be collected in Fiji and Tonga to measure changes in development indexes as a result of research adoption. Given current and forecast levels of adoption, it is not too late to collect meaningful baseline information.

Consistent with this impact assessment, Beyer & Pickering (2017) concluded that mabé and the pearl industry will continue to expand in both Fiji and Tonga, and that there is every indication the industry will be sustainable.

5 Impact of women's involvement in mabé and pearl industries

For the past decade, ACIAR has funded mabé and pearl research in Fiji, contributing to the development of the pearl industry by providing new scientific knowledge and technical solutions for the benefit and improvement of livelihoods for rural communities.

In 2017, ACIAR formally articulated its commitment to gender equitable research in agriculture through the introduction of Gender Guidelines for Project Proposals. Through these guidelines ACIAR maintains a commitment to mainstreaming a gender perspective. This means making women's and men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programs in all political, economic and societal spheres so that women and men benefit equally, and inequality is not perpetuated (ACIAR 2017).

The Australian Government has made a commitment to addressing and promoting gender equity through 80% of Australian aid focusing on gender issues and women's economic empowerment (Australian Government 2017).

In 2012, the Government launched the 10-year, A\$320 million Pacific Women Shaping Pacific Development program, which aims to improve the political, economic and social opportunities of Pacific women. The program includes A\$26 million over 10 years to support women's empowerment in Fiji on four priority areas:

- increasing women in leadership and decision-making
- women's economic empowerment
- eliminating violence against women
- enabling change through coalition building (PWSPD 2016).

The aim of this assessment was to identify benefits and impacts for women involved in ACIAR projects in spat collection, mabé production and pearl handicrafts in Fiji in key areas recognised as indicators of women's empowerment:

- skills and knowledge
- access and control of assets and income

- involvement in decision-making
- leadership
- workloads.

The assessment involved an analysis of ACIAR project documents and literature and 6 fieldwork days with individuals from four communities (24 women and 12 men), ACIAR project leaders and researchers (four men and one woman) and a representative of the Ministry of Fisheries Fiji (one man).

This chapter provides a description of the projects relevant to the assessment, an outline of the methodological framework guiding the assessment and a sociocultural introduction to women in aquaculture in Fiji.

This is followed by discussion of the benefits and challenges identified for women and to a lesser extent youth associated with spat collection, mabé production and mother-of-pearl handicrafts. Finally, lessons learned and conclusions are presented.

5.1 Determining project benefits to women

Although these projects are described earlier in this report, further detail is provided in this section to capture how this cluster of projects came to have a greater focus on women and young people over time.

At the time the pearl research projects were first funded, gender mainstreaming was not a priority for ACIAR, and most project objectives did not address issues of women's empowerment. Early research was gender aware, but gender concerns were not integrated into research objectives. Over time, projects moved towards gender mainstreaming, and began to adopt a focus on women to provide economic opportunities for women as beneficiaries of projects. The information in this section is derived from project documentation.

In 2006, ACIAR-funded research project FIS/2006/138 (*Developing aquaculture-based livelihoods in the Pacific islands region and tropical Australia*). Among the aims of this project was identifying and implementing targeted research activities and technology transfer in response to priority issues identified by PICs, and increasing institutional capacity to support and manage research.

Several mini-projects were conducted as part of this umbrella project. Mini-project MS0803 (*Improving *P. penguin* (winged pearl oyster) juvenile culture and mabé production in Fiji*) was conducted by Masters student Pranesh Kishore in 2008-2009. Mini-project MS0804 '*Recruitment patterns of pearl oysters to spat collectors in Savusavu Bay, Fiji, with emphasis on the black-lip pearl oyster*' was conducted by Masters student Marilyn Vilisoni.

MS0803 included the use of socio-economic surveys to determine if mabé pearl culture could be an alternative source of revenue for local coastal communities. The results confirmed the feasibility and viability of mabé as a highly profitable alternative livelihood for coastal villages. Communities reported a preparedness and interest to participate in mabé production as an alternative source of livelihood. The key constraint identified was low annual incomes, making it difficult to purchase capital items for mabé production. In addition, the unavailability of basic items, such as boats, presented a further barrier to entry into the mabé pearl business, and would add to the expenditure involved in establishing mabé pearl business (Kishore 2010).

MS0804 developed a reliable and efficient black-lip oyster spat collection practice for Fiji that incorporated optimal targeting of spat, and constructed a useful pearl oyster spat identification key.

This research was followed by a cluster of research investments in Fiji focused on improving oyster supply, improving pearl quality, developing new products and improving business skills for the development of a viable pearl industry that would bring livelihood benefits to local communities.

These projects began to recognise and provide opportunities for men, women and youth to develop skills and knowledge within an emerging pearl industry, and gradually increased the focus on women in pearl-related activities.

In 2009 project FIS/2009/057, *Pearl industry development in the western Pacific*, continued to develop hatchery culture methods for black-lip pearl oyster (*P. margaritifera*) and winged pearl oyster (*Pt. penguin*). Women and young people in a small number of villages were trained and equipped to collect spat and supply black-lip oysters to commercial farms. Local communities were provided with an opportunity to engage in pearl-related handicraft skills and business development. A number of capacity related activities were completed for the women's handicraft community at Nusalik, including business training courses delivered by the National Fisheries College. A two-month handicraft skills training program delivered by an Australian Business Volunteer provided specialised creative design training. Consumer surveys provided feedback about product range, price of shell handicrafts and preferred products, and assisted in the design of marketing strategies and targeting appropriate marketing chains (FIS/2009/057).

The ACIAR/PARDI initiative between 2010 and 2014 directed attention to the issue of the limited access to spat as a major obstacle to pearl industry expansion in Fiji. Solutions focused on training village women's groups to collect spat and assessing the potential for the development of the mother-of-pearl handicraft sector. The spat collection program expanded nationally to 15 communities and pearl farms. Further training was provided to communities, and capacity building in research continued with collaborations and scholarships at USP and through training with fisheries' extension staff.

Project FIS/2013/103 (*Pearl Livelihoods in PNG*) aimed to maintain momentum in pearl shell handicraft enterprise development in Fiji in the interim period between the end of the ACIAR/PARDI initiative and the start of the follow-on project FIS/2014/060. In 2013, the PARDI team (led by Professor Paul Southgate and Theo Simos) estimated an annual market value of about F\$4 million for Fiji's mother-of-pearl handicrafts and pearl sector, of which only about 10% was met by local production.

A series of continuous workshops on mother-of-pearl jewellery development started in January 2014. The PARDI team worked with the Ba Women's Forum and the local Ba Town Council to produce jewellery products unique to Fiji. Nine women and one man from the Ba Women's Forum

were trained in jewellery and handicraft production using mother-of-pearl from black-lip and winged pearl oysters. The women were taught handicraft production, business, marketing and retailing skills, jewellery making and design.

FIS/2014/060 (*Developing pearl-based livelihoods in the western Pacific*) involved continuing the expansion of the spat, mabé and handicraft sectors in Fiji.

By 2017, training in spat collection and mabé production had been extended to 17 villages, with women's and youth groups receiving ongoing training and support from ACIAR researcher Dr Pranesh Kishore and Ministry of Fisheries extension staff. Further training on product distribution, jewellery making, business and marketing was provided to the Ba Women's Forum. Tappoo Department Stores and Sigatoka, which service cruise ships, provided the Ba Women's Forum with a trial stocking opportunity for their jewellery.

In the interim, in February 2016 Cyclone Winston caused significant damage to pearl farming infrastructure across a broad region of Fiji, affecting oyster supply to the cultured pearl industry. Assistance was provided by ACIAR to help re-establish infrastructure at pearl farms and spat collecting communities, and re-establish oyster supply to the industry. Continued revenue from oyster sales or from pearl production was a key component allowing farmers to rebuild their farms and to retain pre-cyclone participation levels in the industry.

In summary, between 2008 and 2017, ACIAR investments in pearl industry research resulted in 17 village communities receiving support, including capital items such as 100 m ropes/line collectors and plastic spat collectors. Training progressed in all aspects of spat collecting and mabé production. ACIAR project documentation indicates that spat collection was increasingly recognised as an economic activity for women and youth, and the Ba Women's Forum had become a market for mother-of-pearl and for the production of handicrafts. Women's groups had begun to harvest and sell juvenile oysters to pearl farms and mabé to the Ba Women's Forum.

All these projects were conducted and strengthened through partnerships between ACIAR, the Ministry of Fisheries, Secretariat of the Pacific Community, USP and USC.

5.2 Measuring gender impacts and women's empowerment

For more than 20 years, ACIAR has been systematically undertaking independent impact assessment studies, and has developed guidelines for such assessments to build consistency in methodological approaches, the treatment of information and the presentation of results. Impact assessments set out to measure the changes, both intended and unintended, that result from research, development and extension (Davis et al. 2008). The fundamental task of impact assessment is to trace the way in which research leads to change.

During the past decade, attention has turned to social impacts, including those relating to gender equity and women's economic empowerment in the agriculture sector. This has resulted in the development of specific gender impact assessment frameworks. These frameworks seek to identify the likelihood of beneficial consequences in relation to equality between women and men (European Institute for Gender Equality 2016). Gender impact assessment processes typically use gender criteria or indicators to inform understanding of predicted and realised equality impacts (Oxfam Australia & CPWF 2013).

