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Impact assessment of ACIAR's Aceh aquaculture rehabilitation projects

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Foreword

The Indian Ocean tsunami of 26 December 2004 caused enormous destruction, especially to the Aceh Province in northern Sumatra. In addition to tragic loss of life, which included thousands of fishers and fish farmers, it was estimated that over 200,000 people involved in coastal aquaculture were affected by the damage caused to tambaks (brackish water aquaculture ponds) and associated infrastructure. This damage affected the majority of shrimp hatcheries in Aceh, as well as research facilities.

In the immediate aftermath of the tsunami, the first response by local, Indonesian and global communities was to address critical humanitarian needs. The response then shifted to rebuilding livelihoods and communities. ACIAR was called upon, as part of the Australian Government's aid program, to contribute our unique capabilities to the rehabilitation of the aquaculture industry. Building on close links with Indonesian fisheries agencies, established through long-term research partnerships, Australian and Indonesian researchers initiated and supported projects to rebuild aquaculture in Aceh. In fact as stated in this report, the aim was to 'build back better'. The ACIAR contribution occurred alongside ongoing support of the Indonesian Government and other partner agencies.

This impact assessment focused on two projects supporting tambak redevelopment in Aceh. One project aimed to lift technical capacity of the Balai Perikanan Budidaya Air Payau (BPBAP) and the second worked in partnership with BPBAP to advance aquaculture rehabilitation. ACIAR teams undertook training of BPBAP to develop capacity and knowledge on rebuilding and improving the design of tambaks. The impact assessment highlighted the sustained benefits of developing individual and institutional capacity in the substantially changed social, economic and political settings of Aceh after the disaster.

A key finding of the assessment was that staff of BPBAP and related institutes improved their technical knowledge, leading to improved confidence and greater engagement by staff. The projects improved connectivity and communication between farmers, extension workers and entrepreneurs. Several case studies in the assessment demonstrated the success of resulting extension activities. Farmers had adopted superior management practices and more sustainable production systems, in turn increasing productivity and profitability. It was encouraging to learn that entrepreneurial local operators had encouraged other farmers to adopt new practices.

ACIAR's work in Aceh provides lessons for future natural disasters in partner countries. For example, working with a high-level institution, in a top-down approach, achieved sustainable benefits when funds from aid money were exhausted and responding non-government organisations left Aceh. While it was difficult to ascribe direct net benefits from these projects, the assessment highlighted the effectiveness of the ACIAR approach to providing redevelopment aid.

The projects studied in this impact assessment contributed to building capacity, knowledge, confidence and enthusiasm in the Aceh aquaculture industry. These are critical elements for the recovery of rural livelihoods and communities. These results underline the effectiveness of ACIAR's research partnership model, which alongside robust technical research aims to build capacity of individuals and institutions within our research and scale-out partner networks.

Andrew Campbell
Chief Executive Officer, ACIAR

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This report reviews the impacts and benefits of the contribution of the Australian Centre for International Agricultural Research (ACIAR) to the rehabilitation efforts in Aceh, following the Indian Ocean earthquake and tsunami on 26 December 2004.

Specifically, it comprises an impact assessment of two aquaculture-focused projects:

- FIS/2005/009 *(Technical capacity building and research support for the reconstruction of tsunami-affected, brackish water aquaculture ponds in Aceh)*
- FIS/2006/002 *(Aceh aquaculture rehabilitation project)*.

An estimated 16,000 fishers and fish farmers lost their lives to the Indian Ocean tsunami, and there was extensive damage to tambaks (brackish water aquaculture ponds) and infrastructure, including extensive damage to about 200 of the 297 shrimp hatcheries in Aceh—a socially, economically and environmentally important industry in Aceh. Some estimates put the total number of people affected by the damage to aquaculture at more than 200,000.

Two ACIAR-funded projects focused on providing support to tambak redevelopment activities in Aceh, with an emphasis on building technical capacity within the Balai Perikanan Budidaya Air Payau (BPBAP) in partnership with the Aceh Aquaculture Rehabilitation Project (AARP). Both projects ran from 2006 to 2010.

An impact assessment of the projects was carried out during 2016 and 2017, and involved interviews and surveys, as well as the collection of production and socioeconomic data to ascertain the extent to which project outputs were adopted. Surveys and interviews were conducted across the province with stakeholders involved in the projects, including farmers, extension workers, traders, government officials, project leaders and staff of the BPBAP.

The assessment was carried out more than 10 years after the start of the projects, which created some significant challenges. Many of those who had been involved in the projects had either moved on or struggled to remember details of these projects as distinct from many other projects and programs also implemented at that time.

The relief and recovery efforts in Aceh involved hundreds of agencies and institutions working in different and overlapping sectors. Further, the Aceh landscape had greatly changed over the years since the tsunami—politically, economically, demographically and physically. As a result, it was very difficult to directly attribute changes or benefits solely to the ACIAR investment. However, there was a substantial amount of information and evidence that showed the projects had direct and indirect benefits for Aceh. The projects built on previous ACIAR fisheries and aquaculture projects, applying technical knowledge and capacity building for disaster rehabilitation, to help 'build back better'.

The primary benefits were increased capacity and knowledge through training and education. The staff of BPBAP, local extension officers, local non-government organisations (NGOs) and farmer communities have been the main beneficiaries.

The projects resulted in:

- economic benefits—through better returns on investment from improved farming practices (such as diversified production, improved production, decreased losses)
- environmental benefits—from improved farm management, awareness of different soil profiles and changes to feeding regimes and water quality testing procedures
- social benefits—from improved knowledge and trade networks, greater employment opportunities and improved connectivity among BPBAP and others
- individual benefits—through improved knowledge, promotions, access to further education and increased linkages to networks
- institutional benefits—through increased capacity at BPBAP and up skilling of staff resulting in more engagement with industry and more positions available at BPBAP.

The assessment found that the BPBAP was successfully supported, capacity was built, and the organisation continued to grow, fulfilling an important role in Aceh aquaculture.

In addition, the assessment team heard from entrepreneurial individuals who definitively attribute the two reviewed projects as the reason for their success. The evidence suggests that if ACIAR was again to develop and run programs following a disaster, a similar focus on a higher-level institution and a top-down approach would be recommended.

Abbreviations

AARP	Aceh Aquaculture Rehabilitation Program
ACIAR	Australian Centre for International Agricultural Research
AusAID	Australian Agency for International Development
BMP	best management practice
BPBAP	Balai Perikanan Budidaya Air Payau (formerly referred to as the Regional Brackishwater Aquaculture Development Centre (RBADC))
FAO	United Nations Food and Agriculture Organization
NGO	non-government organisation
NPV	net present value
PCR	polymerase chain reaction

1 Introduction

This report reviews the impacts and benefits of the Australian Centre for International Agricultural Research (ACIAR)'s contribution to the rehabilitation efforts in Aceh following the 2004 Indian Ocean earthquake and tsunami.

Specifically, it comprises an impact assessment of two aquaculture-focused projects:

- FIS/2005/009 *Technical capacity building and research support for the reconstruction of tsunami-affected, brackish water aquaculture ponds in Aceh*
- FIS/2006/002 *Aceh aquaculture rehabilitation project.*

Project FIS/2005/009 was developed to meet an urgent need in post-tsunami Aceh, providing technical support to tambak (brackish water aquaculture pond) redevelopment activities in Aceh. The project ran from 2006 to 2010. It focused on building technical capacity in the Balai Perikanan Budidaya Air Payau (BPBAP), which is often referred to as the Regional Brackishwater Aquaculture Development Centre) in partnership with the Aceh Aquaculture Rehabilitation Project (AARP). The project also aimed to develop technical expertise in the Dinas Kelautan dan Perikanan (Local Department of Marine and Fisheries) to implement district-level technical extension teams, and provide direct technical support to NGOs and farmers involved in the reconstruction effort.

Project FIS/2006/002 was part of a A$4 million project under the Australia–Indonesia Partnership for Reconstruction and Development to support aquaculture rehabilitation in Aceh. The project focused on capacity building for the BPBAP, recognising the importance of the centre as a major provider of technical support services for aquaculture and development in Aceh. It also ran from 2006 to 2010.

ACIAR has provided about A$25 million in support for more than 45 fisheries research projects in Indonesia since the early 1990s, covering both management of wild stocks and aquaculture.

These two projects were different, in their focus on rehabilitation and building capacity after a devastating natural disaster. As a result, this review and impact assessment offers insights that might be valuable for any future ACIAR projects developed in response to a large-scale disaster.

The report is based on information provided by people who were involved with the projects, and people involved with the Ujung Batee BPBAP at the time of assessment more than 10 years later, and with Aceh aquaculture more generally. It briefly describes the origin of the projects, and the various risks and challenges encountered during their development and implementation. These issues set the context for the economic, environmental, institutional and social analysis that follows.

1.1 Background

The Indian Ocean tsunami on 26 December 2004 devastated the coastal areas of Aceh Province in the north of Sumatra. A World Bank report six months after the disaster summarised impacts in Aceh and the nearby island of Nias.

- At least 150,000 people died or were missing.
- About 127,000 houses were destroyed and a similar number damaged.
- More than 500,000 people were homeless.
- Two hospitals were destroyed, five others badly damaged and 26 primary health care centres were destroyed.
- A total of 1,488 schools were destroyed, and 150,000 children were left without education.
- About 230 km of roads and nine seaports were destroyed
- About 11,000 ha of land was damaged—2,900 ha permanently (World Bank 2005).

At the time, it was estimated the economy of the affected region would shrink by at least 14%, including US$1 billion in lost productivity.

1.2 Aquaculture in Aceh before the tsunami

Before the tsunami, aquaculture in Aceh was socially, economically and environmentally important, and a key part of the livelihoods of many of the coastal people. The tambak (brackish water pond) was the main farming system, producing mainly milkfish (*Chanos chanos*) and shrimp.

According to provincial government statistics in 2003, about 6,100 tonnes of milkfish were produced—the majority destined for local domestic food, but some as bait for tuna long lining—and an

estimated 10,300 tonnes of shrimp were harvested for export markets (via traders to Medan), as reported in Phillips and Budhiman (2005).

Dinas Kelautan dan Perikanan statistics estimated these had a farm-gate value at that time of about US$56.3 million. Of this, US$9.7 million was fish and US$46.5 million was crustaceans, with black tiger shrimp (*Penaeus monodon*) making up the biggest proportion (US$41.8 million). Indonesian Ministry of Marine Affairs and Fisheries and World Bank figures gave the fishery sector of Aceh a value of about Rp1.59 trillion (US$176.7 million) (Hutagalung 2005). These figures indicate that the overall value of brackish water aquaculture products was about one-third (32%) of the total fishery value of Aceh.

Aquaculture production in Aceh was also supported by small-scale private enterprises, including shrimp hatcheries, shrimp and fish nurseries and active trading networks that provided fish and shrimp seed, feed, fertiliser and other inputs required for farming.

Shrimp and milkfish farms were mainly traditional, low input and small scale (less than 2 ha). There were 14,859 brackish water farmers at the time (Dinas Kelautan dan Perikanan 2004), although many more people were involved, such as labourers, suppliers of inputs, traders and marketing and service providers. Given each hectare of tambak was estimated to provide direct employment to between one and three people, nearly 100,000 people were estimated to be directly employed in brackish water aquaculture (Phillips & Budhiman 2005).

1.3 Impacts of the tsunami on Aceh aquaculture

The tsunami on 26 December 2004 severely affected the coastal populations in Aceh. A report by Phillips and Budhiman (2005), completed within the first few months after the tsunami, outlined the damage to aquaculture, the likely economic impacts and the steps needed to rebuild and rehabilitate the fishing and aquaculture sector.

The most significant impact for the aquaculture sector from the tsunami, according to the report, was the substantial loss of life. Phillips and Budhiman (2005) estimated that more than 16,000 fishers and fish farmers lost their lives in the tsunami, which crippled the coastal aquaculture industry and households that depended on it for income.

There was also extensive physical destruction, including damage to tambaks and associated infrastructure (dykes, water gates, farmer huts and machinery). There was major damage to the coastal landscape—in some areas the aquaculture farms were completely altered, and many hectares of tambaks and canals were lost to the sea.

The assessment concluded that 20,000 ha of coastal tambaks (of an estimated 47,000 ha before the tsunami) were damaged, with about 9,000 ha of these severely damaged or lost. In addition, dueto about 800 km of irrigation canals being affected by debris and silt, another 5,000 ha of tambaks were unusable.

There was extensive damage to about 200 of the 297 shrimp hatcheries in Aceh. Many farmers also lost much of their crops of milkfish, shrimp and some marine fish. Information from the local government fisheries department (Dinas Kelautan dan Perikanan) confirmed that the fourth quarter was usually the most productive time of year, so farmers' losses close to harvest were significant.

The impacts rippled through the whole seafood value chain. Phillips and Budhiman (2005) estimated that at least 40,000 people directly employed in aquaculture were affected, with a further 50,000 affected in aquaculture-dependent households.

Some estimates put the total number of people affected at more than 200,000. As well as the tambak farmers, these included those working in public services, such as the district and provincial Dinas Kelautan dan Perikanan and the BPBAP, and private services, including suppliers, shrimp and fish collectors, feed businesses, traders and farmer associations.

1.4 Early response and challenges

Much of the immediate response (the relief phase) following the earthquake and tsunami targeted survival, health, food supply and repairing houses and local services. The longer-term rehabilitation work (the recovery phase) started to focus on rebuilding sustainable livelihoods, diversification of livelihoods and improving integrated coastal area management.

Phillips and Budhiman (2005) outlined assistance that was needed to resume livelihood activities in priority areas where short-term rehabilitation was possible. This included cash-for-work schemes,

dredging of water and drainage systems, support to provide inputs needed for tambak production (seed, fertiliser), support to restart hatchery production, and rebuilding essential support services, including capacity to deliver those support services.

They also noted that additional detailed assessment and planning was needed to develop medium and long-term activities for aquaculture rehabilitation, such as better environmental and coastal planning, and supporting implementation of better farming and management practices. They also highlighted as priorities rebuilding capacity at the institutional level, and putting a framework in place to encourage and assist farmers to follow better management practices.

Several organisations joined forces to coordinate efforts in the fisheries and aquaculture sector across the region. The Consortium to Restore Shattered Livelihoods in Tsunami-Devastated Nations brought together the Asia–Pacific Fishery Commission, the Bay of Bengal Programme, the UN Food and Agriculture Organization (FAO), the Network of Aquaculture Centres in Asia-Pacific, the Southeast Asian Fisheries Development Center and WorldFish.

The focus was on the issues of overcapacity, sustainability, the lack of technical expertise and the importance of getting rehabilitation right ('building back better').

The consortium's focus for the aquaculture sector was developing environmentally sound management practices, using appropriate technologies, good on-farm management practices and supporting farmer organisations.

The sheer scale of the disaster created some unique issues for livelihood rehabilitation, including:

- social issues, such as:
    - ensuring correct targeting of vulnerable beneficiaries
    - land ownership matters
    - providing options for people without access to productive or easily rehabilitated tambaks
- environmental issues, such as:
    - ensuring rehabilitation efforts included environmental sensitivity and long-term planning
    - ensuring proper design and carrying capacity, and keeping within the government-assigned green belts
    - proper integration into coastal planning
    - addressing design faults if possible to 'build back better'
- economic issues, such as:
    - investment costs being out of reach of many
    - globally low shrimp prices at the time
    - ensuring rehabilitated enterprises were sustainable
- physical issues, such as:
    - significant areas of severely damaged (or lost) tambak
    - short-term start-ups being impossible to develop due to severe damage
    - alternatives (for example, sea based nurseries) being in short supply
- supporting recovery through building capacity for self-help, such as:
    - the need to consult with community/local tambak farmer associations to plan and implement rehabilitation
    - determining where to start with the rebuilding of local institutions (Phillips & Budhiman 2005).

These issues were compounded by the lack of effective coordination at the district level, and by a program of cash for work. The latter provided payment for assisting in the rebuild, intending to help those who had no other sources of income at the time. But it created some unforeseen issues, as people started moving from their local area for paid work, some developed an expectation of payment regardless of whether a service was provided for free as part of a rehabilitation process and dependency upon aid became significant.

In July 2005, a workshop was held involving various NGOs, government agencies and institutions. Recommendations from the workshop included the need to:

- provide a mechanism for coordination and data collection
- ensure an ongoing resource assessment and management system to monitor overcapacity and management matters
- develop a mapping system
- build infrastructure (for example, BPBAP)
- develop institutional capacity (for example, training programs).

BPBAP staff played a key role in this workshop, and it was emphasised at the workshop that the BPBAP should provide the foundation for communication and coordination of aquaculture rehabilitation efforts (see Section 3 regarding the aquaculture rehabilitation coordination group).

1.5 ACIAR becomes involved

At the time of the Phillips and Budhiman (2005) report, FAO was seemingly already active (FAO had established an office in Aceh following the disaster) and had developed a project proposal to support the rehabilitation of the BPBAP.

This project covered many of the recommendations in the Phillips and Budhiman report, either directly or indirectly, and was expected to be key to rehabilitation of the aquaculture sector. However, the proposal did not progress in a timely manner, so the Australian Government was approached. (The BPBAP was largely independent before the tsunami, and because of the conflict in the region, linkages with central government were limited.)

The Australian Agency for International Development (AusAID) agreed to develop a project to support aquaculture rehabilitation in Aceh, with up to A$4 million of funding, under the Australia-Indonesia Partnership for Reconstruction and Development. Recognising ACIAR's experience in aquaculture in Indonesia, AusAID invited ACIAR to collaborate and carry out a feasibility/design study.

The study team visited Indonesia in 2005 to hold discussions with the main stakeholders, and develop a project outline. The key objective of the AusAID project (which included the two ACIAR projects) was to rehabilitate the BPBAP, and improve the quality of services provided by the centre, including:

- training of trainers' activities for BPBAP at Ujung Batee staff in how best to re-establish tambaks
- enhancing capacity to test for disease
- producing healthy seed for farmers
- disseminating relevant environmental aspects to other programs
- developing rehabilitation plans and guidelines for rebuilding tambaks.

ACIAR had already been active in the first half of 2005, developing small research activities in support of rehabilitation of the agriculture and fisheries industries in Aceh. Project FIS/2005/028 *Technical training and capacity-building program for the restoration of tsunami-impacted brackish water aquaculture ponds* began in April 2005, and provided technical training in soil assessment and tambak reconstruction methods to government fisheries staff, as well as technical support to pilot reconstruction trials. This project became the precursor to FIS/2005/009.

The ACIAR mission in early 2005 recommended the need for:

- soil assessment
- revision of extension materials, reskilling of government and NGO staff to provide technical support to farmers
- provision of research expertise to address current and emerging redevelopment issues in Aceh.

Informal review of the 1-year project FIS/2005/028 recommended continuing the training program under FIS/2005/009, with a focus on building a team who could provide technical training and extension support to, and with, other agencies and donor programs. FIS/2005/028 also identified hydrological and soil constraints on redevelopment that required further research.

The budget for the extended project (FIS/2005/009) was A$591,510, comprising A$448,365 from ACIAR and A$143,145 non-ACIAR funds.

The budget from the Australia–Indonesia Partnership for Reconstruction and Development for the AARP was about A$4 million. The AARP had two components:

- **Component 1:** Implemented by the Aceh Rehabilitation Program Infrastructure Component and managed by AusAID, this component covered the design and construction of the physical facilities of Ujung Batee BPBAP.
- **Component 2:** (FIS/2006/002): Implemented by James Cook University, Australia, in partnership with the Directorate General of Aquaculture, Ministry of Marine Affairs and Fisheries, Indonesia, this component was linked with capacity building to support BPBAP's mandated role to support aquaculture rehabilitation and development in Aceh.

The estimated cost to rebuild the BPBAP infrastructure was A$3.1 million, comprising A$2.5 million for buildings and infrastructure, A$450,000 for scientific equipment fit-out and A$100,000 for project monitoring and evaluation activities.

The inputs into Component 2 (FIS/2006/002) of the AARP largely consisted of technical advisers, training activities and funding for re-establishing polymerase chain reaction (PCR) testing of shrimp brood stock and seed, reestablishing BPBAP brood stock, and operational expenses associated directly with project activities.

An initial ACIAR budget of about A$950,000 plus A$15,000 non-ACIAR funds was provided for Component 2. This was followed up with two extensions to the project providing a further budget of about A$230,000.

The Directorate General of Aquaculture also responded to the urgent needs of the aquaculture industry in Aceh and Sumatra following the tsunami by increasing BPBAP's annual budget significantly to about Rp4 billion (approximately A$400,000) during 2006.

1.6 The Balai Perikanan Budidaya Air Payau

It was recognised and agreed by many at the time that the only organisation within Aceh that had the capacity to provide the necessary assistance was the BPBAP. Before the tsunami, the organisation's activities included:

- restocking of tiger shrimp, milkfish and mud crab juveniles
- supplying quality post-larvae tiger shrimp
- developing control and surveillance systems for wild shrimp brood stock collection
- developing a domestication program for tiger shrimp
- disseminating best management practices (BMPs) for shrimp and milkfish farming
- demonstrating responsible aquaculture activities
- providing training and education for shrimp and milkfish hatchery operators
- providing training for students and farmers
- surveying potential aquaculture areas
- monitoring distribution and incidence of shrimp viral diseases
- providing a PCR testing service for shrimp hatchery operators and grow-out farmers.

BPBAP facilities were lost or badly damaged by the tsunami, and many staff had died, so the BPBAP could not deliver the required services without first receiving significant support.

Dinas Kelautan dan Perikanan, at the provincial and district level, did not have the resources or the technical knowledge to help. As an example of capacity issues following the tsunami, an Australian review team noted in 2008 that many NGOs were not aware that the use of acid sulphate soils to build dykes for tambaks would result in acids leaching into the tambaks for many years, reducing water quality and stressing the fish and shrimp.

Several NGOs developed collaborative agreements with BPBAP to receive technical advice and support to their reconstruction programs, but there was a concern that BPBAP could not meet those commitments with their existing resources.

BPBAP had two key sites in Aceh, at Durung and Neuheun villages (about 1 km apart). Both sites were relatively small, but important for carrying out the BPBAP's objectives. The Neuheun site, which focused on the production of seed, was largely destroyed by the tsunami. The Japan International Cooperation System agreed to fund the reconstruction of the Neuheun infrastructure, but did not fund any capacity building or training activities.

As a result, the two ACIAR projects had emphasis on building technical capacity within the BPBAP, and developing technical expertise within the district Dinas Kelautan dan Perikanan to implement district-level technical extension teams, and to provide direct technical support to NGOs and farmers involved.

With the goal to re-establish coastal aquaculture as a key source of income and employment in Aceh, the two ACIAR projects were in line with recommendations by Phillips and Budhiman (2005), and consistent with the livelihood component of the AARP.

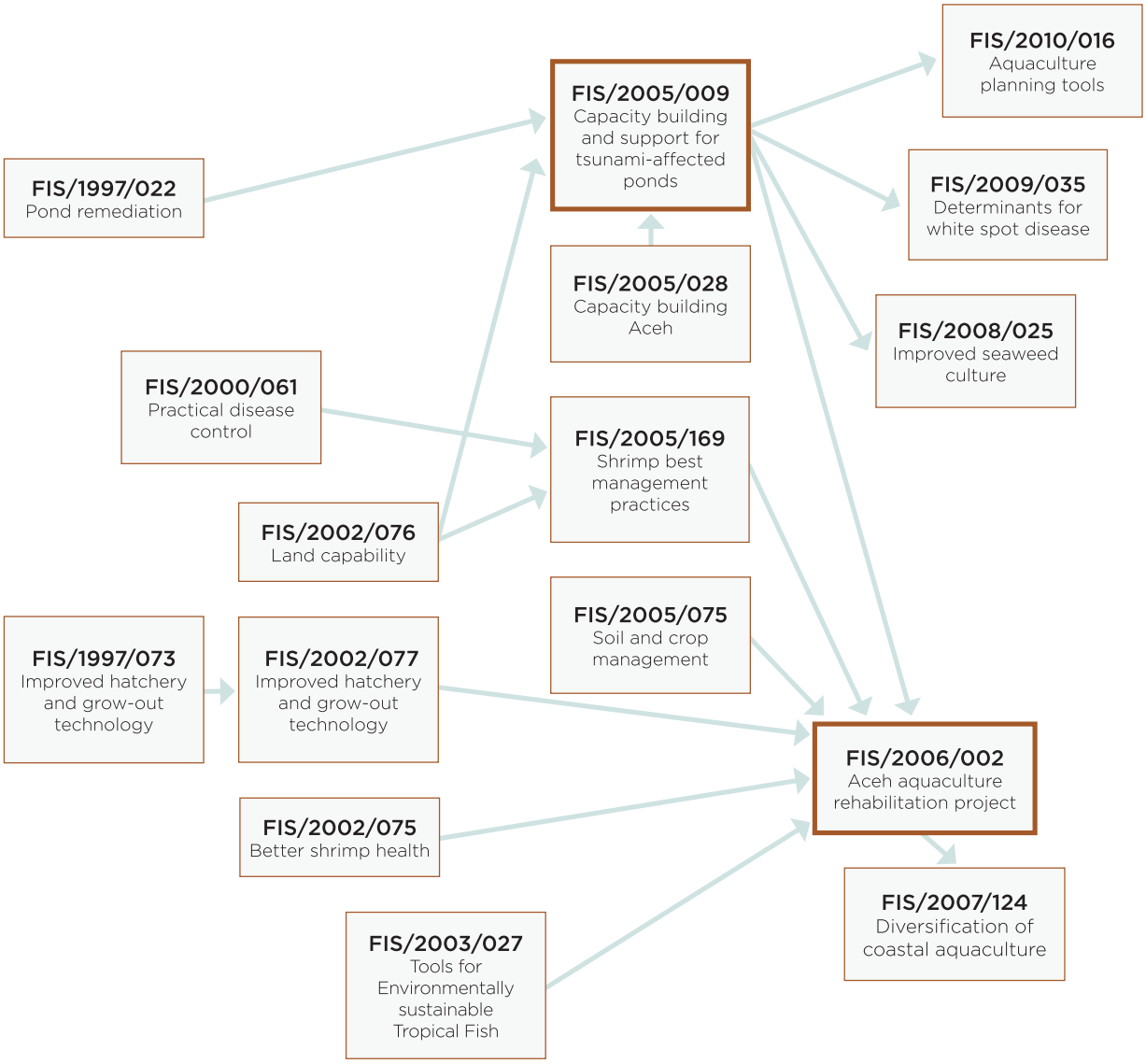

Figure 1: Linkages between FIS/2005/009 and FIS/2006/002 and other ACIAR fisheries projects

Project links

Links between the two projects and other ACIAR fisheries projects are illustrated in Figure 1. More details are available in the final reports of FIS/2005/009 and FIS/2006/002.

There were many external links with stakeholders, including government agencies, aid organisations, NGOs, farmers and farmer associations. The Indonesian Ministry of Marine Affairs and Fisheries was a key collaborating agency, providing staff at the BPBAP to undertake various activities of the project.

Dinas Kelautan dan Perikanan was also an important partner, providing extension services and technical support to the coastal aquaculture industry at provincial, district and subdistrict levels. Its staff were also involved in training programs to increase their capacity to provide these services.

Staff from various NGOs were also trained in appropriate techniques for re-establishing tambaks in Aceh, and implementing best practice for coastal aquaculture in Indonesia. Farmer groups and farmers were trained in BMPs for hatchery production and for shrimp and fish farming. More progressive farmer groups helped to develop demonstration sites that became valuable models for dissemination of BMPs.

The following are some of the key collaborating agencies:

- Asian Development Bank Earthquake and Tsunami Emergency Support Program—supported the rehabilitation of fisheries in Aceh, including subcomponents on community mobilisation, rehabilitation of aquaculture and value-chain infrastructure (such as tambaks, cages, hatcheries), environmental rehabilitation and capacity building with private/public services.
- Aquaculture without Frontiers—helped to rehabilitate tambaks, water supply canals, and hatcheries, and provided farmer training.
- AusAID—implemented Component 1 of AARP and provided AusAID scholarships.
- FAO—provided support and strengthening of government coordination and planning capacity; developed and implemented improved management practices for coastal fisheries; rehabilitated and developed sustainable aquaculture; improved product quality and efficiency in the fish postharvest and marketing sector.
- French Red Cross—disseminated information from the projects.
- German Technical Cooperation—disseminated information from the projects.
- International Finance Corporation—strengthened the climate for business in Aceh; provided sustainable access to finance for local businesses; supported the development of productive economic sectors; and built the capacity of the Bureau for Reconstruction and Rehabilitation for Aceh and Nias to coordinate business and economic growth.
- Japan International Cooperation Agency—helped rebuild Neuheun site.
- Network of Aquaculture Centres in Asia-Pacific—implemented the initial coordination and rehabilitation programs.
- United Nations Development Programme—implemented a major cash-for-work program, and activities in rural coastal areas of the north-east.
- World Wide Fund for Nature—introduced BMPs for shrimp farming.
- World Bank—disseminated information from the projects.