Other assessment tools have focused on women's empowerment. The Women's Empowerment in Agriculture Index (WEAI) measures women's empowerment and inclusion in the agriculture sector (IFPRI 2012).

This instrument tracks the change in women's empowerment that occurs as a direct or indirect result of interventions, and is applied primarily to large-scale national and crossnational datasets gained from extensive household surveys (IFPRI 2012).

Since the original WEAI was developed, an abbreviated form was developed to make it more accessible to different types of users. The abbreviated WEAI preserves the five domains of empowerment: *production, resources, income, leadership and time use*, but reduces the number of indicators from 10 to five (Malapit et al. 2017).

While many development projects aim at empowering women, the measurement of empowerment has proved difficult (Masset 2015). Numerous assessment tools have emerged, including an increasing number of gender indexes (Gupta 2016; Malhota et al. 2002; World Bank 2012;

World Economic Forum 2016). These typically provide definitions of empowerment, frameworks for measuring impact, and indicators against which to measure women's empowerment.

Golla et al. (2011) define women's economic empowerment as the ability to succeed and advance economically, and the power to make and act on economic decisions. This requires skills and resources to compete in markets, together with fair and equal access to economic institutions.

To benefit from economic activities, women need to make and act on decisions and control resources. To this end Golla et al. provide a matrix of indicators across these dimensions that can be applied to a program or intervention. This can be applied as an assessment tool that focuses on women and girls alone rather than on gender (women and men).

5.2.1 Framework for assessment of women's empowerment

Given that no single program or intervention is likely to address all of the factors or indicators that contribute to women's empowerment, and that there is no universal set of indicators of change, Golla et al. (2011) recommend that assessments should align with 'a slice' of indicators that can reasonably assess change in any particular and specific context or program.

Thus, the framework for analysis in this assessment of impacts for women in spat and mabé production in Fiji was adapted from the abbreviated Women's Economic Empowerment Index, and the framework for the measurement of women's economic empowerment by Golla et al. (2011).

The following domains were selected for inclusion in the assessment:

- skills and knowledge
- access and control of productive assets and income
- decision-making
- leadership, time and workload.

Specific indicators were identified for each of these domains.

The assessment included literature review, qualitative individual and group interviews and document analysis to identify how women have benefited in key areas that are recognised as indicators of women's empowerment.

A series of interview guides were developed, and a summary of the study design and interview guides are found in Appendix 1.

In this assessment, a gender impact assessment incorporating an analysis of benefits for both men and women was not in the scope of this assessment, so the focus was on impacts for women. Typically, a broader analysis would simultaneously consider impacts on men and women.

Nor does the assessment address broader social impacts, although consideration was given to understanding, as far as possible, some of the variables usually considered in social impact assessments (population demographics, community and institutional structures, political and social resources, changes for individuals and families and community resources). Social impacts identified from interviews and group discussions were incorporated into small vignettes about communities involved in the ACIAR-linked projects.

The two assessors were accompanied by Mr Vinesh Prasad, ACIAR Country Manager Fiji and the Pacific, Dr Pranesh Kishore, post-doctoral research fellow USC, and Ms Divya Lata, Administrative Officer ACIAR Country Office.

Sampling was purposive due to time limitations. Selection of communities for inclusion was made on the recommendations of FIS/2014/060 project leader Professor Southgate and Dr Kishore.

5.3 Gender, culture and aquaculture in Fiji

A context analysis is an important first step to understand how communities are structured, how they function, and the roles and responsibilities of women and men in these communities.

This can ensure that impact assessments are conducted in a way that respects the social, cultural and local processes of communities involved. Context analysis is usually conducted at the start of industry projects, and provides baseline information across various domains:

- women's and men's roles and the gender division of labour
- the differences between women's and men's access to and control of resources and income
- factors influencing gender inequality within culture, state, community and family
- women's, men's and the community's resources, assets and strengths.

Although ACIAR pearl-related project documents offer some local context to each project, their focus has been primarily on outlining research and the scientific and technical developments that have emerged from the projects. Some ACIAR pearl-related projects include aims to contribute to the empowerment of women, and have indicated benefits for women (ACIAR/PARDI/2010/2013; FIS/2014/060; FIS/2014/103), but detailed information on social and cultural contexts is limited.

In the absence of a full context analysis, the following is a brief introduction to the cultural and gender context within which ACIAR pearl-related research has occurred over the past 10 years, focusing specifically on issues of gender in fisheries and aquaculture industries.

In 2017, the FAO published guidelines for gender-equitable small-scale fisheries governance and development (FAO 2017). The document refers to gender as the socially constructed attributes and opportunities associated with being male and female. It recognises gender as a source of power (or powerlessness) in any society or culture and because cultures change, the power associated with gender can also change.

Across different societies and cultures, there is considerable variability between men and women in terms of their privileges and responsibilities. However, while gender expresses itself differently in different social contexts, it is equally the case that certain patterns in the expression of gender repeat themselves.

Within any layer of society, including within fishing communities, women generally have fewer privileges, fewer rights, more domestic responsibilities, and less of a voice in socioeconomic and political decision-making than their male counterparts.

In small-scale fishing communities, gender inequality is often sustained through structures and institutional practices at various levels—from community customs that reinforce restrictive gender norms to national policies that marginalise women in the sector. These structures and practices, however, are not intractable; they yield to pressure and influence, and change over time (FAO 2017).

Fiji has made considerable progress in recognising gender issues in areas of gender and development, narrowing differences in educational attainment for women and men and introducing legal protections

from discrimination and violence against women (Asia Development Bank 2015).

However, the Global Gender Gap Report ranks Fiji at 122 of 136 countries in terms of gender disparity across four broad areas including:

- economic participation and opportunity
- educational attainment
- political empowerment
- health and survival (United Nations 2015).

Gender gaps in labour force participation are significant. Employment for both men and women is mainly in the informal sector. About three-quarters (78%) of all informal sector activity in Fiji involves agriculture, forestry and fishing, and one-third of those involved in such activities are women. Fiji has the highest labour force participation rate among PICs, for men at 80 per cent, with women at 46 per cent (Australian Aid & PWSPD n.d.).

Women participate in almost all aspects of agricultural production in Fiji, including farming, marketing, food processing and distribution. Fijian laws accord its male and female citizens the same rights to inheritance, as well as access to and ownership of land and assets, but in reality, control of benefits from these rights are inequitable between men and women (Australian Aid & PWSPD n.d.). This can negatively influence women's economic status in Fiji.

Rural communities in general maintain more traditional gender norms than urban communities, with fewer opportunities for rural women to earn their own incomes. Fiji is a multicultural society with varying traditions and values within ethnic groups.

In iTaukei communities, there is evidence that women are beginning to hold positions as village chiefs and as heads of landowning units in traditional leadership, but the numbers are still small. Data from the Ministry of iTaukei Affairs show that, across Fiji, women hold 7% of village chief positions and 8% of positions as head of landowning units (Asia Development Bank 2015).

Vuki (2016) describes the roles of men and women in Fiji and explains that the traditional roles of men and women have been very stable over the years. Women raise the children and take care of household chores. They also play an important role in making handicrafts such as weaving mats and tapa (fibrous cloth), and these are important for traditional obligations such as weddings

and funerals. Women also take an active role in fishing, especially in reef gleaning and inshore fishing. Men, on the other hand, are traditionally the decision-makers and play an important role in maintaining gardens for food security.

More specifically, in relation to fishing, Vunisea (2014) notes that the cultural roles of women continue to define and determine their spheres of influence at the community level, and dictate their roles and participation in the various fisheries sectors.

Gender plays a role in determining where women and men work, and separates traditional knowledge, roles and responsibilities, while customary ownership of rights to fishing grounds (*i qoliqoli*), determines how community groups, including women, participate in fishing.

In many parts of Fiji, women fish regularly to feed their families with lines or nets, and glean reefs for shellfish, octopus and seaweed. A 2009 survey of women in artisanal fisheries in Fiji identified that women may be full-time, seasonal or casual fishers. The survey also identified that women who work in artisanal fisheries are earning relatively low incomes. Of the 25 women surveyed, 75% said fishing was their main source of income. Net income after deduction of expenses varied from F\$10 to F\$100 per week.

Finally, as a result of ACIAR pearl-related research, the Ministry of Fisheries identified pearl-related aquaculture as a potentially highly profitable opportunity for women to earn income.

5.4 Benefits of spat collection and mabé production

This section examines benefits for women resulting from ACIAR-funded mabé research activities. The discussion that follows draws upon the analysis of interviews and documents. The results are reported in relation to benefits based on selected domains, and indicators of women's empowerment:

- skills and knowledge
- access and control of productive assets and income
- decision-making and leadership
- time
- workload.

Specific indicators were identified for each of these domains.

5.4.1 Participation and inclusion in mabé and pearl production activities

Improving women's livelihood opportunities is one of the most powerful pathways to women's economic empowerment. Participation and inclusion in activities is a first step in that pathway. Participation considers the number of women involved and how they became involved, as well as barriers to participation and the difference in the involvement of men and women.

A total of 15 communities and 22 project sites were established through a national spat collection program developed through ACIAR/PARDI and the Ministry of Fisheries between 2010 and 2014 (see Figure 9).

By 2017, two more villages had been included and the Ministry of Fisheries is continuing to investigate further suitable sites and communities for spat collection activities. Some village communities were not able to be included due to unsuitable biological or environmental conditions for spat collection and this was the only barrier to participation identified by researchers.

Intensive effort is currently focused on five of 17 communities: Ravita, Naturu, Raviravi, Namarai and Qamea. This impact assessment involved group interviews with men and women from the first four of these communities.

Early research by Dr Kishore and interviews with Professor Paul Southgate confirm that spat and mabé production activities were suitable for whole communities, and that the initial focus was not specifically targeted towards women.

Over time, ACIAR projects placed more emphasis on involving women in spat collection and mabé production because women have traditionally been involved in harvesting oysters for food, and spat collection and mabé production were considered compatible with women's daily work without adding greatly to the overall work burden. This would enable women to increase the volume of spat available to commercial pearl farmers who also rely on communities for spat collection.

Many villages have village councils as well as specific groups for women and youth. Women's groups are typical everywhere in Fiji. Their activities include sewing, weaving and fundraising. Groups can be effective in getting results when women's cooperative efforts contribute to providing funds for village projects (Vuki n.d.).

Table 30 identifies some of the reported ways in which men and women participate in spat and mabé production activities. In all four villages visited as part of this impact assessment, women were actively involved in all aspects of production, including boat-related activities, but women indicated that male input was either helpful or needed for some of the heavier tasks. In some cases, women employed husbands or young men from the village to assist them.

Table 30: Typical involvement of men and women in spat and mabé production

Activities	Women/ girls	Men/ boys
Spat collection		
Preparing lines, anchors, buoys, chaplets	X	X
Deploying lines	X	X
Monitoring spat collectors	X	
Cleaning shells	X	X
Harvesting	X	X
Mabé production		
Preparing lines, anchors, buoys	X	X
Deploying lines		X
Monitoring lines and floats	X	
Cleaning shells	X	
Drilling and suspending spat	X	
Implanting nucleus	X	
Harvesting	X	X
Selling	X	X

5.5 Knowledge and skill development

The primary vehicle for capacity development for women involves building skills and knowledge needed in the pearl industry generally, but specifically of spat collection and mabé production. Training and extension are important pathways for integrating women into the developing pearl industry. Education and training provides people with the capabilities and confidence required to undertake the tasks needed for production, contributing to women's empowerment.

At the community level, before training could begin, negotiations with key community leaders took place, and necessary equipment was provided to the community.

Training included the development of skills in infrastructure set-up, spat collection, oyster husbandry, mabé production and business management. The development of knowledge and skills for spat collection and mabé production takes time and considerable resources in terms of both trainers and researchers. A period of 5–6 years to fully develop spat and mabé enterprises within communities was estimated. Project leaders and Ministry of Fisheries representatives indicated that returns can be slow, and long-term community assistance is needed.

Of the 17 communities involved in ACIAR/PARDI training activities, many appear to be at different stages of progress and production. Dr Kishore, in conjunction with Ministry of Fisheries officers, has provided training and technological support to communities engaged in spat and mabé production since 2008.

Without exception all consulted as part of this impact assessment held Dr Kishore in high regard in respect of the training provided to communities. The Raviravi women's group commented that while fisheries officers provide practical support (such as assistance with checking lines) ACIAR, via Dr Kishore provided detailed technical knowledge, skills and problem solving over an extended period of time.

Professor Paul Southgate (Project Leader) felt that Dr Kishore was an essential key to continuity across projects over time. Dr Kishore is aware of social politics, and can go into Fijian villages and communicate with people in their own language. His position assists in building strength and trust within communities.

Mr Garry Bingnald (Fisheries Assistant, Pearl Oyster Project) indicated that Fisheries officers did not receive specialist training in pearl production. However, Dr Kishore provided fisheries extension officers with training as part of ACIAR project activities. As a result, fisheries extension officers can play a critical role as community cultural intermediaries, as well as offering specialised technical knowledge to support new communities in spat and mabé production. Fisheries officers also have the capacity to provide advocacy for community groups accessing funding or further specialised training.

Fisheries officers have links with various agencies including the newly re-established Women in Fisheries Network. The network has a new Strategic Plan (2016–2020), and aims to facilitate

networks and partnerships to enable opportunities for women to become informed about all aspects of sustainable fisheries in Fiji. Women's groups may benefit from connections with such agencies in terms of support to develop their small business enterprises. Currently eight to nine male fisheries officers are involved in supporting the ACIAR projects.

Women in each of the communities interviewed spoke of the essential need for ongoing support from the ACIAR team and Ministry of Fisheries extension officers, including those who had been operating in the pearl industry for 12 years (Raviravi village).

Although they were technically able to undertake the tasks required, they appeared to lack confidence to continue operations without support. All the women's groups interviewed were aware of the need to reach a point of independence and sustainability by 2020. Further consideration might need to be given to transitions in support beyond the end of ACIAR project FIS/2014/060.

Vignette 1 describes a community of women in the early stages of developing their skills and knowledge. Although enthusiastic and motivated, they did not feel ready to continue without the support of Ministry of Fisheries officers and Dr Kishore.

5.6 Access and control of productive assets and income

ACIAR pearl-related projects have provided communities with the required equipment to undertake spat and mabé production activities, including spat collectors (floats, ropes, chaplets and anchors) and winged pearl oyster mabé culture equipment. In some cases, ACIAR has also provided replacement equipment after damage from Cyclone Winston.

Each of the village groups were visited at differing stages of development. In two of the three villages, women's groups had already been involved in various community projects, raising funds for the village. In the village of Raviravi, women were well organised, had records of income and expenditure, and had clearly articulated goals for how income would be used. They had already reinvested into infrastructure for further spat collection from income earned.

Three villages (Ravita, Naturu and Raviravi) indicated that a big challenge was not having a boat to undertake monitoring activities. Raviravi had lost two boats as a result of Cyclone Winston. Boats have been hired by women for F\$25–30 per day with additional fuel costs of F\$5–10. Raviravi women's group hoped to buy a boat in the future from funds gained through spat and mabé collection.

The Navatudua women's group featured in Vignette 2 in Raviravi have access to and own assets for pearl production activities. They have acquired resources from their production and exercise control over how income and resources will be used.

Vignette 1: Dromromala Women's Group, Ravita

Ravita is a small coastal village community consisting of 11 families in the Vaturova district of Cakaudrove Province, Vanua Levu, with a population of 35 adults and 20 children. Seven men and five women met with the assessment team to discuss their involvement in spat collection. The community has active village groups for men, women and youth focusing on community priorities, such as farming, building projects, weaving, fundraising and crime prevention.

Every Tuesday a group of 14 women from the Dromromala Women's Group meet as the local women's development group. Most of the women are 36–65 years, and their activities are both social and focused on fundraising to support the needs of women in the group and the broader community. They have been active for many years, have a formal governance structure with a president, treasurer and secretary and use a group bank account into which women contribute available income.

The women have already been successful in setting up a village canteen (store), and have savings of F\$1,000. The community has a reliable source of food from taro, vegetables, prawns and fish, and their main source of income is from the sale of copra and kava, assorted vegetables and forestry products.

Copra is harvested twice a month, and sold to wholesalers on the roadside. All community members, including children, participate in copra harvesting. The main expenses for women in the community are boarding fees for older children living away from home, transport costs for the bus to town and high costs of foods purchased from stores. The village relies on solar, kerosene and a generator for power, and most have water tanks. The Ravita women's group assists other women when needed, and has a goal of saving enough money to build a multi-purpose hall for the community at an approximate cost of F\$70,000.

The Dromromala Women's Group became interested in pearls as a result of seeing a youth group in a nearby village engaging in spat collection. They wrote a letter to the local Ministry of Fisheries requesting to be included as a village in the pearl research project, and were recommended for inclusion to the ACIAR research Project Leader.

As a result, they began training with Dr Kishore and Ministry of Fisheries officers in 2016. This is mutually beneficial, as Dr Kishore and Ministry of Fisheries officers provide training and ongoing support in techniques of spat collection, and the site was included in ACIAR research. A senior village man is the main contact for the project. Women described men in the community as very supportive of women's involvement, and they assist with checking the spat lines when needed, although women mostly do this on their own.

During the first year, Dr Kishore and Ministry of Fisheries officers visited monthly to assist the community to deploy one longline with 280 oysters for mabé and four to five spat collectors, with another 20 spat collectors to be deployed by the end of 2017.

Women learned how to check and maintain the spat lines, and are yet to receive training in seeding techniques. Dr Kishore believes about 5–6 monthly training sessions are necessary to support spat collection skill development. Training was available to the whole community, so men and boys in the village were also trained. The women had recently harvested two lines of juvenile black-lip oysters, receiving F\$70 from the sale (35 oysters at F\$2 each). The first payment for oysters was a strong motivating factor for the women.

The biggest challenge identified by the women was not having their own boat, although they can be hired for F\$25–30 dollars per day. Monitoring lines is not hard, but the lines are heavy and help is needed from fisheries officers or from men in the village.

This Ravita women's group are entrepreneurial and eager to move forward following their first successful harvest. They had advocated on their own behalf to participate, and the men in the village acknowledged that the pearl project was a women's project. Women were clear about their goals and articulated their own plans for how they hoped to use the money in the future. Business training and money management were areas women identified for further training.