1.7 Project outputs

1.7.1 FIS/2006/002—Aceh aquaculture rehabilitation project

FIS/2006/002, Component 2 of the AARP, focused on capacity building for the BPBAP. The project ran from 2006 to 2010. Appendix 1 provides the overarching goal, purpose and the three key outputs of this project, with their indicators, means of verification and a brief outline of the results reported.

Component 1 of the AARP focused on the physical rehabilitation of the Durung site at the BPBAP, including both a design and construction component. Construction delays not only slowed activities of the centre, but also delayed Component 2, project FIS/2006/002, as the laboratories were needed to achieve the outcomes of the project.

Cook & Nuryartono (2008) noted in their review that the relevance of the project suffered due to delays in the construction of the centre and start of hatchery operations. But project FIS/2006/002 still achieved many of its planned outputs, including enabling some additional diversification activities.

The BPBAP kept records of:

- the number of PCR tests completed
- the number of hatcheries and farmers providing samples for testing
- production of priority species
- the number of hatcheries buying seed.

The figures up to 2010 are provided in the project final report. In addition, a list of training activities carried out by the BPBAP is summarised in Table 1.

Training included:

- better management practices for shrimp farming
- soil assessment and remediation
- diversification and polyculture
- extension and dissemination techniques.

Table 1: Training provided and number of people trained by BPBAP in conjunction with the projects

Topic of training	Number	Date
Better management practices for shrimp farming		
Training of trainers—BMPs	24	5–7 Feb 2007
District training—BMPs	150	8–16 Feb 2007
Training of trainers—BMPs for shrimp farming	10	15–20 Apr 2007
Farmer training—seed acclimation and stocking	8	18 Mar 2008
Farmer training—water quality, feed and shrimp health management	21	16 Jul 2008
Farmer training—tambak preparation	10	28 Aug 2008
Farmer training—seed selection and stocking	4	20 Sep 2008
Identification of plankton in tambaks	1	5–16 May 2008
Subtotal (February 2007–May 2008)	*228*	
Soils assessment and remediation (training provided by ACIAR project FIS/2005/009)		
Soil and environmental assessment for tambak reconstruction and management	16	17–18 Nov 2006
District training—soil and environmental assessment for tambak reconstruction and management	124	23 Feb–2 Mar 2007
Tambak soil remediation	20	21–22 Aug 2007
Soil analysis	10	18–23 Oct 2008
Laboratory analysis of soils	4	24 Oct–11 Nov 2008
Practical training— BMPs in soil analysis at demonstration tambaks	3	10–13 Feb 2009
Tambak soil remediation	20	21–22 Aug 2007
Soil analysis	10	18–23 Oct2008
Laboratory analysis of soils	4	24 Oct–11 Nov 2008
Practical training—BMPs in soil analysis at demonstration tambaks	3	10–13 Feb 2009
Geographic information systems	10	4–18 Jul 2009
Subtotal (November 2006–July 2009)	*224*	
Diversification and polyculture		
Shrimp and Gracilaria culture—new trends for a changing world (cooperation with AquaFish Collaborative Research Support Programs (CRSP) and Aquaculture without Frontiers)	62	29 Apr–2 May 2008
Technical workshop on alternative farming systems for brackish water pond (provided by ACIAR project FIS/2005/009)	22	12–16 May 2008
Cage aquaculture decision support software (provided by ACIAR project FIS/2003/027)	21	4 Aug 2008
Nursing of grouper and tilapia with acclimation of tilapia to brackish water	20	5–6 Nov 2008
Farm-made feeds for marine finfish culture	89	20–24 Nov 2009
Culture of soft-shell crabs (cooperation with AquaFish Collaborative Research Support Programs (CRSP) and Aquaculture without Frontiers)	59	21–23 Jul 2009
Subtotal (April 2008–July 2009)	*273*	

Topic of training	Number	Date
Extension and dissemination techniques		
Basic extension methods	20	11–13 Jul 2007
Extension techniques for aquaculture in Aceh—extension materials and presentations	18	10–18 Dec 2007
Extension skills training—extension materials and workshops	20	8–17 Ap 2008
Farmer feedback on extension materials	25	14–15 Apr 2008
Extension skills training (follow-up)	12	16–20 Jun 2008
Subtotal (July 2007–June 2008)	*95*	

Personnel who received the training were from a multitude of agencies and people on the ground, including:

- BPBAP
- Indonesian Ministry of Marine Affairs and Fisheries
- the Regional Development Planning Board
- the Bureau for Reconstruction and Rehabilitation for Aceh and Nias
- the Asian Development Bank
- Sekolah Usaha Perikanan Menengah (SUPM) Ladong
- International Finance Corporation
- vocational schools
- the World Wide Fund for Nature
- local farmers
- field facilitators
- hatchery staff.

The project also provided support for the development of demonstration ponds, provided 'hands-on' training experience in BMPs, and enabled on-site research into alternatives commodities other than shrimp. This approach to diversification, and the flexibility shown in the project appears to be a significant catalyst for the changes that occurred in both practices and the commodities farmed (see sections 2.2.4 and 2.4.1).

1.7.2 FIS/2005/009—Technical capacity building and research support for the reconstruction of tsunami-affected, brackish water aquaculture ponds in Aceh

This project focused on providing technical support to tambak redevelopment activities in Aceh. It had emphasis on building technical capacity within the BPBAP, in partnership with the AARP, and developing technical expertise within Dinas Kelautan dan Perikanan to implement district-level technical extension teams, and provide direct technical support to NGOs and farmers involved in the reconstruction effort. Appendix 2 provides the objectives, activities, outputs and some comments on this project.

The technical capacity-building component focused on building the skills of staff at the BPBAP, Dinas Kelautan dan Perikanan and NGOs. Skills included:

- soil sampling design and methods
- field and laboratory analyses of soil and water samples
- calculation of lime and fertiliser dosages based on soil data
- tambak soil remediation
- tambak management
- aquaculture engineering, with a focus on tambak, dyke and canal design

- hydrological measurements and data analysis
  - surveying
  - application of geographic information systems (GIS) and remote sensing to aquaculture planning and land capability assessment
  - soil and land capability mapping
  - acid sulphate soil remediation.

The project produced technical notes and revised extension materials from FIS/1997/022, and contributed to FAO publications. The research support component of the project generated:

- acid sulphate soil probability map of Aceh
- soil texture maps of selected rehabilitation areas
- soil mapping models for GIS-based mapping
- improved methods of image analysis from remote sensing data
- chemical and physical descriptions of local soil types
- PondTool software
- tambak engineering recommendations for local soil types
- hydrological models for local conditions.

It was reported (during both informal and formal interviews) that these outputs were used by government agencies and NGOs to plan redevelopment, and select appropriate soil remediation and management strategies.

Trained government staff and extension officers employed by NGOs applied their skills in the farming communities. Extension teams, guided and supported by this project and the AARP, provided technical support to farmers and rehabilitation projects from Banda Aceh across to Lhokseumawe. However, once the rehabilitation work was completed in Aceh in 2009 and 2010, the maps and images developed at the time were no longer used in Ujung Batee BPBAPor the relevant Dinas. Little explanation was provided, but it is possible that there was little further need, as a much smaller number of new tambaks were being built.

2 Impact assessment of the Aceh aquaculture rehabilitation projects

The impact assessment process involved interviews and surveys alongside the collection of production and socioeconomic data to ascertain the extent to which project outputs were adopted.

Surveys and interviews were conducted across the province with stakeholders involved in the projects. These included farmers, extension workers, traders, government officials, project leaders and staff of Ujung Batee BPBAP. Several case studies are also provided as examples of project impacts and benefits on individuals and flow-on effects.

The impact assessment of ACIAR projects FIS/2005/009 and FIS/2006/002 was carried out during 2016 and 2017. It was more than 10 years since the start of the projects, and this time lag created some significant challenges. Many of those who had been involved had either moved on, or struggled to remember details of these projects as distinct from the many other projects and programs being implemented at the time.

The relief and recovery efforts in Aceh involved hundreds of agencies and institutions working in different and overlapping sectors. Further, the Aceh landscape has greatly changed over the years since the tsunami—politically, economically, demographically and physically. As a result of all of these factors, it is very difficult to directly attribute changes or benefits solely to ACIAR investment. But the assessment found that the BPBAP was successfully supported, capacity was built, and the organisation has continued to grow, fulfilling an important role in Aceh aquaculture and across Indonesia.

In addition, the assessment team heard from individuals who definitively attribute the two reviewed projects as the reason for their success. The evidence suggests that if ACIAR were again to develop and run programs following a disaster, a similar focus on a higher-level institute and a top-down approach would be recommended.

2.1 Methods

The first impact assessment visit to Aceh Province took place on 18–24 August 2016. The team visited Ujung Batee BPBAP to discuss the two projects with staff, including Mr Coco Kokarkin Soetrisno, Directorate General of Aquaculture at the Indonesian Ministry of Marine Affairs and Fisheries (who was the Director of BPBAP during the latter stage of the project), and Mr Hasanuddin, a key member of staff both during the projects and currently.

One day was spent interviewing BPBAP staff about their involvement in the projects, their work both at the time and subsequently, and the skills that they developed. A semi-structured questionnaire was used for the initial interviews.

Field visits were also undertaken to locations involved in both projects and to areas involved in subsequent and related ACIAR projects. In the field, discussions were held with entrepreneurs, farmers, feed processors and distributors, cooperative directors, NGOs involved in the aquaculture sector at the time of the projects, extension officers, nursery operators and local government.

A preliminary cost–benefit study was conducted in the field, with participants (fish farmers and extension officers) assessing the costs and benefits of fish farming in 2005 (right after tsunami) and 10 years later in 2015–16. Net income (profit) was computed using a financial net present value approach, while gross income was computed using an economic present value approach, as follows:

$$NPV = \sum_{t=0}^{n} \frac{(benefit - costs)_t}{(1+r)^t}$$

where
NPV = net present value
r = discount rate
t = year
n = analytic horizon (in years)

As well as face-to-face interviews, questionnaires were sent to participants of training courses under the two projects who had since left Ujung Batee BPBAP. The aim was to understand the skills developed and to get their perception about benefits from the training. But given the time that had passed, it was difficult to locate individuals, and, when located, it was often difficult for them to remember what direct benefits could be attributed to their particular training. For this reason, results are presented as more general descriptions based on an overview of findings.

During a second visit to Aceh in late February 2017, a more structured questionnaire was developed (Appendixes 3–5), and interviews were done from May to June 2017 by BPBAP staff (Table 2). Respondents were fish farmers, field extension workers and traders (fish and shrimp).

Primary data collected from the respondents aimed to estimate and evaluate the benefits to stakeholders of the ACIAR projects. The farmer respondents were those involved directly with the ACIAR projects. Cost–benefit analyses were carried out for the farmer ventures—profit growth was computed by comparing profits in 2006–2010 and 2017. Flow-on effects were also assessed with respect to social and environmental benefits and technology transfer.

Extension workers interviewed worked at the Marine and Fisheries Service Office (four people) and the Agriculture, Fisheries, and Forestry Extension Institute in Bireuen regency (five people), with time in their jobs ranging from 7 to 22 years. Thirteen traders were interviewed, from Aceh Utara and Bireuen Regencies. Their average age was 42 years, ranging from 27 to 49.

Table 2: Respondents interviewed, Aceh Province, 2017

Respondents	Regency	Number of persons
Farmers	Bireuen	82
	Aceh Utara	132
	Subtotal	*214*
Extension workers	Bireuen	9
	Subtotal	*9*
Traders	Aceh Utara	10
	Bireuen	3
	Subtotal	*13*
	Total	**227**

2.2 Challenges affecting project impacts

Challenges came to light during the course of the projects, during the intervening years, or during the impact assessment. They might have affected outcomes and impacts of the projects, so are described here, ahead of the section on project benefits.

2.2.1 Technical challenges

Coastal aquaculture is a risky business at the best of times, and requires careful management. Best management practices were emphasised during the rehabilitation process in Aceh, across all components of the production cycle. This included ensuring that:

- Shrimp brood stock was free of specific pathogens (especially white spot syndrome virus)
- farmers used healthy or specific-pathogen-free seed stock
- problem soils were avoided in tambak re-establishment
- water quality was monitored regularly
- appropriate nutrition regimes were in place throughout the grow-out process.

However, disease was a problem in the early rehabilitation of aquaculture tambak. This was at least partly due to that fact that many agencies were involved, most with limited knowledge of aquaculture. An estimated 500 agencies were operating in Aceh at the peak of the rehabilitation period, and many acknowledged that they did not have the technical ability for tambak rehabilitation. Many were attempting to address diverse aspects of human health, reconstruction, food, water and livelihoods, but might have been overambitious in terms of the skills available within the teams.

2.2.2 Limited capacity

Household-level shrimp producers in Indonesia often have limited capabilities, from the perspective of livelihood capital and the type of value chain that can be accessed (Sari 2015). They have low human capital, a lack of social networks, limited access to formal banking and a lack of technology. All of these affect their ability to comply with the food safety, eco-label certification and traceability needed to access high-value markets.

2.2.3 Risk-averse farmers

Small-scale farmers are often risk averse, sometimes suspicious of new ways of working, and hesitant to provide (or limited by) capital to change. Usually it is necessary to demonstrate new practices and how they will lead to better financial outcomes. Further, farmers often revert to previous ways if they do not see results immediately. The demonstration sites aimed to address these issues, but the final report of the AARP outlined that they had not worked as hoped, although there was a positive outcome when sites focused attention on species other than shrimp.

2.2.4 Other interventions

Sari (2015) reported that global aquaculture production grew by 13,011% from 1950 to 2011, from 638,577 to 83,090,736 tonnes. In Indonesia, significant external interventions from government and NGOs were necessary to improve the capabilities and returns of household-scale shrimp producers.

At the time of the tsunami, black tiger shrimp (*Penaeus monodon*) accounted for the greatest production (volume). Since then vannamei shrimp (*Litopenaeus vannamei*) has more than doubled in production—likely due to fast growth rates and tolerance of disease, high stocking rates and a range of salinities (Briggs et al. 2005). Production volume for vannamei shrimp is now higher than black tiger shrimp, which has remained stable. While the main focus of the two projects was rehabilitating BPBAP and up skilling the staff, and therefore, as much as possible, independent of the commodities being farmed, the change in commodities could affect the economic benefits of aquaculture projects (not just the two under review) following the tsunami.

The AARP projects, especially FIS/2006/002, found that shrimp was not as good as initially assumed in terms of production and profit. The Indonesian Government was focused on shrimp production by small aquaculture producers, and wanted to see the shrimp harvests continue (Indonesian Government Ministerial Decree number KEP.41/MEN/2001 includes vannamei as a priority species; Sari 2015), but the returns for shrimp failed to live up to expectations.

Consequently, smallholders moved into other commodities. Tilapia culture in brackish water ponds was found to be of equivalent or better profitability, particularly during the wet season, so some farmers alternated between shrimp in the dry season and tilapia in the wet—allowing year-round production, and good use of water.

The cash-for-work program created unforeseen issues. Some of the survivors moved to find work, rather than remaining in their original locations and rebuilding their lives (Ruhe 2017). Also, expectations were raised towards receiving some form of payment, regardless of whether a project was delivering a service for free.

Project leaders and BPBAP staff said some farmers were looking for cash payments to come and pick up material that they were getting for free. Wijaya and Sammut (2015) also noted the negative impact of the significant amount of aid, creating dependency on external funding and support. This also incited tensions where aid was perceived to be unevenly distributed. These issues had the unintended outcome of driving communities formerly involved in brackish water aquaculture away from this sector.

2.2.5 Coordination and reporting

With the sheer volume of aid and ambitious deadlines for rehabilitation, coordination was a major challenge. There were overlapping efforts and also mis-targeted projects that were not well planned or implemented (Wijaya & Sammut 2015). This created additional complexities that might have affected the outcomes of the aquaculture projects.

Rimmer et al. (2012) noted that although the impacts of the earthquake and tsunami on lives and infrastructure in Aceh and the responses are well documented, the rehabilitation effort on coastal fish farming livelihoods is less so.

This is at least partly because of the many agencies that were involved, and the broad and spatially oriented approach many of them took to coastal rehabilitation. Many agencies worked across the sectors within a defined area, but few focused directly on aquaculture. The agencies also mostly reported to their own headquarters rather than to coordinating bodies such as the Bureau for Reconstruction and Rehabilitation for Aceh and Nias (coordinated by the Government of Indonesia), so it was difficult to know exactly who was doing what.

However, an aquaculture rehabilitation coordination group was set up, which at the time of the two ACIAR projects planned to meet monthly at the BPBAP (Rimmer et al. 2012). The purpose was to exchange information, provide technical assistance to those who needed it, coordinate requests for assistance and standardise technical information provided to farmers and others. This group was referred to several times during interviews and discussions for this report, and it seems to have been a mechanism for the provision of information and the distribution of good management practices.

2.3 Knowledge management and dissemination

The Aceh Aquaculture Communications Centre was established at the BPBAP with support from the Asian Development Bank's Earthquake and Tsunami Emergency Support Project. The aim of the centre was to ensure that the implementation of BMPs continued. It produced a monthly newsletter that was distributed through local agencies, including provincial government fisheries departments.

Through groups and individuals trained under the ACIAR projects, farmers were trained and supported to use BMPs. From 2007 to 2010, one group trained and disseminated the information through pamphlets, CDs and radio programs (by topic, with call-in abilities for farmers). This group was initially supported under the International Finance Corporation, but worked in collaboration with FAO, the Network of Aquaculture Centres in Asia-Pacific, WorldFish and the Asian Development Bank (those agencies working closely with Ujung Batee BPBAP).

They also socialised BMPs directly and via broadcast videos. This particular group started with 45 farmers in 2007, but by the end of their funding they had 15 field facilitators who had distributed information to more than 5,000 farmers, and were working consistently with about 2,650 farmers. As an example of their success, in 2008 a group of farmers sent two tonnes of shrimp to Japan.

It was reported by the organisers that by 2010, about 80% of the farmers this group had been working with were farming in a manner consistent with the best management practices, but by 2011 (when all rehabilitation funding stopped), it was reported be in the order of only 30%–40%—although how this was estimated is uncertain given the comments from farmers during interviews.

Following this, in 2011 the Aquaculture Livelihood Service Centre was established with similar personnel (trained under the ACIAR programs), though it never ran particularly well. By 2012, those still involved in Aceh aquaculture programs, including those involved in the ACIAR projects and those who had received training, formed the Aceh Aquaculture Cooperative.

Of the original 15 staff, four re-joined the program and, at the time of interviews, they had 350 farmer members. They were hopeful they would have 1,000 members in the cooperative by the beginning of 2018. To date, there has been no government support, and this cooperative has been in part developed because of the work from the AARP, with additional support provided by WorldFish in 2015–16.

2.4 Benefits from the projects

A substantial amount of information and evidence supports the fact that the projects had direct and indirect benefits for Aceh. Discussions with BPBAP staff, local NGOs, provincial fisheries officials, extension workers and farmers indicated that the two projects were well received, and that there were benefits, especially in terms of improved practices over the projects' duration.

The projects built on previous fisheries and aquaculture ACIAR projects, applying technical knowledge and capacity building for disaster rehabilitation, to help 'build back better'.

The primary benefits from these projects are increased capacity and knowledge through training and education. The staff of BPBAP Ujung Batee, local extension officers, local NGOs and farmer communities have been the main beneficiaries.

Figure 2 shows pathways from project outputs to outcomes and impacts. Impacts, or benefits, are grouped into five categories, and discussed in more detail in Section 2.4. The categories are:

- economic benefits—through better returns on investment from improved farming practices (such as diversified production, improved production, decreased losses)
- environmental benefits—from improved farm management, awareness of differing soil profiles and changes to feeding regime and water quality testing procedures
- social benefits—from improved knowledge and trade networks, greater employment opportunities and improved connectivity among BPBAP and others
- individual benefits—through improved knowledge, promotions, access to further education and increased linkages to networks
- institutional benefits—through increased capacity at BPBAP and up skilling of staff resulting in more engagement with industry and more positions made available at BPBAP.

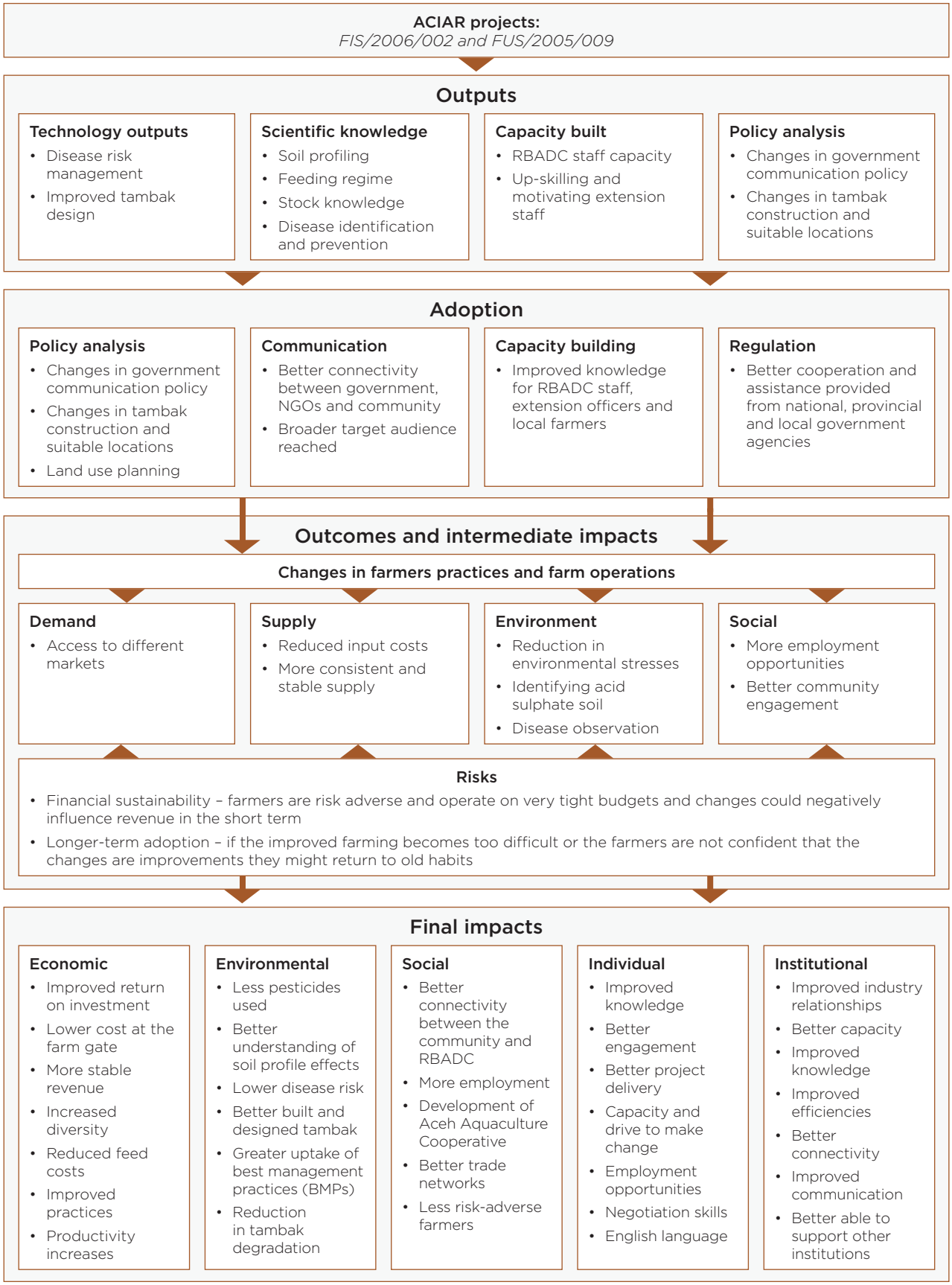

Figure 2: Pathways to benefits from ACIAR's Aceh aquaculture rehabilitation projects

2.4.1 Economic benefits

A significant economic benefit from the projects resulted from the assistance provided to support the shift to farming tilapia instead of shrimp, as it was found to be equally or more profitable than shrimp in 'traditional' brackish water farming systems.

Project FIS/2006/002 appears to have facilitated this shift to some extent, as researchers were informed that the BPBAP were fundamental to the change. During the wet season the salinity drop in the tambaks makes them more suitable for tilapia, and alternating shrimp in the dry season and tilapia in the wet has good benefits, including year-round production from the tambaks. Increasing the diversity of species farmed also helped to limit disease outbreak.

A review in 2015 under project FIS/2007/124 (the follow-on project from FIS/2006/002) reported 80%–90% of farmers across three districts were involved in the polyculture of shrimp and tilapia. The farmers noted that tilapia grew faster than shrimp, fetched a better price and had less disease. Staff from BPBAP also noted that alternating tilapia with shrimp culture in brackish water tambaks improved tambak soil quality, benefiting the local environment.

The goal of the AARP was to help re-establish coastal aquaculture as a key source of income and employment in Aceh. Before the tsunami, the annual value of farm-gate aquaculture production for Aceh Province was about US$56 million. However, not surprisingly, production values in Aceh dropped 40% in 2005 from the previous year. They increased again in 2006 to values near to those seen before the tsunami, although they did not exceed them until 2009, with an additional jump in production values again in 2010 (Figure 3).

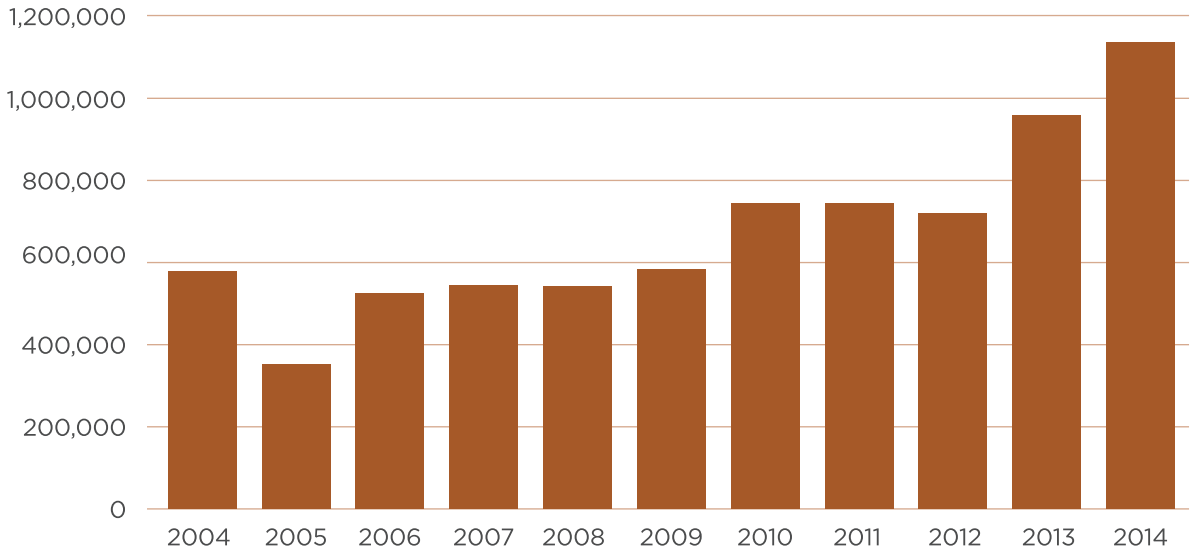

Figure 3: Value (IDR millions) of brackish water tambak aquaculture in Aceh, by year, 2004–2014
Source: Aceh Dinas Kelautan dan Perikanan yearly statistics.

Separating the figures into fish and crustaceans shows a decline in value for fish in both 2005 and 2006, followed by growth from 2007 to 2014, with a slight fall in 2012 (Figure 4). Shrimp production showed a recovery in 2006 to previous values, only to decline again through to 2009. This is consistent with what was reported as occurring at the time—that is, a move towards tilapia and a general decline in the focus on shrimp through to 2010 (Figure 5), due to concerns surrounding disease and profitability (BPBAP staff pers. comm., August 2016).

Given project FIS/2006/002's prudent change in the last years towards promoting tilapia and new fish species (such as grouper), there is an indication that even if the BPBAP was not responsible for this increased production in different fish commodities, it was at least able to support village production desires or demands and the changes that followed after the project was completed.

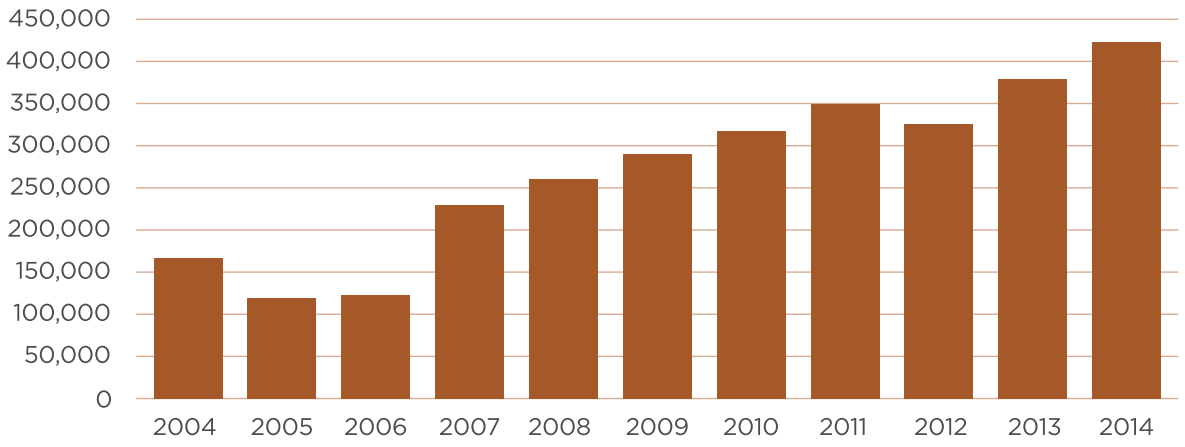

Figure 4: Value (IDR millions) of brackish water tambak fish aquaculture in Aceh, by year, 2004–2014
Source: Aceh Dinas Kelautan dan Perikanan yearly statistics.