Vignette 2: Navatudua women's group Raviravi, Macuata Province, Vanua Levu

Navatudua women's group is located in the village of Raviravi, at Basa Bay, Macuata Province, Vanua Levu. Twelve women met with the impact assessment team to share their experience of working in the pearl industry over the past 12 years.

The village has about 73 males and 74 females, mostly aged 30–59 years. The closest town centre is Labasa, about 1 hour's drive, and the nearest school is 13 kilometres by rough road. Co-located at the school are 11 houses where women and children live during the week to access the school, as it is not possible to travel daily due to distance and cost.

The village has special arrangements to hire transport to get women and children to the school. Women rotate the care of children in the houses during the week so they can maintain their work at home. Many older children attend school in town centres, such as Labasa or Suva. The area is rich in marine resources and the main livelihoods activities are fishing and small-scale subsistence agriculture (root vegetables, poultry, pigs, goats and coconut). The men in the village previously made an income from sandfish (*Holothuria scabra*), but this is no longer possible as a result of a ban on harvesting. Some men have been able to gain seasonal work in cane cutting.

The women's group has 34 members, and young women join when they have completed their schooling. The group has been engaged in the pearl industry since 2005 when they started harvesting wild pearl oysters from their reef.

They established a relationship with J Hunter Pearls, selling black-lip oysters for F\$5 per kilogram. At that time, it was possible for women to collect 25–30 kg of black-lip oysters in a day.

Initially six women were engaged in the activity, but more women became interested. Their ambition was to have their own pearl farm, producing round pearls, but they lacked the technical skills.

In 2009, Ministry of Fisheries extension officers invited the women to become involved in spat collection. They provided 11 spat collectors, and two women from the village spent six months training in Savusavu with J Hunter Pearls. Another two women were trained as seeding technicians by Dr Maria Hawes from the University of Hawaii. The women trained in these skills have since left the village. The pearls they produced during this time were of poor quality.

Raviravi became one of the 15 sites included in the ACIAR/PARDI initiative in 2014. They were provided with an extensive training program in pearl husbandry, seeding techniques and business skills.

Gradually, they moved from spat collecting to mabé production. By 2015, 250 oysters were kept on longlines. In 2016, women celebrated the financial success of their first mabé harvest, which earned F\$3,800. They held their first mabé harvest festival, and reinvested their earnings into the purchase of more longlines and spat collectors. In 2017, women sold their second harvest to the Ba Women's Forum for F\$44 (A\$26.40) per shell.

The group have also been involved in handicrafts, earning F\$6,000 from the production of Keshi necklaces, bracelets, and rings. In 2018, they will receive further training in shell and mabé handicraft production as part of FIS/2014/060.

The group are active and well organised in the community, and have a 5-year plan with the clearly identified objectives of:

- maintaining a sustainable source of income
- improving living standards in their village
- involving women in business
- ensuring women are participating in village development.

Navatudua women's group is recognised for their achievements and the contributions they make to the village.

In the past, they have used pearl oyster income to support small business initiatives for women in the village with F\$50 micro-loans for income generating activities (such as the raising of pigs, goats and poultry). They have established a small village shop, and contributed to the building of the village hall. Income from spat and mabé has contributed to the purchase of generators and to the employment of boys and men in the village to provide income support to families.

The group maintains their money in a group bank account, and keep good records of production, income and expenditure.

They hope to invest future funds in the purchase of a boat (to replace a boat lost in the cyclone) and buy specialised equipment for shell crafting. The major constraints identified by the group were:

- no seeding shed
- no boat and outboard motor for monitoring their lines
- the isolation of the village and lack of transport
- the need for ongoing support and training.

The members of the Navatudia women's group are highly capable and determined, demonstrating a long-term involvement in and commitment to the pearl industry. ACIAR investments have strengthened their capacity to succeed. The women's group appears to have the support of the community to make decisions and control their income while both contributing to the community as a whole and supporting individual families.

5.7 Income distribution

Detailed income estimates and projections for spat and mabé production in Fiji are provided in Chapter 4.

There is an established commercial pearl industry in Fiji. Local communities are engaged to provide oysters to at least four commercially successful pearl farmers. Although women are involved in community pearl enterprises, the extent to which women are engaged in the supply of oysters to pearl farms is not clear. For example, communities such as Yaroi village have been providing oysters to J Hunter Pearls since 2009. Before ACIAR/PARDI in 2010, Raviravi women group were selling oysters to J Hunter Pearls, and communities in Namarai had arrangements with Desci Malolo Pearls (Namarai). Civa pearls from Tavenui also engage communities in spat collection.

Mr Claude Provost from Civa Pearls indicated the support gained from ACIAR had strengthened his pearl operations, and this had 'trickle on' effects to the communities of those he employs (eight male employees support families with up to 40 children).

As a result of training provided by Dr Kishore, communities associated with Civa Pearls are now collecting spat, and have received mabé training. Civa Pearls provides a small amount of work for women, such as untangling chaplets at 10 cents per chaplet. Mr Provost estimated he could provide

2,000 shells a year to women who could seed them and grow them out as mabé with a direct value of F\$20,000. Mabé could be sold to the yet to be established handicrafts centre in Tavenui in 2018 (FIS/2014/060).

The communities visited during this assessment had all reached the stage of generating some income from the harvest and sale of juvenile oysters or mabé, but these enterprises are not yet fully realised. Of the 17 communities engaged through ACIAR project investments, only five are at the stage of mabé production and income generation (Mr Garry Bingnald, Team Leader Pearl Oyster Project, Ministry of Fisheries, pers. comm., 2017).

How income is distributed in the community differs according to various factors, including whether the chief has a casual or major interest in activities and whether his or her family is involved. Income distribution varies in response to community-driven agendas or different family relationships. In some instances, women keep and spend their money, in others it goes into a pool and is used for community priorities.

A critical factor for continued income from the sale of mabé will be the capacity of the small number of handicraft makers to buy mabé from a growing number of shell producers.

Currently, Ba Women's Forum is the only market for pearl shell and mabé. In 2018, the Raviravi Women's Group will begin to receive training and support to develop pearl handicrafts and jewellery as part of project FIS/2014/060. Mabé producers will be dependent on these handicraft businesses to buy their product. The purchase of mabé is currently orchestrated using ACIAR project funds, but these businesses will need to find a market for their handicraft products, and become profitable and competitive.

Income from the sale of juvenile oysters and shells with mabé in a timely manner is also important to maintaining women's motivation in the early years of production. Currently, ACIAR project staff and Ministry of Fisheries extension officers are involved in collecting and delivering product from communities to pearl farmers or handicrafts producers. Women's groups are benefiting from this arrangement. However, Ministry of Fisheries extension officers might not be able to continue this service indefinitely. In the long term, for the supply chain to be successful, women producing mabé will need to develop direct relationships or supply channels with handicraft makers.

The control of income is a complex issue culturally and socially. In some villages (such as Raviravi), women have considerable autonomy in their decision-making and use of income. In other villages, the women's groups appear to be operating in the service of broader community plans and structures that bring benefits to the community in a different way. It was not possible to establish how individual women have benefited financially from spat or mabé enterprises, but some community benefits are clearly evident, such as the purchase of equipment and contributions to community infrastructure.

5.8 Decision-making and leadership

All groups interviewed had formal governance structures within their groups and within the community. To fully understand the decision-making within their communities would require more detailed engagement with the women.

Some women's groups might have more autonomy to make decisions and exercise leadership than others, depending on the power structures and relationships within communities.

Dr Kishore noted that in some groups women had taken an active role in meetings with government officials and Ministry of Fisheries representatives. Some women's groups had advocated on their own behalf, and sought assistance and information when needed.

The opportunity to engage in economic activity that brings financial benefits to the broader community and affords a level of respect and power within the community was apparent in the relationships between men and women.

5.9 Time and workload

Researchers and Ministry of Fisheries representatives indicated that the work required to undertake spat collection and mabé production was not demanding of women's time and did not interfere with other tasks of daily life. Women's groups who were interviewed confirmed this observation.

The only barrier reported was the lack of boats, making the task of monitoring spat collection lines more difficult. Although women are involved in other work within the household, care for children and subsistence food production, they did not feel the added activities involved in spat or mabé production were burdensome.

5.10 Broader social benefits

Spat collection and mabé production have contributed to social benefits in communities. Young people have opportunities to participate in an industry where they can see the possibility of making an income within their own community.

The activities of spat and mabé have productive roles for both young men and women, and young people are learning about and developing an appreciation of stewardship of the ocean (Dr Pranesh Kishore, Project Scientist, Fiji, pers. comm., 2017).

Research activities completed by young male and female Masters of Science students engaged through FIS/2014/060 and completed in villages have involved youth. These activities have sparked interest among some young people, enabling them to contribute in small ways as citizen scientists within the projects.

The women who participated in the interviews were proud of their achievements and were developing more confidence in their ability

to achieve their goals. Women reported being supported by men in their communities, and families were receiving some economic benefits from the pearl-related activities.

Professor Paul Southgate noted he had observed improved housing in communities involved in pearling activities in comparison to some of their neighbours, and commercial pearl farmers were

also providing employment opportunities and other forms of support such as school scholarships to students (Southgate 2008; pers. comm., 2017).