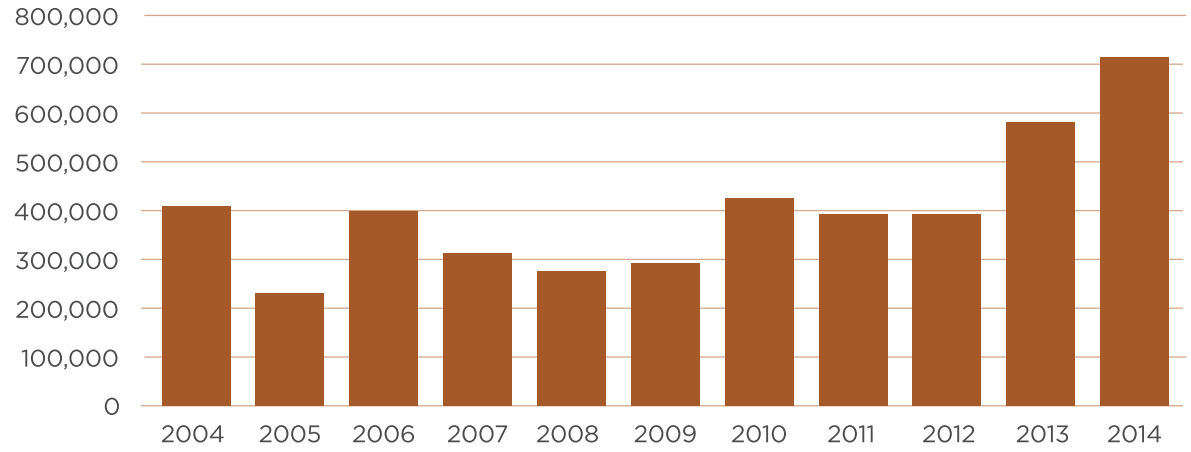

Figure 5: Value (IDR millions) of brackish water tambak crustacean aquaculture in Aceh, by year, 2004–2014
Source: Aceh Dinas Kelautan dan Perikanan yearly statistics.

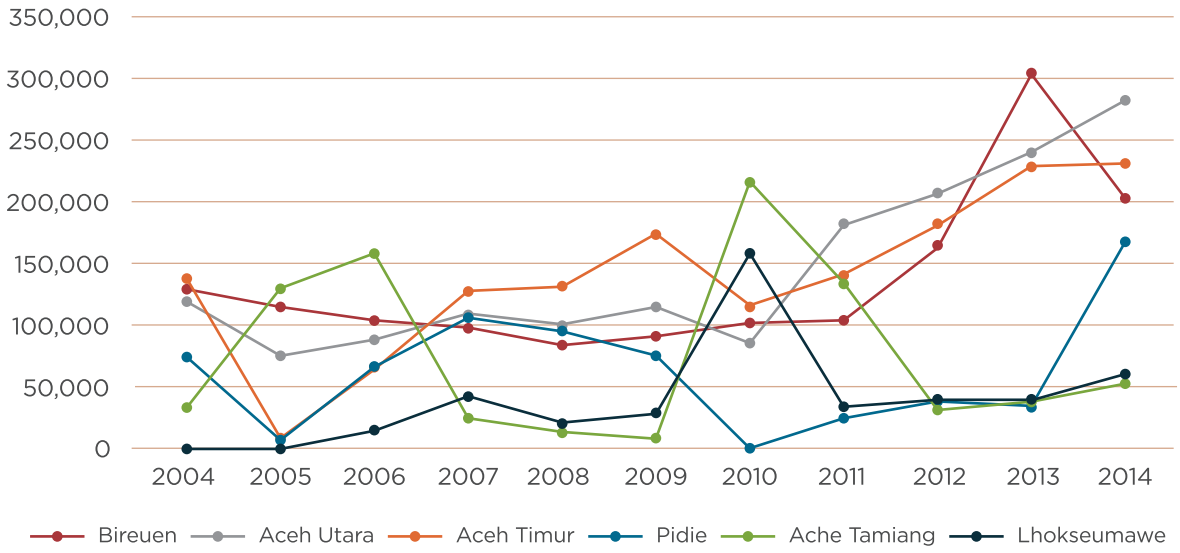

Figure 6: Value (IDR millions) of brackish water tambak aquaculture in Aceh, by kabupaten, 2004–2014
Source: Aceh Dinas Kelautan dan Perikanan yearly statistics.

The kabupaten (regencies) with the highest production values before the tsunami—those located along the coastal areas in the north-east—show clear declines in production and value in 2005.

The kabupatens of Aceh Utara, Aceh Timur and Pidie were affected greatly by the tsunami, with about 76% of all tambak damage occurring in these locations. Inevitably, production values declined for these areas in 2005, taking one or two years to return to previous values (Figure 6).

The information from the surveys confirmed much of the above, with 17% of farmers saying that they stopped producing shrimp for 6 months following the tsunami. Those interviewed reported that about 75% of their assets were damaged. Shrimp was the most common product, with about 88% of farmers reporting it was their major commodity between 2006 and 2010. But researchers were informed that this has declined marginally, with about 70% currently producing shrimp, and a larger proportion now producing milkfish.

It is not surprising that many of the farmers reported higher current production compared with immediately after the tsunami (2005). Farmers from one district reported their production of fish had increased, and cost–benefit analysis suggests that their profit had increased about 31.5% per year (Appendix 6).

According to the farmers, issues surrounding fish production had not altered significantly, with fish disease being the major problem, but they reported there was a significant decline since the tsunami and since technical guidance was provided between 2006 and 2010.

In the original AARP documentation outlining the project, it was suggested that it would take at least three years from the beginning of the project before tambak production would reach pre-tsunami levels. It was estimated that at the lower end of possibilities the project could generate low or negative internal rates of return, but it would be reasonable to assume internal rates of return of more than 12%. At the time, this was considered a benchmark for financial viability.

It was also considered that the introduction of BMPs, disease testing, new species and improved tambak construction could each increase the value of tambak production by at least 5% per year. And it was emphasised that there was no alternative institution to BPBAP to promote such improved practices.

Appendixes 6–8 show substantial increases in estimated profits from 2005 through the years of the project of about 44% per year, with increases up to 2017, on average, of about 31% per year.

The introduction of BMPs, disease testing, better feeding regimes and improved tambak construction through the AARP projects could have played a part in these profit increases, although the rise in the price per kilogram is also a significant factor since 2010.

Through the interviews and surveys, researchers were informed that the improved farming practices provided by the BPBAP (and therefore the ACIAR projects) led to lower disease occurrence and a reduction in mortality. This improvement was reportedly due to better water quality, improved feeding regimes and possibly also the reduction in pesticide and chemical use.

The most noticeable and easiest change farmers made after being provided information about BMPs in 2007 was to use less feed. Before training, farmers would supply about 3 kg of feed for 1 kg of product; after the training, the feed ratio was reportedly reduced to 1:1. Not only did this reduce feed costs, but it also reportedly reduced mortality from about 40% to less than 30%, which in turn improved farmers' return on investment.

Traders reported collecting fish and shrimp from villages in the district and/or the surrounding districts. They sold shrimp to local markets, and other areas such as Bireuen, Lhokseumawe and Banda Aceh. Some shrimp was also marketed to Medan in North Sumatra Province. Several traders bought and sold shrimp for one month only (September), while the others varied their activities from four months to year round. Most of the shrimp marketed was *Litopenaeus vannamei*, ranging in size from 25 to 30 shrimp per kilogram.

The traders informed researchers that the shrimp was placed inside an icebox for transportation to the market. Motorbikes were used for transporting lower shrimp volumes and for shorter distances, and cars were used for larger volumes and longer distances.

Depending on the size of the shrimp, traders reported buying them from farmers at prices ranging from Rp16,000 to Rp150,000 per kilogram (Rp91,000 per kilogram on average). Their selling price ranged from Rp20,000 to Rp155,000 per kilogram (Rp95,000 per kilogram on average), giving an average margin of about 5%.

The traders reported that the marketing channel was relatively simple, with farmers selling to collecting traders who would sell on to the markets, either inside or outside the area. Some traders said they had received knowledge from local extension workers about best practices of storing shrimp. Some noted that they often faced constraints such as a lack of capital, limited storage box ownership, and narrow marketing margins. They said they used their profits for education, clothes and house improvements.

The majority of traders reported that after the tsunami they did not purchase or sell fish for about seven months. But during 2006–2010, traders reported they could purchase and sell up to seven tonnes per week per cycle. And according to them, the most profitable period for fish sales has been after 2010. This cannot be attributed to altered practices or increased production resulting from the ACIAR projects, as there was no hard evidence and there was also a change in market price (which could be caused by either demand surpassing supply or production of a better-quality product). But there were comments in the survey responses suggesting that training by the projects had played a role in their increased profits after 2010.

2.4.2 Environmental benefits

The tsunami caused some direct and significant environmental damage. For example, a study by the Tsunami and Disaster Mitigation Research Center in 2012 found that mangrove forests were completely destroyed in some villages that relied on fishing and aquaculture (Nazamuddin et al. 2012).

A key environmental benefit from the ACIAR projects is likely to have been the raising of awareness on the environmental aspects relating to tambak reconstruction and production recovery among the many agencies working to recover livelihoods. Early attempts to re-establish tambaks in Aceh without technical support led to crop failures due to soil acidity and disease. As the projects were implemented, and through collaboration with other agencies, these environmental aspects were more widely recognised and addressed.

Before the projects began, it was suggested to researchers that stakeholders had very little knowledge of environmental constraints or corrective actions. Those interviewed said that there is now widespread understanding of acid soils, sandy soils, tambak engineering requirements, the need for water quality management and site requirements. In addition, agencies such as the Aceh Aquaculture Cooperative have reportedly improved their extension materials by incorporating information on soil assessment and management, and have also applied the technologies to their demonstration sites and community programs.

Soil assessment activities and mapping within the projects identified significant environmental risks associated with sandy and acid soils. This has led to the BPBAP providing better information on soil profiles and improved farming practices, and has helped avoid further development in high-risk areas.

The identification and management of problematic soils potentially minimises further acidification of the coastal lowlands and reduces the erosion and sedimentation problems associated with sandy soils.

To explore whether there were any environmentally beneficial changes in farmer practices following the two projects, researchers examined the relevant answers in the questionnaires, finding that:

- one-quarter (25%) of farmers who had participated in the training from BPBAP Ujung Batee said they now planted additional mangroves around their tambaks (this differs from responses by Dinas Kelautan dan Perikanan staff, who thought the figure was a lot higher at 77.78%)
- about two-thirds (65%) of the farmers now followed a more concerted soil management program in their tambaks
- more than half (57%) of the farmers said that they now use lime, in what they consider appropriate dosages, when preparing their tambaks to increase water alkalinity and stimulate plankton growth
- nearly three-quarters (70%) of the farmers reported using filters in their tambaks to both preserve the water quality and exclude wild fish, with 65% of them now changing the water regularly
- just under half of the farmers responded that since the training, they had ceased to use pesticides, which is significant, as it has been noted on several occasions that farmers often return to past practices, especially if messages from training, cooperatives or agencies are not continued
- many of the farmers are leaving the tambak dry for a 15–20-day period after harvesting rather than using chemicals like chlorine to kill pests. The loss of production time has increased their costs, but their production has increased and the reduction of chemical costs have offset this. This means reduced impacts on the surrounding environment through reduced pollution, disease and degradation of the tambaks.

2.4.3 Social benefits

A social benefit related to AARP activities and the ACIAR-funded work was increased employment over the duration of the projects. The physical rebuilding of BPBAP provided employment opportunities, and the staff numbers grew throughout the life of the two projects (up to 88 employees in 2010).

The target beneficiaries of the projects were ultimately small-scale, brackish water aquaculture farmers, who are often vulnerable to risk and crop losses. The projects appear to have boosted income through better knowledge on management practices, improved information sharing and increased support to diversify production techniques and commodities. The support provided by BPBAP Ujung Batee to small-scale enterprises including hatcheries and nurseries, farming communities and trading networks appears to have also improved since the projects.

However, given the number of programs and projects working in the area during this period, it is extremely difficult to attribute any direct social benefits specifically to the ACIAR-funded work.

Traditionally, fish farms are run by the males in the household, with income often supplemented by the women (through earnings from public service, trading local goods or poultry farming, for example) (Fachry 2008).

Women might have a role in tambak farming, but this is usually limited to feeding and harvesting in family-owned tambaks, particularly with milkfish. This is similar to other areas of Asia, where women take only a limited role in brackish water aquaculture (although women are often more involved in freshwater aquaculture).

While this report did not examine gender-related issues, the main social benefits observed (that is, employment, improved trade networks and particularly improved farmer profits) could be surmised as providing benefits to all members of the household. But this would need further study to be confirmed.

It was noted that women had a reasonable level of representation at BPBAP Ujung Batee. Although only about 20% of staff were female, several women were in senior positions. The engagement of women at the centre depends on the women having studied relevant fields at tertiary institutions, so depends on their access to this level of education.

It was reported that women were heavily involved in agricultural extension in Aceh, although this might be a result of the low wages, which are insufficient for a male head of the household to support his family (at about Rp250,000 or A$36 per month).

Traditional and subsistence farmers tend to be risk adverse, as there are substantial implications from crop failure. But the demonstration tambaks developed in the AARP went some way to address this through the extension of best management practices and the provision of alternative practices (and species). Researchers were informed by BPBAP staff that this encouraged some of the farmers to step outside their comfort zone and try something that they previously would not have attempted.

2.4.4 Individual benefits

It was difficult to quantify individual benefits (but see Section 2.5 for descriptions of some examples). The project final reports did not quantify outcomes, other than reporting the number of participants in each workshop or training session and noting they 'significantly' improved their skills. Self-assessments, expert opinions or reviewer ratings were provided, but not how the individual capacity development translated into benefits, and this was difficult to examine given the time passed.