Namarai village had collectively decided that the village youth group would take charge of spat and mabé production.

Vignette 3: Namarai village, Rakiraki, Ba Province

The Namarai area of Rakiraki has a history of pearl farming dating back to 1997, when Japanese pearl farmer Mr Yasuharu Tokito set up a pearl farm, harvesting round pearls from black-lip oysters.

One woman and four men were employed from the village during that time, but Tokito Pearls often made donations to the community for specific projects. The farm was taken over by Atila Desci after Tokito Pearls moved to a new location. In 2012, the first deployment of spat collectors occurred in Namarai village as part of the ACIAR/PARDI project.

In 2016, the Namarai village area was significantly affected by Cyclone Winston, and is still undertaking recovery efforts. Before the cyclone, fisheries officers had been actively involved in extension in the areas of seaweed production, pearls and giant clams.

As a result of the cyclone most of the reef's marine resources were significantly damaged and fish and other food sources were depleted. Although damage was sustained to the reefs, pearls were seen as a hope for the future.

Although spat collection will not be income producing for some time, the spat collectors are attracting the fish back to the reef (Garry Bingnald, Fisheries Assistant, ACIAR Pearl Oyster Project; pers. comm., 2017).

Other sources of income have included cassava, kava, taro and fishing, but to access markets, produce must be transported by boat in town centres.

Researchers met with the resident Fisheries and Agriculture officer to the Province of Ba, and a young man from the Namarai village youth group. The village has a population of about 300 people.

As with most coastal iTaukei villages, there is a village development plan, with women's and youth groups undertaking specific projects in the community.

The village development committee decided that the youth group would take charge of the spat collection project. The youth group meet monthly, and report to the village committee. It has 30 members aged 16–30 years, and has been operating for about 5 years.

The group has equal numbers of male and female members. Members are involved in various projects, including weaving, gardening and spat collection.

A small group of about six young men have been trained in all aspects of spat collection, and a wider group have also participated in some training, but are not as involved.

Dr Kishore, ACIAR Project Scientist, delivered training to Ministry of Fisheries extension officers, including preparation of spat collectors, oyster drilling, tying and hanging chaplets, maintaining lines and harvesting black-lip oysters.

The girls in the group have mainly been involved in land-based activities, such as cleaning and harvesting, as they find it difficult to manage the heavy spat lines. Although not all engage in all spat collection activities, they all have had training and opportunities to gain experience in spat collection.

The youth group has already sold winged pearl oysters, receiving F\$400. It is not known how this money was dispersed or used.

5.10.1 Empowering women through pearl-related research

Table 31 assesses benefits of ACIAR pearl-related research projects in spat and mabé production against indicators of women’s empowerment across four domains. A simple ‘tick’ scale shows progress towards successful achievement of the indicators within each domain.

As with the mini-project assessment, three ticks indicate a strong performance against the indicator, two ticks indicate a moderate performance and a single tick indicate some achievement.

The most consistent achievements have been made in the area of capacity development for women, with training providing skills and knowledge to enable women to begin spat or mabé production in their communities. That this work can be done in close proximity to women’s current daily activities is important for women’s availability in terms of time and workload.

Some women’s groups are operating with a high level of autonomy and taking control of decision-making about production and income while others are less involved in decision-making, which occurs instead more collectively at the village level. There is also variation in the range of resources and income derived from pearl-related activities. In all areas, spat and mabé activities are yet to be fully realised.

5.11 Benefits of jewellery and shell handicrafts

In 2010, a value-chain analysis of the pearl industry and handicrafts sector in Fiji was conducted as part of ACIAR project PARDI/PRA/2010.01. A strategy was developed to increase the production of juvenile oysters from spat and mabé by village communities, and simultaneously develop a handicrafts centre that would buy mabé from village communities, and value add to produce high-end products for local and export markets.

A further pearl livelihood development project (FIS/2014/103) was introduced to maintain momentum in pearl shell handicraft enterprise development through:

- the provision of training for women in handicraft skills and tool use
- product design and production
- business skilling and enterprise development
- quality control
- marketing
- retail activities.

Table 31: Progress towards women’s empowerment among spat and mabé producers

Empowerment domain	Indicators	Success level
Capacity development: skills and knowledge	Training is available to women and girls in spat and mabé production	√√
	Women acquire new knowledge and technical skills in spat and/or mabé production	√√
	Women are able to apply skills and knowledge to practice independently	√
	Women gain increased confidence and recognition in their community	√√
Access and control of productive assets and income	Women have access to/ownership of resources/assets to engage in production	√
	Women derive income as a result of production	√
	Women have control over how to spend earned income	√
	Women buy new resources/assets from pearling activity income	√
Decision-making and leadership	Women are involved in decisions about production	√
	Women are involved in leadership in production	√
	Women are involved in leadership in community	√
Workload and time	Women’s work hours and conditions are manageable	√√

The objective was to test the market potential of locally made handicraft products that could compete against pearl shell imports.

Mr Theo Simos from the University of Adelaide organised and ran a series of mother-of-pearl training workshops for the Ba Women's Forum in the town of Ba, about 62 km from Nadi, Viti Levu.

The Ba Women's Forum is an umbrella organisation comprised of 79 women's groups engaged in a wide range of training and social activities. In conjunction with the Ba Town Council, the Ba Women's Forum became the location for the development of the handicraft centre, and for training in mother-of-pearl handicraft and jewellery production.

Significant investments in equipment were made, and nine women and one man received specialist training in jewellery and handicraft design and making. Subsequently, the Ba women marketed their product under the Marama Shell-Craft brand. Marketing has included a trial stocking opportunity with department stores.

Through FIS/2014/060 women learned more about customer needs, sales, operating in a competitive market, merchandising, product placement, point-of-sale promotion, pricing and trading margins.

Marama Shell-Craft established its own trading account in 2016, allowing for accounting of sales income and expenses, which can then be shared openly and in a transparent manner. The account is managed by the treasurer of the Ba Women's Forum, and overseen by the executive and USC. There are two signatories from the Ba Women's Forum and the New Zealand trainer engaged to work with the women. Women trainees do not have access to the account at this point in time.

Incentive payments were made to trainees for the calendar year 2015. These were based on 33% of gross sales achieved during the year. The women trainees determined this figure under their own constitution. The balance of 66% is made up of 33% banked as savings and 33% accumulated for ongoing sales and marketing expenses. The 33% incentive amount is paid at the end of the calendar year, and is calculated by the trainees based on workshop attendance. An additional incentive of 10% of sales is paid on all sales revenues facilitated directly by trainees.

Table 32 shows the annual income from the sales of handicraft products between 2015 and 2017. In accordance with the above distribution method, annual payments to individual women trainees varied from F\$189 to F\$772. Sales have been made through a variety of retail outlets, and directly from the Ba bure.

Table 32: Marama Shell-Craft income from sales

Year	Total sales	Payments to women trainees
2015	F\$1,180	F\$393
2016	F\$6,000	F\$1,972
2017	F\$,310	F\$2,436
Total		F\$4,801

5.11.2 Empowerment of women through research investments

Table 33 assesses benefits of ACIAR pearl-related handicraft investments against the domains and indicators of women's empowerment. A simple tick scale shows progress towards successful achievement of the indicator.

The most consistent benefits for women involved in the mother-of-pearl and mabé handicrafts projects are skills and capacity for shell handicrafts. Rather than feeling overburdened by the pressures of intermittent work, women indicated a desire to work more regularly, and to have access to their work environment at the Marama Craft Centre, independently from the visits of project staff.

Opportunities for women to be involved in decision-making are somewhat constrained by the structures of the Ba Women's Forum, as well as in their trainee status within the business model. Individual financial benefits derived from income are improving annually, but they are relatively small at the individual level. Opportunities are apparent for women to take a greater role in leadership and decision-making, as well as the overall management of the centre.

Vignette 4: Mareema Shell-Craft, Ba (Ba Women's Handicraft Centre), Ba Vita Levu

In 2017, five women were producing shell handicrafts 3 days a week at the Mareema Shell Craft Centre in Ba. Two Australian Scope Global volunteers worked with the women to investigate markets, assist with sales, and act as site managers, the latter fulfilling an essential role as women are unable to work at the centre without a site manager on location.

Site manager duties include administration and salaries, product packaging, pricing, finding sales channels and product sales; site managers also contribute to safety and security.

Mr Theo Simos explained that the previous lack of a site manager had presented considerable challenges and frustration for the day-to-day operations of the Craft Centre.

He currently maintains overall oversight of the initiative to continue to support the women in sales and in seeking markets for products.

Efforts to recruit a site manager from the Ba Women's Forum, or elsewhere in Fiji were unsuccessful, and it took 18 months to recruit the two Australian volunteers who are currently undertaking this role. Without a site manager, women were unable to access the Craft Centre, apart from those times when the ACIAR research team was in-country or when the two New Zealand trainers were available.

Team Leader Professor Southgate reports the successful recruitment of a site manager in late 2017 (Professor Paul Southgate, pers. comm., 2018). New Zealand trainers are funded to continue to travel to the Craft Centre for periods of up to 2 weeks, 5-6 times a year, to support the skill development of women in jewellery crafting. Local trainers are not available in Fiji with the capacity to produce high-end market quality products.