The local government agencies were usually responsible for choosing course participants, rather than the project, and this was a potential constraint noted by both project leaders. It was also difficult to establish a baseline level of competency, because this varied among the participants. But knowledge and benefits gained by individuals who attended the training that were consistently reported were:

- better negotiation skills and how to be more successful when promoting an idea, such as how to explain an idea in detail, providing reasons for the idea, objectives and benefits
- improved species culturing knowledge—without the training, farmers would not have considered culturing tilapia, which are easier to farm, have a more consistent value and are easier to market with a greater demand
- improved farming practices, which resulted in better feeding regimes, less pesticide used and better disease identification and management
- quicker timeframes for learning new skills as opposed to the time it would take to learn without assistance
- stronger theoretical understanding behind their practical knowledge, enabling them to explain methods in a much clearer way
- knowledge, networking and encouragement that gave participants the confidence and enthusiasm to work towards improving the aquaculture industry in Aceh.

Individuals acquiring these skills would also contribute to institutional capacity building and economic growth (Gordon & Chadwick 2007).

Since the two projects ended, there has been considerable staff movement, both within the BPBAP and Dinas Kelautan dan Perikanan. This cannot be attributed to the projects specifically, but researchers were informed by BPBAP senior staff that at least nine staff members who received training as part of the projects received promotions or were provided with the opportunity to take higher level education, including within Australia.

In addition to the potential benefits provided to staff, and from the questionnaires, farmers reported that they had improved their understanding on various aquaculture issues. For example, they noted improved awareness on monitoring fish disease. It was also reported that Dinas Kelautan dan Perikanan staff have also now introduced sampling methods to monitor fish disease, which it was implied was the result of the training provided during the projects.

Farmers also noted that before technical guidance was provided, some needed to earn additional income as handymen, entrepreneurs, salesmen or factory workers, with only about half reporting that they were actually fish farmers. But during the time the projects were in operation, and as the BPBAP expanded, some of those interviewed noted they began activities more related to tambak aquaculture and their farming operations, including provision of fish seed, tambak rehabilitation and provision of vitamins and waterquality testing services.

Fish farmers and traders also reported they now have a good understanding of postharvest handling, which was provided through guidance or counselling from Dinas Kelautan dan Perikanan staff focused on storage, management, communication and sales training.

2.4.5 Institutional benefits

The benefits to institutions and improvements to institutional capacity in Aceh were imperative for the long-term recovery and sustainability of the Aceh aquaculture sector. The institutional benefits are not just the physical repair, but the building of staff capacity, industry relationships, professional scientific collaboration and improved diplomatic relationships. The latter was exemplified by the BPBAP being officially opened by the then Prime Minister of Australia, The Hon. Kevin Rudd, and the Governor of Nanggroe Aceh Darussalam, Dr Irwandi Yusuf, mid way through 2008.

As noted in the final project reports and repeatedly emphasised during the interviews, benefits from rebuilding capacity at BPBAP Ujung Batee include:

- improved laboratory capabilities
- improved knowledge of pathology, water environments, hatchery and brood stock development
- and milkfish, grouper and barramundi support.

Before the tsunami, there were poor ties between BPBAP and the community, industry and government, mostly due to a lack of community/industry trust and the difficulties associated with operating in Aceh.

This has been much improved since then, at least partly due to the projects. The projects have led to better linkages between BPBAP and other relevant centres around the country—for example, the Dinas Kelautan dan Perikanan extension services are using the BPBAP facilities for some of their industry engagement work.

Links also improved with the Indonesian Ministry of Marine Affairs and Fisheries. The Government of Indonesia recognised the contribution that BPBAP was making in supporting the post-tsunami reconstruction effort, and through the Directorate General of Aquaculture made a significant commitment of additional staff and budget resources to help rebuild the capacity of the BPBAP. This resulted in staff numbers more than doubling at BPBAP (staff numbers have now increased to more than 80).

By 2012, the BPBAP annual reports started to note the technological improvements the centre was making, including some direct institutional benefits resulting from the projects such as:

- improved efficiency of the BPBAP and more services being providing, including provision of seedlings in 2009 onwards (for example, PCR tests increased from 104 per year to 230 per year during the lifetime of the FIS/2006/002 project, with more than 400 as reported in 2016)
- greater levels of communication, coordination and support to improve the capacity of individuals, groups and institutes, some of which are highlighted in the case studies section of this report (and also include the greater use of social media, presence at conferences and seminars, and Dinas Kelautan dan Perikanan and extension staff and Indonesian Ministry of Marine Affairs and Fisheries centres located in other provinces) including a greater number of reports of improved performance between 2008 to 2016
- staff attendance at more official events (91 in 2008 up to more than 320 in 2015) and an increased number of peer reviewed scientific publications
- greater capacity with greater numbers of BPBAP staff (staff were increased to 88 employees by the end of the project, which has been maintained up until 2017) who are able to provide services to industry (and to extension officers operating in the field)
- additional technical knowledge and the ability to diversify (such as comprehensive laboratory services and a greater diversity of species)
- more effective ways to disseminate information (for example, the Aceh Aquaculture Communications Centre and greater confidence among the staff) and an increased number of research participants utilising the laboratory (157 researchers in 2008 up to 345 in 2016).

2.5 Case studies—direct benefits from ACIAR investment

2.5.1 Mr Ibnu Sahidir, Ujung Batee BPBAP staff

Mr Ibnu Sahidir, a staff member of BPBAP Ujung Batee, received training under the projects, and has since developed an important role in the Aceh aquaculture industry.

The ACIAR projects provided him with enthusiasm, networking and knowledge, and opened the door to many opportunities. Since the training he has provided significant support and assistance to numerous farmers, improving their farming practices.

He has also developed and introduced better feed technology (such as floating feed and farmer-produced probiotics), better feeding regimes and changes to species stocking rates, and has worked on improving water quality for farmers—all of which he says are a direct result of the capacity building he received from the two ACIAR projects.

These changes in farming practices have substantially improved the products, reduced feed costs and resulted in greater returns on investments for the associated farmers.

For example, Mr Sahidir introduced his improved feed technology to catfish farmers. Usually farmers buy probiotics from feed companies, but Mr Sahidir provided the necessary technical information to the farmers so that they could produce the probiotics themselves. Through social media such as WhatsApp, Blogspot, Facebook and various websites, including his own web page (<www.sahidhir.com/p/tentang-saya.html>), he has widely disseminated the probiotic-making process, and how to feed it to fish.

Researchers tried to assess the economic impact of sharing this technology. There are now at least 11 social media groups on fish farming and applying farmer-made probiotics around Indonesia.

Mr Sahidir's group was established in 2009, and in 2017 this group's followers are estimated at more than 70,000. On the assumption that only 10% applied the technology (an assumption Mr Sahidir suggested could be reasonable), the cost savings between using self-made probiotics and commercially bought is significant.

The commercial probiotic price is about Rp100,000 (approximately A$10) per litre. Catfish farmers need about 150 ml of commercially made probiotic for each 10 m^2 of tambak per month, which costs about Rp15,000. On the assumption that, on average, each catfish farmer manages 200 m^2 of tambak, they could spend up to Rp300,000 per month. But to produce the probiotic themselves costs about Rp1,000 per litre. If each farmer needs 5 litres of self-made probiotic per 10 m^2 tambak per month, their cost will be about Rp100,000 per month (it was unclear why the self-made probiotic needed to be used in greater volumes). So farmers can save about Rp200,000 per month if they produce probiotic themselves.

Usually farmers raise catfish for four 3-month seasons each year, so the estimated economic benefit of using self-made probiotic could be about Rp6.7 billion ($A670,000) over the 8 years the site has been operational.

If Mr Sahidir has influenced other sites, also providing information to catfish farmers, and on the same assumptions as above, this could amount to up to Rp13 billion in benefits since 2009 (details presented in Appendix 9). The total number of groups adopting the probiotic technology is likely to be larger, as some of the followers have now established their own groups.

Mr Sahidir has also developed a Facebook page, and helps manage a forum with about 16,000 members, which is helping to bridge the gap between industry and government. He speaks locally, and has been invited to present at national fisheries forums to talk of his work and experience. Recently, he has started to support aquaculture companies in other provinces, including Java.

Clearly, all of the above cannot be attributed to the projects alone, but it provides an example of how one person can make a major contribution with significant outcomes for smallholders and the industry in general.

Mr Sahidir was adamant that the training provided had been very important to his work, and emphasised additional skills (encouragement, enthusiasm and confidence) that he gained from the projects.

2.5.2 Mr Muhammad Faikal, entrepreneur

Mr Muhammad Faikal is a 33-year-old graduate in accounting from the Medan State University, North Sumatra. In 2014, he established a company producing fish feed (for tilapia, carp and catfish) in the Syiah Kuala district of Banda Aceh.

Some of the feed he produces is sold to fish farmers, but he also owns his own fish farm, and he uses some for his own business. He also produces catfish at his feed-processing plant in Banda Aceh, and he manages tilapia and carp tambaks in Jantho Baro village, Kota Jantho district, Aceh Besar, where he rents the tambaks from the local fisheries service office.

At this latter site, he also leads a cooperative-style program, share-farming with local fish farmers. Mr Faikal supplies the seed and feed to the farmers, and the farmers provide the labour. Mr Faikal also plays a role in marketing the harvested fish. After the fish are harvested, the fish sale value is deducted by the seed and feed sale value and the remaining profits are divided between Mr Faikal and the farmers equally.

In 2015, Mr Faikal established a restaurant promoting freshwater fish in Aceh, offering fried catfish as one of the key items on the menu. His family manages the restaurant, and most of his customers are from the adjacent area, including college students studying in the nearby university.

Mr Faikal adds value to his fish feed through his farms and his restaurant. He advised that he started his fish feed company through assistance provided by BPBAP, namely fish feed processing and fish farming technologies from the researchers of BPBAP Ujung Batee.

Based on the interview with Mr Faikal, researchers estimated the financial net present value (NPV) of his business (consisting of fish feed production, fish farming and fish-share farming) between 2014 and 2017 at about Rp1.25 billion (A$125,000). This includes a discount rate of 6% per year to account for average annual inflation. Fish farming contributed more than his fish feed business. See Appendix 10 for more information.

Appendix 11 provides estimates of the economic NPV of Mr Faikal's business. Economic NPV shows business income with no cost deductions, and estimates the direct economic impact generated by the business. In fact, the production costs of the business provide incomes to other business stakeholders, such as labour, feed producers and seed producers. The overall economic NPV of Mr Faikal's business, using a discount rate of 6% per year, is Rp4.21 billion (A$421,000). Again, fish farming generates more economic value than his fish feed business. But the fish feed business is creating employment, adding value and providing inputs to Mr Faikal's own fish farms, including those to which he has a share arrangement.

Again, not all of this can be attributed directly to the projects, but the information provided by BPBAP to Mr Faikal, together with the ongoing assistance, has enabled him to both expand his business and provide assistance to other farmer groups.

2.5.3 Farmers in Bireuen regency

Three farmers from Bireuen regency, Mr Jamaludin, Mr Muhammad Isa and Mr Muhammad Chairil, were interviewed for this impact assessment study.

Mr Jamaludin from Jangkalubi village informed researchers that his vannamei shrimp farming business operated in about 7,000 m^2 of rented tambak. He noted the only inputs he applied in 2005 were seed, saponin and growth hormones.

Additional feed was not applied at the time, due to the lack of capital. His tambak production was about 100 kg of shrimp per cycle, at a time when the selling price was about Rp[1]45,000 per kilogram. So, his total income was about Rp4,500,000 with a total expenditure of about Rp2,627,000.

Consequently, he received about Rp1,873,000 in profit, or 73% of the total cost (Appendix 12). In 2015, using the same tambak but armed with additional information from extension officers and the BPBAP, Mr Jamaludin was able to intensify his vannamei shrimp production. He said that his total production cost was Rp13,405,000, and the harvest was about 300 kg—substantially more than in 2005. Given the sale price of shrimp at the time of Rp60,000 per kilogram, his estimated income increased to about Rp18,000,000, so he received a net profit of Rp4,595,000 or 34% of total cost (Appendix 13).

1 Rp10,000 equals A$1, approximately

Mr M. Isa advised that, in July 2005, he stocked milkfish in a rented tambak of about 15,000 m^2 with low-level inputs. He said his total production costs were about Rp2,315,000, and with a production of 450 kg, valued at Rp2,700,000, he received a net profit of Rp385,000, or 17% of his total cost (Appendix 14).

However, in 2015, with more technical knowledge provided by BPBAP, he was able to intensify his operation. Using the same tambak, but increasing the inputs at a cost of about Rp10,610,000, he produced about 1,200 kg of milkfish, valued at Rp16,800,000. His net profit this time was Rp6,190,000, or 58% of the total cost compared with 2005 (Appendix 15).

In Kareung village, Bireuen regency, Mr Muhammad Chairil said he raised vannamei shrimp in his own tambak of about 2,000 m^2 in 2005. At the time he used relatively high inputs, although, as with many farmers, he did not use aeration paddle wheels.

He seeded the tambaks with about 10,000 shrimp, and incurred production costs of about Rp2,850,000. The volume of shrimp harvested was about 67 kg (Rp5,159,000), which provided him with about Rp2,309,000 of net profit, or 81% of total cost (Appendix 16).

In 2015, he shifted to tilapia farming in a rented tambak of 3,000 m^2. His production costs were roughly Rp4,010,000, and he harvested about 400 kg of tilapia, earning Rp5,600,000. His net profit for this enterprise was Rp1,590,000, or 40% of total cost (Appendix 17).

All three examples not only show gains through engagement with the BPBAP, but it was clear from the discussions that the farmers valued the input and time provided to them by the BPBAP staff.

2.5.4 Mr Syekh Mathaban, tilapia nursery operator

Mr Syekh Mathaban noted that if BPBAP staff had not come to his area and provided support through training and other inputs, including the demonstration tambak and brood stock, he would not have started farming tilapia.

Under FIS/2006/002 a demonstration tambak was set up in his area, with an original focus on shrimp. This tambak was for the villagers' information and understanding, at a location where BMP training could be provided.

At around the same time, Asian Development Bank started to provide training and support towards culture and marketing of tilapia and black tiger shrimp. For reasons given earlier in this report, and because a certain element of flexibility was provided in the project, the tambak was changed to focus on tilapia, and 12 farmers in the area were provided inputs (seed and fertiliser) to try tilapia farming in 2010. Mr Mathaban was one of the 12 farmers, and in 2011 he started to collaborate further with BPBAP and ACIAR under the FIS/2007/124 project (see Figure 1).

Unfortunately, the original farmers are no longer farming tilapia—due to the lack of seed throughout the region—but tilapia seed farming was reportedly profitable. However, some of the brood stock was lost due to floods in the second year. Despite it being profitable Mr Mathaban was not willing to buy the brood stock, as he expected to receive them free from government programs.