Although a relationship exists with retail outlets, further challenges persist in relation to ensuring a regular supply, and selling at the right price points for tourists. Most products currently made by the women are about F\$175.

Placement of product has been a challenge and it has not been easy to gain access to local resorts due to competition with other local women selling handicrafts. Mr Simos noted that, although Ba is a tourist destination, the location is some distance from other major tourist centres such as Suva or Nadi.

Women have no access to vehicles apart from public transport, affecting their ability to travel to sell their jewellery and other pearl products. Despite the challenges, women have been building their skills in developing unique Fiji mother-of-pearl products. The challenge remains for the women to become independent in their operations.

Three women trainees and two women Scope Global volunteers met with the impact assessment team to discuss their involvement in the centre, and some of the challenges they face.

Women explained the processes used to produce various shell and mabé jewellery products, explaining the time involved and how their learning had progressed with the trainers from New Zealand and Australia. They expressed great pride in displaying their work, and were enjoying the creativity involved in beginning to incorporate some of their own designs into their work.

They felt the work provided them with a rewarding activity outside the home and skills that few others had in the community. In 2017, the women had to fit all their activities into 3 days and, with only three or four trainees attending, the volume of work was high. Despite this they expressed a desire to work more regularly, rather than only when trainers or researchers were on site.

One woman who was responsible for shell grinding talked about the difficulty of working regularly with shell dust, despite the provision of ear muffs and dust masks. Another woman said that they wanted to earn their own income. She discussed some of the challenges associated with the administration of funds and payments to women, stating that they had only been paid once a year. Mr Simos indicated that the cyclone in the previous year had disrupted activities and payments to women in 2016.

The women hoped that new members would soon be recruited to the group. They felt they could take on some of the running of the Craft Centre, and become more involved in management. Mr Simos has supported two of the women in learning skills in market development, and the two Australian Scope Global volunteers will continue to assist with identifying markets. The challenge is for the group to move to independence.

Table 33: Progress towards women’s empowerment in pearl shell handicrafts

Empowerment domain	Indicators	Success level
Capacity development: skills and knowledge	Training is available to women and girls in handicraft production.	√√√
	Women acquire new knowledge and technical skills in handicraft production.	√√√
	Women are able to apply skills and knowledge to practice independently.	√
	Women gain increased confidence and recognition in their community.	√√√
Access and control of productive assets and income	Women have access to/ownership of resources/assets to engage in production.	√
	Women derive income as a result of production.	√√
	Women have control over how to spend earned income.	^a
	Women buy new resources/assets from handicraft income.	^a
Decision-making and leadership	Women are involved in decisions about production.	√√
	Women are involved in leadership in production.	√√
	Women are involved in leadership in community.	^a
Workload and time	Women’s work hours and conditions are manageable.	√√

^a Insufficient information was available to make an assessment of these indicators.

5.12 Lessons learned

ACIAR-funded pearl-related research projects in Fiji between 2008 and 2017 have resulted in discernible benefits to women involved in spat collection, mabé production and mother-of-pearl handicrafts.

These benefits have arisen within research projects whose initial focus was on the resolution of technical and scientific problems, and these research teams have not necessarily had funding or social science expertise to focus on social and gender issues.

Over time, ACIAR funded projects recognised the possibilities of supporting women’s groups within communities to participate in pearl-related activities. As a result, while women’s participation and economic gain might not have been an objective in early research, this became an objective in later projects: PRA/2013/01 *Explore the potential of mother-of-pearl handicraft and jewellery production for the creation of economic opportunity for women in Fijian coastal communities* and FIS/2014/060 *Expand pearl and mother-of-pearl handicraft production by community and women’s groups in PNG*.

5.12.1 Culture and gender

ACIAR research projects have been able to work within the existing cultural structures and gender relationships within communities (social roles, responsibilities, obligations and gender norms).

Training and extension activities were done in an inclusive manner so men, women, boys and girls had equal opportunities to learn and engage. This appears to have resulted in community-level acceptance and support for women’s involvement. Projects have not attempted to challenge existing gender relationships within communities, nor has research sought to overtly analyse the contributions of gender in projects that might contribute to development outcomes.

This assessment focused specifically on the benefits and impacts for women. Although some information has been gained from both men and women, it is not enough to ascertain how the experiences of men and women *differ* during participation in ACIAR funded pearl projects. As such, this assessment should not be seen as a comprehensive gender impact assessment.

To undertake more comprehensive gender and social impact assessments would require more time, and ideally be gender based on disaggregated data from baseline and monitoring activities within projects. Assessments might also take more time to understand individual women’s experiences and their empowerment needs.

5.12.1 Economic benefits

ACIAR research activities have created opportunities for small groups of women and young people in coastal communities to gain some income from their pearl-related activities.

When income has been sufficient, it has been used to continue to grow their pearl-related activities, to buy resources for the community, and to support individual women and families. The full economic benefits of these small enterprises are yet to be fully developed, but good progress continues to be made to build capacity and infrastructure that will contribute to sales income from pearl-related activities. A continuing challenge for researchers and participants will be to establish market opportunities for shell handicrafts and jewellery, as this is a critical component of the supply chain from spat producer to handicraft sellers.

In this assessment women's economic empowerment was understood as the ability to advance economically and to have the power to make and act on economic decisions.

The women who participated in this assessment demonstrated they were all engaged in economic activity, and had evolving skills and resources to compete in markets. They varied in their autonomy to make decisions and control over productive income and resources.

5.12.2 Skill development and knowledge

Women gained skills and knowledge in spat collection, mabé production and pearl shell handicrafts and jewellery making.

Staffing appears to be a potentially limiting factor in the provision of training in the first year of engagement. In the area of spat and mabé production training must be done in-situ within the community. This requires coordination of research teams and Ministry of Fisheries extension officers, travel to various locations and the gradual introduction of techniques over 5–6 visits over 12 months. Support and assistance in the deployment of spat collectors, and guidance in relation to monitoring, seeding and harvesting continues for a further 12–18 months as women develop confidence and the proficiency required for independent operation.

Ministry of Fisheries extension officers are critical to the ongoing maintenance of existing community operations, and for the introduction of spat and mabé production to new communities.

ACIAR researchers are providing training to Ministry of Fisheries officers to enable them to continue supporting communities beyond the life of projects. Currently, only male fisheries officers are involved in work with ACIAR research projects.

Future projects might consider supporting capacity development of women in fisheries, or greater linkages with organisations such as the Women in Fisheries Network.

Women handicraft makers continue to receive ongoing specialised training 5–6 times a year for intensive 2-week periods. This training has been delivered by specialist trainers from New Zealand due to a lack of expertise in Fiji.

At this point, five women are producing quality mother-of-pearl shell craft jewellery for sale, but are not yet at the stage of operating independently. The women have yet to develop the required skills and knowledge in business management and product marketing to take responsibility for the operations of the handicraft centre. This could be a priority area for the next phase of the project activities.

Given the lack of local trainers who have expertise in shell and jewellery making, consideration could also be given to developing the skills of existing women as trainers of others over the next phase of the project.

Two new communities and women's groups will be receiving similar specialised training in shell handicrafts production between 2018 and 2020. For long-term sustainability, women's groups will require not only skills in the production techniques of handicraft and jewellery making, but also knowledge in business operations, management and marketing. Currently, research teams and Ministry of Fisheries officers are acting as intermediaries between the producers of mabé and handicraft makers, but it might also be beneficial to develop direct relationships between producers and handicraft makers.

Women have a variety of interests in handicraft enterprises. Fewer women currently have an interest in business management, and this has presented a challenge for ACIAR researchers and a risk for long-term sustainability of their enterprises. A strategy might be to foster linkages to programs, networks or initiatives in Fiji that support business development for small and micro-businesses.

5.12.3 Resources and infrastructure

ACIAR research projects have provided communities with resources and infrastructure to undertake activities in spat collection, mabé production and pearl shell handicraft making. Although ACIAR research staff expressed the

view that boats are not essential for spat and mabé production, all communities identified the lack of safe and appropriate watercraft as an impediment to efficient activity.

Ministry of Fisheries representative Mr Garry Bingnald indicated that the Ministry of Fisheries was in a position to assist and advocate for communities to secure government grants or other support for boats.

While women state that they have adequate respiratory protection, some women in the Marama Craft Centre expressed concern about skin and clothing exposure to dust associated with shell grinding. This might be an issue worthy of further research in relation to workplace safety.

Key enablers include the extensive training provided through ACIAR pearl-related research projects. Relationships between ACIAR research projects and partners, such as Ministry of Fisheries and commercial pearl farmers, enable women and communities to develop strong relationships that foster sustainability over time.

The opportunities for women to work together organise within their communities and demonstrate their agency within economic activity builds their confidence and their standing within their communities.

5.13 Conclusions on women's impacts

The Fijian mabé and pearl industry has been identified as potentially highly profitable with economic and livelihood opportunities for local communities. The pearl-related activities of spat collection, mabé production and shell handicrafts have been supported through ACIAR mabé and pearl-related research investments since 2008.

These investments have provided women with an opportunity to develop their skills and knowledge in this area of aquaculture, enabling them to engage in economic activity to contribute to family and community livelihoods. Although the economic benefits of women's pearl-related activities are still at an early stage, the commitment and capacity of women to be productive in this area is clearly established.