Despite this, Mr Mathaban suggested that tilapia was not only easier to market, it was also more in demand. He said that if he had 1 tonne of tilapia available, the traders would come immediately. Tiger shrimp was not difficult to market, but it was difficult to produce, with issues of disease also affecting production. He attributed the majority of his initial success to BPBAP Ujung Batee through the inputs and technical assistance provided. This was not only an improvement in farming practices, it also improved his return on investment at the time.

3 Conclusions and future considerations

With more than 10 years passing since these projects were conceived and delivered, it has been challenging to determine and quantify their impacts. Many individuals originally associated with the projects have moved on, and others could not distinguish the ACIAR projects in this report from subsequent ACIAR projects, nor from the many others provided by other agencies following the tsunami.

In addition, the disaster inevitably led to immense change across Aceh, including economic and political settings, destruction (and rebuilding) of infrastructure and environmental issues, all of which further complicated the attribution of change.

A key factor affecting the projects and outcomes was the cash-for-work program, and other monetary assistance available after the tsunami. While this obviously had an important role in the rehabilitation and repair work that was required in Aceh, it unfortunately created a 'false economy'. Farmers became reliant on the free inputs and subsidised technical support. It was then difficult for extension workers to engage farmers in projects that did not provide such free inputs and support. As an example, farmers were slow to join the Aceh Aquaculture Cooperative in the early stage of its development, as they were still receiving direct financial aid.

The Aceh Aquaculture Cooperative, a beneficiary of the projects and the AACC, was set up with little or no assistance from aid or government organisations, yet has been successful through the continuing efforts of some local staff. This is hopefully set to continue, providing support mechanisms for continued production, including operating a hatchery and possibly certification in the future. Some of this success can be claimed as a result of the initial information provided under the ACIAR projects.

It is clear that stock production and value have improved post-tsunami, and there is anecdotal evidence this might be related to changes in farming practices, some of which can be attributed to the information provided by the BPBAP and other institutions delivering similar and coordinated messages.

One of the more tangible changes in production was the shift from black tiger shrimp to vannamei shrimp, and from shrimp in general to tilapia, in part due to the direction change towards the end of project FIS/2006/002. But this has also added to the difficulty of understanding the economic benefits of the aquaculture projects.

Information and training provided by the projects was important for building capacity to rehabilitate and improve ('building back better') aquaculture production systems, and the wider skills and support services needed for viable enterprises.

BPBAP staff and other stakeholders gained knowledge and confidence, leading to greater engagement. This contributed to better connectivity and improved communication between farmers, extension workers and entrepreneurs, which likely played a role in greater awareness of improved environmental and management practices.

Farmers benefited from direct training, including information and learning provided via demonstration ponds set up by the projects. Farmers saw the benefits of tambak redevelopment, changing management practices, and diversification of production systems.

The improved productivity and profit seen in the Aceh aquaculture sector is almost certainly due to all of these reasons (although specific attribution is not possible). The institutional development of the BPBAP was key to these positive results. This built on the existing strengths of the BPBAP, improving its ability to:

- disseminate information in an effective and coordinated way to districts, extension workers, farmers, traders and others working on the ground, which included identifying and developing communication systems and mechanisms (such as social media, farmer meetings and communication centres), and providing practical solutions that extension officers and farmers can trial within the timeframe of a 3–4-year project
- develop (or build on existing) strong relationships with relevant agencies and institutions locally, nationally and (in the case of such a major disaster) internationally

- develop and showcase improved technologies for farmers
- provide support to input and output aspects of the supply chain (particularly during periods of crisis)
- understand the changing circumstances and needs of the farmers
- understand market dynamics, and support farmers to anticipate and deliver products in demand
- provide continuing support after the relief and recovery phase has ended, including continuing training in financial management and planning, as well as technical farming practices.

These were unusual projects for ACIAR, which is not normally involved with disaster rehabilitation efforts. It has been difficult to determine direct benefits from the projects, and it is also challenging to draw clear lessons for similar work in the future. But it is clear that the projects contributed to positive outcomes in the aquaculture sector, through building capacity, knowledge, confidence and enthusiasm.

If similar projects are considered by ACIAR in the future, the following measures are recommended.

- An impact assessment should be carried out as soon as possible after the event, to identify losses and critical needs, and to understand the relevant agencies affected and any other key issues (economic, environmental and social).
- A coordination mechanism should be established early on, to ensure roles and activities of all actors (government, multinational organisations or NGOs) are well coordinated, and to disseminate technical information.
- Opportunities for improvement, new technologies and diversification should be continually examined.
- The project should be flexible to allow for changing circumstances, but with a clear monitoring and evaluation process built into the project, with measurable indicators.
- Consideration should be given to cultural and social aspects, not only to get rehabilitation right and to build back better, but also to reduce aid dependency and address farmer risk aversion.
- An exit strategy should be developed that ensures government agencies have the capability to continue support when the project has ended.

In conclusion, this review highlights that working with a respected technical agency was key to achieving positive outcomes, and this approach would be highly recommended for future similar projects. A focus on capacity building, with flexible and adaptable arrangements, is advocated as the best approach.

Appendixes

Appendix 1. Outputs, indicators and results of FIS/2006/002

Code	Narrative summary	Verifiable indicators	Means of verification	Comments
Goal	To re-establish coastal aquaculture as a key source of income and employment in Aceh	• Number/area of tambaks in production • Production and value from coastal aquaculture in Aceh	• Data collected by government agencies	• NGOs and donors continue support to tambak re-establishment • Farmers can access essential inputs to re-establish production • Functional market chains are re-established and maintained
Purpose	**Rehabilitation of the Ujung Batee Balai Perikanan Budidaya Air Payau (BPBAP)**			
	Ujung Batee BPBAP providing quality services including: (i) validated best management practices to agencies involved in extension, hatcheries and farmers	• Number of farmers and hatcheries adopting best management practices	• Survey of aquaculture practices implemented by hatcheries and farmers	• Dinas Perikanan will use and disseminate information provided • Effective communication linkages between BPBAP and Dinas Perikanan • Farmers are willing to adopt best management practices
	(ii) disease control and management	• Number of hatcheries using Ujung Batee BPBAP services to test for diseases • Number of farmers using Ujung Batee BPBAP services to test for diseases	• Survey of hatcheries • Survey of farmers • Log of farmers queries • Number of farm visits	• Service that collects samples meets quality standards • Dinas Perikanan effectively disseminate value of disease testing
	(iii) seed production technologies	• Volume of seed production • Number of hatcheries and farms buying eggs/seed from BPBAP	• BPBAP records • Survey of hatcheries	• Hatcheries and farmers are aware of the importance of buying quality seed

Output	Verifiable indicators	Means of verification	Results
Component 2: Capacity building at BPBAP			
Output 2.1 The extent to which BPBAP staff teams demonstrate the capacity to meet best management practices (shrimp farming and soil analysis)	• Best management practices documented and disseminated to appropriate agencies and farmers • Agencies actively and effectively disseminating information about best management practices to hatcheries and farmers • Capacity of Ujung Batee BPBAP staff to undertake soil and water quality testing increased	• Advice and documentation assessed by independent experts as consistent with better aquaculture practice. • Reports by Dinas Perikanan about their extension activities • Number of soil and water quality tests carried out • Number of test reports to farmers	• BMPs for shrimp farming in Aceh have been documented and harmonised across various donor and implementing agencies, including ACIAR, Asian Development Bank, Aquaculture without Frontiers, FAO, German Technical Cooperation, International Finance Corporation, Network of Aquaculture Centres in Asia-Pacific and the World Wide Fund for Nature • Staff successfully completed soil training and passed competency testing, and applied their skills to projects coordinated by FAO, Asian Development Bank, French Red Cross and smaller NGO programs
Output 2.2 The extent to which the BPBAP provides disease diagnostic and fish health management services to a defined standard	• Number of PCR tests completed • Number of hatcheries and farmers providing samples for testing • Capacity of Ujung Batee BPBAP staff to undertake disease diagnostic testing increased	• Ujung Batee BPBAP records of PCR tests • Ujung Batee BPBAP records of the sources of requests for tests • Number of test reports to farmers	• The number of tests increased from 104 in 2007 to 230 in 2010 (January to June only) • Nearly all the hatcheries in Aceh providing samples (although the number of hatcheries significantly declined following the tsunami, with only 17 operational shrimp hatcheries found in 2008) • The estimated number of farmers providing samples for PCR testing was 1,500–2,000 in 2010
Output 2.3 The number of seed stock available for each new species	• Production of priority species (shrimp, milkfish, grouper) • Validation and dissemination of new seed production technologies • At least one commercial small-scale hatchery in Aceh • Number of hatcheries buying seed from Ujung Batee BPBAP	• Ujung Batee BPBAP records of production • Ujung Batee BPBAP records of buyers of eggs and seed • Number of hatcheries	• Seed production of shrimp and finfish species started again in 2009 following the reconstruction at Neuheun and Durung • Production of black tiger shrimp increased from 925,000 in 2009 to one million in January–June 2010 • The BPBAP is also producing other species to allow smallholder coastal farmers in Aceh to diversify • Six hatcheries were reported to have started again by mid-2010 and all were buying seed from Ujung Batee BPBAP

Appendix 2. Objectives, activities and outputs of FIS/2005/009

Objectives and activities	Outputs	Comments
Objective 1: **To characterise the chemical and physical properties of soils and describe other environmental constraints, and urgently disseminate this information to NGOs government agencies and other donor programs.**		
Activity 1.1 Collect soil samples and characterise their chemical and physical properties and assess presence and depth of acid sulfate soil materials	• Database of soil properties (for example, pH, texture, structure, metals, major ions) • Increased awareness of acid sulfate soils and depth of oxidised and unoxidised sediments	• The project mapped more than 470,000 ha of acid sulfate soils • The project variation supported more detailed soil assessment at new locations on the north-east coast • The project made other organisations aware of the problems associated with acid sulfate soils and sandy soils, and promoted avoidance and management strategies
Activity 1.2 Model local hydrological conditions using field measurements and predictive modelling	• Tidal charts showing tidal variation and tidal position by time of day for 365 days	• Hydrological data were provided to NGOs and other agencies to assist in tambak engineering work • The model was added to the PondTool software to enable stakeholders to apply it at other locations • BPBAP and NGO staff were trained to use the model
Activity 1.3 Disseminate information on environmental constraints to target groups	• Technical notes, brochures and other publications. • Revised material from FIS/1997/022	• Extension materials were revised and reprinted twice during the project period • Content was also contributed to FAO-funded publications
Objective 2: **To contribute to the development of rehabilitation plans in collaboration with other agencies. The rehabilitation plans will classify tambaks according to their level of degradation, and recommend new tambak and canal layouts for farm clusters.**		
Activity 2.1 Provide technical inputs on the design of tambak and canal layouts	• Engineering information on tambak and canal dimensions and layout	• This activity was ongoing to provide assistance to new projects on the northern coast
Activity 2.2 Assist with the production of rehabilitation maps and supporting guidelines	• Tambak rehabilitation maps showing tambak and canal layouts	• This activity was completed for German Technical Cooperation, FAO and French Red Cross programs

Objectives and activities	Outputs	Comments
Objective 3: **To develop guidelines for the reconstruction and re-engineering of tambaks, dykes and canals for different soil types and hydro geomorphic conditions**		
Activity 3.1 Analyse field and laboratory data from objective 1, and spatial data from objective 1.3 to determine engineering and environmental limitations on tambak, dyke and canal design	• Identification of engineering and environmental limitations (and risk factors for production)	• Sandy soils were identified as a major constraint on tambak engineering • Advice on optimal tambak dimensions and soil conservation measures have been provided to NGOs and other programs • The project supported the AARP demonstration tambak activities
Activity 3.2 Produce written guidelines and software packages to reconstruct and re-engineer tambaks, canals and dykes	• Technical manual with user friendly guidelines • Non-technical brochures for farmers and NGOs • Computer program to calculate lime requirements and optimal dyke, tambak and canal dimensions • Computer programs to enable accurate long-term tidal predictions	• Written guidelines are being revised to include material from FIS/2000/062 (disease project) and FIS/2002/076 (land-based mapping), as well as findings from two Government of Indonesia projects at the Research Institute for Coastal Aquaculture (Indonesia), which will be published under FIS/2010/016 • PondTool software is being revised to add more modules—this work is being done at UNSW by Tarunamulia and Sammut
Objective 4: **To build technical capacity within BPBAP, Dinas Perikanan, NGOs and farmer groups through field and laboratory-based training programs and through the provision of basic field resources**		
Activity 4.1 Conduct class and field-based workshops on soil assessment, tambak, dyke and canal reconstruction, water management and tambak management	• Increased skill base and expertise on soil assessment, tambak engineering and management in government staff, NGOs and farmers • New methods, largely based on simple techniques, to quickly assess soils	• This activity was part of a program of skill building that will continue under FIS/2007/124 and FIS/2010/016 • The BPBAP staff have used their skills to train Dinas Perikanan and NGOs, and are also training new staff at the centre • The project shifted the training to practical activities following a review of the technical program in 2008
Activity 4.2 provide laboratory training at BPBAP on soil testing as the basis for establishing a soiltesting service to farmers and other programs	• BPBAP staff skilled to provide a soiltesting service	• The environmental laboratory was commissioned in June 2008, and the soil laboratory was equipped in late 2008 • The Research Institute for Coastal Aquaculture trained BPBAP staff at Maros before the laboratory was commissioned, and then conducted follow-up training in 2009 using the new laboratory • This training will continue for laboratory staff under FIS/2007/124

Objectives and activities	Outputs	Comments
Activity 4.3 Retrain Dinas Perikanan district extension teams, and provide work plans and field supervision	• Skilled district-level technical/ extension teams • Work plans with clearly defined objectives	• This was a difficult task, because Dinas Perikanan is not sufficiently resourced to carry out the level of required extension • But the BPBAP staff have provided training to Dinas Perikanan • FIS/2007/124 and FIS/2010/016 will provide further training and supervisory support to this activity
Activity 4.4 Provide basic field resources, such as soil sampling and testing equipment to Dinas Perikanan and BPBAP extension teams		The project provided: • soil augers, gouges and Russian D-section corers • pH/Redox probes and meters, chemical reagents • Munsell Soil Colour Charts and soil data cards
Objective 5: **To deliver technical training to the Indonesian Ministry of Marine Affairs and Fisheries brackish water Technical Implementation Units to build capacity in soil assessment, remediation and management, and pond engineering, site selection and pond/canal design**		
Activity 5.1 Conduct field and class-based training on soil remediation, soil assessment and soil management, using materials from FIS/97/22	• Increase technical skills in soil assessment and management for field officers involved in community extension programs	• A new activity under project variation approved in May 2008 began in August 2008 • Stage 1 of training was completed (theory-based training), but Stage 2 (practical) had to be delayed, because the project team was involved in other activities, and it was difficult to arrange mutually agreed dates with the Technical Implementation Units (TIUs).
Activity 5.2 Conduct field and class-based training on tambak engineering and tambak/canal design, as well as layout from FIS/2005/009 and site selection from FIS/2002/07	• Improved skills in tambak design and tambak engineering relevant to the restoration of degraded farming areas throughout Indonesia	• As above
Activity 5.3 Extend and encourage adoption of written guidelines developed under FIS/2005/009 and FIS/2002/076	• Material produced by FIS/97/22, FIS/2005/009 and FIS/2002/076 will be reproduced and extended at workshops • Participants will be able to improve institutional adoption of guidelines and methods	• As above—publication of the guidelines from FIS/2002/076 was not completed but will be carried over into a proposed extension

Appendix 3. Farmer questionnaire

Name : ..... (Male/Female)

Age : ..... years old

Address: .....