Pathways to women's empowerment are diverse and contextual. For women to move towards empowerment, particular enablers and barriers might facilitate or hinder their journey.

The main barrier identified through this assessment involved the establishment of reliable, sustainable and growing markets for shell handicrafts.

6 Conclusions

This impact assessment has reviewed 40 mini-projects, used the review to select four case studies, and subjected the most prospective case study to a full impact assessment.

The full impact assessment has shown that even when the costs from linked project investments are considered, forecast returns are sufficient to provide an overall positive return on total research cost.

Total investment in impact assessment study projects of \$9.09 million (present value terms) has been estimated to produce gross benefits of A\$10.37 million (present value terms), providing a net present value of A\$1.28 million, and a benefit:cost ratio of 1.14:1 (over 30 years, using a 5% discount rate). Realisation of this return will depend on ongoing adoption of research outputs, and the development of a discerning market for mabé products.

In addition, the assessment of impacts on women involved in mabé production and the pearl industry in Fiji has shown that there are positive outcomes for capacity development, access and control of productive assets and income, decision-making and leadership. These gains in women's empowerment have been realised without an excessive burden on women's work hours and conditions.

Appendix: Women's impact assessment study design

Table 34: Women's impact assessment guide 1

Methods	Actors involved	Focal areas
Structured interviews	<ul style="list-style-type: none"> • ACIAR Project Leader Professor Paul Southgate (USC) • Postdoctoral Research Fellow Dr Pranesh Kinshore (USP/USC) • Mr Theo Simos (University of Adelaide) • ACIAR Country Officer Vinesh Prasad • Mr Garry Bingnald, Ministry of Fisheries officer • Provincial Fisheries Officer Namarai, Ba province • Claud Provost (CIVA Pearls) 	<ul style="list-style-type: none"> • Project outcomes • Project development and history • Participation • Partnerships • Challenges and benefits • Resources and income derived • Gender and social impacts • Lessons learned
Community group interviews	<ul style="list-style-type: none"> • Ravita—7 men, 5 women • Naturu—6 women, 2 men • (only 2 women involved in spat activities) • Ravi Ravi—12 women, 1 man • Namarai—1 male member of community youth group 	<ul style="list-style-type: none"> • Assessment against women's empowerment indicators • Social impacts
ACIAR document analysis	<ul style="list-style-type: none"> • MSO803 (FIS/2006/138) • FIS/2009/057 • PARDI/PRA/2010.01 • FIS/2014/103 • FIS/2014/060 	<ul style="list-style-type: none"> • Women's involvement in ACIAR linked pearl-related research investments • Gender and social impacts reported
Review of literature		<ul style="list-style-type: none"> • Gender and social impact assessment • Context analysis • Women in fisheries and gender

Impact dimension and indicators	Questions for researchers/industry/project personnel/partner agencies
Participation: <ul style="list-style-type: none"> - Demographics - Inclusion - Industry involvement 	<ul style="list-style-type: none"> • Role in the project. • Tell me about the project and who was involved. • Situation before mini-project. • Locations/village. • Number of community-based pearl enterprises, pre-ACIAR investment and current. • Connections to other projects/industry partners involved. • Number of women, young people and men engaged. • Ages. • Social/cultural groupings represented. • How were men and women involved? • How were participants selected? • Were there women who did not participate and why? • Number of women who started and dropped out. • Barriers that kept women from attending. • How were young people and men involved? • Time period.

Impact dimension and indicators	Questions for researchers/industry/project personnel/partner agencies
Project impacts:	<ul style="list-style-type: none"> • Describe main impacts of project overall. • Describe any impacts for women and men.
Production: <ul style="list-style-type: none"> – Input into productive decisions 	<ul style="list-style-type: none"> • Women’s involvement in activity before project. • New skills and knowledge gained about production. • Continued production after project. • Women and men’s role in production. • Women’s involvement in decision-making regarding production. • Who made decisions about activities (women/men/community/other)?
Resources: <ul style="list-style-type: none"> – Access to resources – Ownership and distribution of assets 	<ul style="list-style-type: none"> • How was this distributed in the family/community? • Who made decisions about production purchases? • Were women able to make money from involvement in the project? • Were they able to make decisions about the purchase of resources • Access to markets.
Income: <ul style="list-style-type: none"> – Control over the use of income 	<ul style="list-style-type: none"> • How much income per year per village and per family from activity? • Variations in income between men and women. • Did women have their own income? • How was extra income used (for example, health care, infrastructure, education, re-invest, discretionary)? • Where were there savings? • Did money have to be borrowed money? Where from? Was credit history established? • Changes any additional income earned has made to family life.
Family and community: <ul style="list-style-type: none"> – Gender roles – Leadership – Collaboration – Culture 	<ul style="list-style-type: none"> • Changes in women’s roles in family or community. • Leadership opportunities. • Skills and knowledge sharing with other women, working in groups. • How has it affected your family and community relationships? • Did it fit with family and cultural responsibilities? • Male reactions to the women’s success.
Time: <ul style="list-style-type: none"> – Workload 	<ul style="list-style-type: none"> • Compatibility with women’s existing responsibilities. • Hours committed to activities. • Did activities conflict with other income-generating activities? • Effect on patterns of work in family, division of labour.
Concluding considerations	<ul style="list-style-type: none"> • Implications for the design of future ACIAR projects. • Most significant change. • Unintended impacts positive or negative. • Life after project.

Table 35: Women’s impact assessment guide 2

Impact dimension and indicators	Questions for women leaders/participants
Participation: <ul style="list-style-type: none"> - Demographics - Inclusion - Industry involvement 	<ul style="list-style-type: none"> • Tell me about your involvement in spat/mabé production. • How were you involved? • How were men and youth involved? • Were there women who did not participate and why? • Were others involved? • Time period.
Project impacts	<ul style="list-style-type: none"> • What sort of effects/changes did this project bring to you individually, your family and your community? • What effects did it have on women and men?
Production: <ul style="list-style-type: none"> - Input into productive decisions 	<ul style="list-style-type: none"> • Did you gain any new skills and knowledge? • Describe the activities involved. • How does your community/women’s group make decisions about these activities?
Resources and income: <ul style="list-style-type: none"> - Access to resources - Ownership of assets 	<ul style="list-style-type: none"> • Were you able to make money from your involvement in the project? • How many harvests/sales did you complete? • Were you able to make decisions about how this money was spent? • How have you used the money you have made? • How has the money been distributed? • Have you been involved in saving and banking or borrowed money for your production? • Did the additional income earned make any further changes to family life?
Family and community: <ul style="list-style-type: none"> - Gender roles - Leadership - Collaboration - Culture - Time 	<ul style="list-style-type: none"> • How is your women’s group organised? • How have men reacted to women’s involvement? • How did the project affect your family and community? • Did you gain any leadership, organisation skills or opportunities? • Were there any skills and knowledge sharing with other women? Were you working in groups? • Did it fit with family and cultural responsibilities? • Did activities conflict with other income generation activities?
Concluding considerations	<ul style="list-style-type: none"> • Recommendation for future. • Unintended impacts positive or negative.

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Impact assessment series

No.	Author(s) and year of publication	Title	ACIAR project numbers
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6	Ryan J.G. 1998	Pigeonpea improvement	CS1/1982/001, CS1/1985/067
7	Centre for International Economics 1998	Reducing fish losses due to epizootic ulcerative syndrome—an ex ante evaluation	FIS/1991/030
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9	ACIL Consulting 1998	Sulfur test KCL-40 and growth of the Australian canola industry	PN/1983/028, PN/1988/004
10	AACM International 1998	Conservation tillage and controlled traffic	LWR2/1992/009
11	Chudleigh P. 1998	Postharvest R&D concerning tropical fruits	PHT/1983/056, PHT/1988/044
12	Waterhouse D., Dillon B. and Vincent D. 1999	Biological control of the banana skipper in Papua New Guinea	CS2/1988/002-C
13	Chudleigh P. 1999	Breeding and quality analysis of rapeseed	CS1/1984/069, CS1/1988/039
14	McLeod R., Isvilanonda S. and Wattanutchariya S. 1999	Improved drying of high moisture grains	PHT/1983/008, PHT/1986/008, PHT/1990/008
15	Chudleigh P. 1999	Use and management of grain protectants in China and Australia	PHT/1990/035
16	McLeod R. 2001	Control of footrot in small ruminants of Nepal	AS2/1991/017, AS2/1996/021
17	Tisdell C. and Wilson C. 2001	Breeding and feeding pigs in Australia and Vietnam	AS2/1994/023
18	Vincent D. and Quirke D. 2002	Controlling <i>Phalaris minor</i> in the Indian rice-wheat belt	CS1/1996/013
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20	Warner R. and Bauer M. 2002	<i>Mama Lus Frut</i> 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, 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

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23	McLeod R. 2003	Improved methods for the diagnosis and control of bluetongue in small ruminants in Asia and the epidemiology and control of bovine ephemeral fever in China	AS1/1984/055, AS2/1990/011, AS2/1993/001
24	Palis F.G., Sumalde Z.M. and Hossain M. 2004	Assessment of the rodent control projects in Vietnam funded by ACIAR and AusAID: adoption and impact	AS1/1998/036
25	Brennan J.P. and Quade K.J. 2004	Genetics of and breeding for rust resistance in wheat in India and Pakistan	CS1/1983/037, CS1/1988/014
26	Mullen J.D. 2004	Impact assessment of ACIAR-funded projects on grain-market reform in China	ADP/1997/021, ANREI/1992/028
27	van Bueren M. 2004	Acacia hybrids in Vietnam	FST/1986/030
28	Harris D. 2004	Water and nitrogen management in wheat-maize production on the North China Plain	LWR1/1996/164
29	Lindner R. 2004	Impact assessment of research on the biology and management of coconut crabs on Vanuatu	FIS/1983/081
30	van Bueren M. 2004	Eucalypt tree improvement in China	FST/1984/057, FST/1987/036, FST/1988/048, FST/1990/044, FST/1994/025, FST/1996/125, FST/1997/077
31	Pearce D. 2005	Review of ACIAR's research on agricultural policy	
32	Tingsong Jiang and Pearce D. 2005	Shelf-life extension of leafy vegetables –evaluating the impacts	PHT/1994/016
33	Vere D. 2005	Research into conservation tillage for dryland cropping in Australia and China	LWR2/1992/009, LWR2/1996/143
34	Pearce D. 2005	Identifying the sex pheromone of the sugarcane borer moth	CS2/1991/680
35	Raitzer D.A. and Lindner R. 2005	Review of the returns to ACIAR's bilateral R&D investments	
36	Lindner R. 2005	Impacts of mud crab hatchery technology in Vietnam	FIS/1992/017, FIS/1999/076
37	McLeod R. 2005	Management of fruit flies in the Pacific	CS2/1989/020, CS2/1994/003, CS2/1994/115, CS2/1996/225
38	ACIAR 2006	Future directions for ACIAR's animal health research	
39	Pearce D., Monck M., Chadwick K. and Corbishley J. 2006	Benefits to Australia from ACIAR-funded research	AS2/1990/028, AS2/1994/017, AS2/1994/018, AS2/1999/060, CS1/1990/012, CS1/1994/968, FST/1993/016, PHT/1990/051
40	Corbishley J. and Pearce D. 2006.	Zero tillage for weed control in India: the contribution to poverty alleviation	CS1/1996/013

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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 CABl products	
43	Harris D.N. 2006	Water management in public irrigation schemes in Vietnam	LWR1/1998/034, LWR2/1994/004
44	Gordon J. and Chadwick K. 2007	Impact assessment of capacity building and training: assessment framework and two case studies	CS1/1982/001, CS1/1985/067, LWR2/1994/004, LWR2/1998/034
45	Turnbull J.W. 2007	Development of sustainable forestry plantations in China: a review	
46	Monck M. and Pearce D. 2007	Mite pests of honey bees in the Asia-Pacific region	AS2/1990/028, AS2/1994/017, AS2/1994/018, AS2/1999/060
47	Fisher H. and Gordon J. 2007	Improved Australian tree species for Vietnam	FST/1993/118 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	Monck M. and Pearce D. 2007. Improved trade in mangoes from the Philippines, Thailand and Australia	CS1/1990/012, PHT/1990/051
51	Corbishley J. and Pearce D. 2007	Growing trees on salt-affected land	FST/1993/016
52	Fisher H. and Gordon J. 2008	Breeding and feeding pigs in Vietnam: assessment of capacity building and an update on impacts	AS2/1994/023
53	Monck M. and Pearce D. 2008	The impact of increasing efficiency and productivity of ruminants in India by the use of protected nutrient technology	AH/1997/115
54	Monck M. and Pearce D. 2008	Impact of improved management of white grubs in peanut-cropping systems in India	CS2/1994/050
55	Martin G. 2008	ACIAR fisheries projects in Indonesia: review and impact assessment	FIS/1997/022, FIS/1997/125, FIS/2000/061, FIS/2001/079, FIS/2002/074, FIS/2002/076, FIS/2005/169, FIS/2006/144
56	Lindher B. and McLeod P. 2008	A review and impact assessment of ACIAR's fruitfly research partnerships—1984–2007	CP/1997/079, CP/2001/027, CP/2002/086, CP/2007/002, CP/2007/187, CS2/1983/043, CS2/1989/019, CS2/1989/020, CS2/1994/003, CS2/1994/115, CS2/1996/225, CS2/1997/101, CS2/1998/005, CS2/2003/036, PHT/1990/051, PHT/1993/87, PHT/1994/133

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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	Chungco A., Dumayas E. and Mullen J. 2008	Two-stage grain drying in the Philippines	PHT/1983/008, PHT/1986/008, PHT/1990/008
60	Centre for International Economics 2009	ACIAR Database for Impact Assessments (ADIA): an outline of the database structure and a guide to its operation	
61	Fisher H. and Pearce D. 2009	Salinity reduction in tannery effluents in India and Australia	AS1/2001/005
62	Francisco S.R., Mangabat M.C., Mataia A.B., Acda M.A., Kagaoan C.V., Laguna J.P., Ramos M., Garabiag K.A., Paguia F.L. and Mullen J.D. 2009	Integrated management of insect pests of stored grain in the Philippines	PHT/1983/009, PHT/1983/011, PHT/1986/009, PHT/1990/009
63	Harding M., Tingsong Jiang and Pearce D. 2009	Analysis of ACIAR's returns on investment: appropriateness, efficiency and effectiveness	
64	Mullen J.D. 2010	Reform of domestic grain markets in China: a reassessment of the contribution of ACIAR-funded economic policy research	ADP/1997/021 and ANREI/1992/028
65	Martin G. 2010	ACIAR investment in research on forages in Indonesia	AS2/2000/103, AS2/2000/124, AS2/2001/125, LPS/2004/005, SMAR/2006/061, SMAR/2006/096
66	Harris D.N. 2010	Extending low-cost fish farming in Thailand: an ACIAR-World Vision collaborative program	PLIA/2000/165
67	Fisher H. 2010	The biology, socioeconomics and management of the barramundi fishery in Papua New Guinea's Western Province	FIS/1998/024
68	McClintock A. and Griffith G. 2010	Benefit-cost meta-analysis of investment in the International Agricultural Research Centres	
69	Pearce D. 2010	Lessons learned from past ACIAR impact assessments, adoption studies and experience	
70	Harris D.N. 2011	Extending low-chill fruit in northern Thailand: an ACIAR-World Vision collaborative project	PLIA/2000/165
71	Lindner R. 2011	The economic impact in Indonesia and Australia from ACIAR's investment in plantation forestry research, 1987-2009	FST/1986/013, FST/1990/043, FST/1993/118, FST/1995/110, FST/1995/124, FST/1996/182, FST/1997/035, FST/1998/096, FST/2000/122, FST/2000/123, FST/2003/048, FST/2004/058
72	Lindner R. 2011	Frameworks for assessing policy research and ACIAR's investment in policy-oriented projects in Indonesia	ADP/1994/049, ADP/2000/100, ADP/2000/126, AGB/2000/072, AGB/2004/028, ANREI/1990/038, ANREI/1993/023, ANREI/1993/705, EFS/1983/062, EFS/1988/022

No.	Author(s) and year of publication	Title	ACIAR project numbers
73	Fisher H. 2011	Forestry in Papua New Guinea: a review of ACIAR's program	FST/1994/033, FST/1995/123, FST/1998/118, FST/2002/010, FST/2004/050, FST/2004/055, FST/2004/061, FST/2006/048, FST/2006/088, FST/2006/120, FST/2007/078, FST/2009/012
74	Brennan J.P. and Malabayabas A. 2011	International Rice Research Institute's contribution to rice varietal yield improvement in South-East Asia	
75	Harris D.N. 2011	Extending rice crop yield improvements in Lao PDR: an ACIAR-World Vision collaborative project	CIM/1999/048, CSI/1995/100, PLIA/2000/165
76	Grewal B., Grunfeld H. and Sheehan P. 2011	The contribution of agricultural growth to poverty reduction	
77	Saunders C., Davis L. and Pearce D. 2012	Rice-wheat cropping systems in India and Australia, and development of the 'Happy Seeder'	LWR/2000/089, LWR/2006/132, CSE/2006/124
78	Carpenter D. and McGillivray M. 2012	A methodology for assessing the poverty-reducing impacts of Australia's international agricultural research	
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	ASI/1983/003, ASI/1995/040, ASI/1995/111, ASI/1996/096, ASI/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, LWR2/1996/215, LWR2/1997/038, SMCN/1999/003, SMCN/1999/004, SMCN/2000/173, SMCN/2001/028

No.	Author(s) and year of publication	Title	ACIAR project numbers
83	Pallis 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, ASI/1994/020, ASI/1996/079, ASI/1998/036, CARD 2000/024, PLIA/2000/165
84	Mayne J. and Stern E. 2013	Impact evaluation of natural resource management research programs: a broader view	
85	Jilani A., Pearce D. and Bailo F. 2013	ACIAR wheat and maize projects in Afghanistan	SMCN/2002/028, CIM/2004/002, CIM/2007/065
86	Lindner B., McLeod P. and Mullen J. 2013	Returns to ACIAR's investment in bilateral agricultural research	
87	Fisher H. 2014	Newcastle disease control in Africa	ASI/1995/040, ASI/1996/096
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