Phone : .....

Project titles

1. Technical capacity building and research support for the reconstruction of tsunami-affected, brackish water aquaculture ponds in Aceh (FIS/2005/009)
2. Aceh aquaculture rehabilitation project (FIS/2006/002)

ACIAR FISHERIES PROJECT ASSESSMENT

UJUNG BATEE BPBAP, ACEH

MARET 2017

A. GENERAL QUESTIONS

1. Experience as a shrimp farmer: ..... years (since.....)
2. Did you shrimp tambak since 2005 (after tsunami)? (yes/no)
3. What kind of fish tambak or breeding? What kind did you run from 2006 to 2010? (shrimp/milkfish/grouper/crab/others.....)
4. What kind of fish are you focused on currently?
5. How much did it cost to rent area of shrimp ponds in 2005? (ha/m^2)
6. How much did it cost to rent area of shrimp ponds in 2006–2010? (ha/m^2)
7. How much did it cost to rent area of shrimp ponds after 2010? (ha/m^2)

B. ECONOMY IMPACTS

Outcomes:

1. How long did you stop producing shrimp after tsunami?..... month/year
2. Is there any asset/equipment/facility damaged by the tsunami? If any, explain.
    a.
    b.
    c.
3. What activities did you do in 2005 (before a counsel of technical guidance from extension workers/ Dinas Kelautan dan Perikanan)?
4. What kind of help did you get in aquaculture activities during the 2006–2009 period?
    a. Rehabilitation of tambak/ponds
    b. Shrimp/fish seeds
    c. Feed
    d. Vitamins
    e. Water quality test service (year ..... how many times .....)
    f. Guidance from BPBAP staff/Dinas Kelautan dan Perikanan/extension workers
    g. .....
5. Who provided input and technical assistance during 2006–2010?
6. What kind of help did you get in aquaculture activities during 2010–2016?
    a. Rehabilitation of tambak/ponds
    b. Shrimp/fish seeds
    c. Feed
    d. Vitamins
    e. Water quality test service (year ..... how many times .....)
    f. Guidance from BPBAP staff/Dinas Perikanan/extension workers
    g. .....

7. Who provided technical assistance during 2010–2016?
8. Where do you get the shrimp/fish currently?
9. How much is the price of shrimp/fish currently?
    a. Shrimp IDR ..... per .....
    b. Milkfish IDR ..... per .....
    c. Others .....
10. How much was the price of shrimp/fish seeds after the 2005 tsunami?
    a. Shrimp IDR ..... per .....
    b. Milkfish IDR ..... per .....
    c. Others .....
11. How is the current production situation of shrimp/fish, compared with after the tsunami (2005)?
    a. more
    b. less
    c. proportional
12. How is the current selling price of shrimp fish?
    a. Shrimp IDR ..... per .....
    b. Milkfish IDR ..... per .....
    c. Others .....
13. How was the selling price of shrimp/fish after the tsunami (2005)?
    a. Shrimp IDR ..... per .....
    b. Milkfish IDR ..... per .....
    c. Others .....
14. What problems did you face in producing shrimp/fish after the tsunami (before technical guidance)?
15. What kind of problems did you have in shrimp/fish production during 2006–2010?
16. What kind of problems do you have in shrimp/fish production currently?
17. Could you explain the supply chain of shrimp and fish production?

18. Cost and revenue of shrimp production year in 2005 (after the tsunami)

Number	Cost/income	Volume	Price (Rp/unit)	Total price (Rp)
A.1	Fixed cost			
1	Pond rent			
2	Water pump rent			
3	Wheel pump			
4	.....			
	Subtotal			
A.2	Operational cost			
1	Preparation and maintenance			
2	Shrimp/fish seed			
3	Feed			
4	Fertiliser			
5	Dolomite			
6	Saponin			
7	Zeolite			
8	Disinfectant			
9	Probiotic			
10	Additional feed			
11	Fuel			
12	Family labour			
13	Non-family labour			
14	Harvesting cost			
15	Shrimp/fish section for workers			
16	Other costs.....			
	Subtotal			
	Total cost			
B	Revenue			
1	Shrimp/fish production			
	Profit = (B–A1–A2)			

19. Cost and revenue of shrimp production year in 2005–2010 (after the tsunami)

Number	Cost/income	Volume	Price (Rp/unit)	Total price (Rp)
A.1.	Fixed cost			
1	Pond rent			
2	Water pump rent			
3	Wheel pump			
4	.....			
	Subtotal			
A.2.	Operational cost			
1	Preparation and maintenance			
2	Shrimp/fish seed			
3	Feed			
4	Fertiliser			
5	Dolomite			
6	Saponin			
7	Zeolite			
8	Disinfectant			
9	Probiotic			
10	Additional feed			
11	Fuel			
12	Family labour			
13	Non-family labour			
14	Harvesting cost			
15	Shrimp/fish section for workers			
16	Other costs.....			
	Subtotal			
	Total cost			
B	Revenue			
1	Shrimp/fish production			
	Revenue = (B–A1–A2)			

20. Cost and revenue of shrimp production at present (after the tsunami)

Number	Cost/income	Volume	Price (Rp/unit)	Total price (Rp)
A.1.	Fixed cost			
1	Pond rent			
2	Water pump rent			
3	Wheel pump			
4	.....			
	Subtotal			
A.2.	Operational cost			
1	Preparation and maintenance			
2	Shrimp/fish seed			
3	Feed			
4	Fertiliser			
5	Dolomite			
6	Saponin			
7	Zeolite			
8	Disinfectant			
9	Probiotic			
10	Additional feed			
11	Fuel			
12	Family labour			
13	Non-family labour			
14	Harvesting cost			
15	Shrimp/fish section for workers			
16	Other costs.....			
	Subtotal			
	Total cost			
B	Revenue			
1	Shrimp/fish production			
	Revenue = (B–A1–A2)			

C. SOCIAL IMPACTS

1. How many of your family members are involved in shrimp/fish farming?
   Male: ... (person), Female: ... (person)
2. How many people outside of your family members are involved in shrimp/fish farming? ...(person)
3. How did you use the revenue from shrimp/fish farming?
   a. the cost of producing shrimp/fish in the next season
   b. tuition fees
   c. house repair
   d. clothing
   e. others (specify): .....

Technology applied by farmers not training participants

4. Is there any other shrimp/fish farmer who followed or imitated the farming system that you did according to the guidance of Ujung Batee BPBAP/extension workers in 2006–2010?

   (yes/no). How many people?

D. ENVIROMENTAL IMPACTS

1. What is the impact of shrimp/fish production activities to the environment?
2. Do you plant the mangroves in the pond/tambak? (yes/no)
3. If yes, how many mangroves in each pond/tambak?
4. What is the reason to plant mangroves?
5. What is the reason to not plant mangroves?
6. According to you, what are the benefits of mangrove plants?

E. TECHNOLOGY TRANSFERRED IMPACTS

1. Preparation method
   a. How long does/did it take to dry your ponds/tambak?
   b. What did you do with the mud of your ponds/tambak? How many cycles did you do to throw the mud?
   c. Did you conduct any soil tests? Who gives the test service?
      If yes, when did you do the test? How many times have you ever conducted the soil test?
   d. Do you use lime during preparation of ponds/tambak? What kind of lime do you use?
   e. How did you do the water entry? Is there any use of filter? How many layers of filter do you use?
   f. What is the depth of water you prepared? (centimetre)
   g. What is the depth of your ponds/tambaks that can hold water? (centimetre)
   h. What fertiliser do you use for the preparation of the ponds/tambak?
   i. What kind of materials did you use to eradicate the wild fish?
   j. What is your opinion of using pesticides? Does it have a good or bad impact on the ponds/tambak?

    k. Do you still use pesticides? If yes, what pesticides do you use?
    l. Is there any difference in the impact between using saponin (natural pesticides) and toxic (artificial pesticides)?

2. How did you spread the seed of
    a. shrimp ..... stocking density..... /m^2
    b. milkfish ..... stocking density..... /m^2
    c. others .....
3. How often did you feed
    a. shrimp .....
    b. milkfish .....
    c. others .....
4. How do you manage water quality of your ponds/tambak?
    a. Do you change the water regularly?
    b. Do you give fertiliser regularly?
5. How do you monitor fish with disease or sick fish?
6. How do you do postharvest treatment?
7. How do you record daily activities of the pond?
8. Is the farmer group still run ongoing activities?
9. How is the joint stocking process according to you? Is it ongoing currently or has it finished?
10. How can the cultivation calendar system you know about be apply to the current situation?
11. What do you think about the method of polyculture farming? Does it still exist? What kind of fish is kept in polyculture?
12. Is there any pollution in your pond/tambak? (yes/no)
13. If yes, explain .....
14. Is there any pollution in water canal surrounding your pond/tambak? (yes/no)
15. If yes, explain .....

Appendix 4. Trader questionnaire

Name : ..... (Male/Female)

Age : ..... years old

Address: .....

Phone : .....

Project titles

1. Technical capacity building and research support for the reconstruction of tsunami-affected, brackish water aquaculture ponds in Aceh (FIS/2005/009)
2. Aceh aquaculture rehabilitation project (FIS/2006/002)

ACIAR FISHERIES PROJECT ASSESSMENT

UJUNG BATEE BPBAP, ACEH

MARET 2017

A. GENERAL QUESTIONS

1. Types of trader: (i) collectors, (ii) wholesalers, (iii) retailers, (iv) exporters
2. Experience in selling shrimp/fish: ..... year (since .....)
3. Where are the fish and shrimp sources obtained? How many village/districts?
4. Where is the market of fish and shrimp?

B. ECONOMIC IMPACTS

Outcomes:

1. After the tsunami (2005) how long did you not purchase and sell shrimp/fish? (month/year)
2. In 2006–2010, how many tonnes of shrimp did you purchase or sell per cycle (per day/week/month)?
3. When is the shrimp (or prawn)/fish harvest season?
4. What type and quality of shrimp/fish do you buy/sell?
    a. Varieties: (i) windu, (ii) poles, (iii) bananas, (iv) ....., (v) .....?
    b. Shrimp/fish weight: ..... gram (..... individual/kg)
5. Distribution of shrimp/fish
    a. What is the procedure of shrimp/fish packing (or packaging)?
        a) .....
        b) .....
        c) .....
    b. Transportation
    How do you transport shrimps/fish to wholesalers or retailers?
    c. Marketing
    How do you sell shrimp/fish?
6. How is the price of shrimp/fish that you buy from farmers?
    a. IDR ..... /size ..... /kg
    b. IDR..... /size ..... /kg
    c. IDR..... /size ..... /kg
7. How is the price of shrimp/fish that you sell?
    a. IDR..... /size ..... /kg
    b. IDR..... /size ..... /kg
    c. IDR..... /size ..... /kg
8. Could you explain the marketing chain of shrimp/fish?
9. Did you get counselling from BPBAP/Dinas Kelautan dan Perikanan/extension workers on how to harvest and sell shrimp? (yes/no)
10. What kind or information? What are the main obstacles as a shrimp/fish trader?
11. Which period is more profitable as a shrimp/fish trader, after the tsunami (2005), the period 2006–2010, or 2010–present? Explain why?

12. What is the impacts of pond culture activities to the environment?

13. Cost and revenue analysis of shrimp/fish marketing after tsunami (2005)

Number	Type of shrimp/fish	Volume	Price per individual/kg (Rp/kg)	Total price (Rp)
A	Marketing cost			
1	Purchase price of shrimp/fish			
2	Packing cost			
3	Number of labourers			
4	Labour salary			
5	Transportation cost			
6	Depreciation cost			
7	Risks of the unsold shrimp/fish			
8	Refrigerator			
9	.....			
	Total cost			
B	Revenue			
1	Selling			
	Revenue = (B–A)			

14. Cost and revenue analysis of shrimp/fish marketing after tsunami (2006–2010)

Number	Type of shrimp/fish	Volume	Price per individual/kg (Rp/kg)	Total price (Rp)
A	Marketing cost			
1	Purchase price of shrimp/fish			
2	Packing cost			
3	Number of labourers			
4	Labour salary			
5	Transportation cost			
6	Depreciation cost			
7	Risks of the unsold shrimp/fish			
8	Refrigerator			
9	.....			
	Total cost			
B	Revenue			
1	Selling			
	Revenue = (B–A)			

15. Cost and revenue analysis of shrimp/fish marketing after tsunami (2010–present)

Number	Type of shrimp/fish	Volume	Price per individual/kg (Rp/kg)	Total price (Rp)
A	Marketing cost			
1	Purchase price of shrimp/fish			
2	Packing cost			
3	Number of labour			
4	Labour salary			
5	Transportation cost			
6	Depreciation cost			
7	Risks of the unsold shrimp/fish			
8	Refrigerator			
9	.....			
	Total cost			
B	Revenue			
1	Selling			
	Revenue = (B–A)			

C. SOCIAL IMPACTS

1. How many of your family are involved in shrimp/fish marketing?
2. How many people outside of your family are involved in shrimp/fish marketing? ...(person)
3. How did you use the revenue from shrimp/fish marketing?
    a. the cost of producing shrimp/fish in the next season
    b. tuition fees
    c. house repair
    d. clothing
    e. others (specific): .....

Technology applied by farmers not training participants

4. Is there any other shrimp/fish farmer who followed or imitated the farming system according to the guidance of Ujung Batee BPBAP/Dinas Kelautan dan Perikanan/extension workers in 2006–2010? (yes/no). How many people?

D. ENVIROMENTAL IMPACTS

1. What is the impact of shrimp/fish production activities to the environment?
2. Do the farmers plant mangroves in the pond/tambak? (yes/no)
3. If yes, how many mangroves in each pond/tambak?
4. What is the reason to plant mangroves?
5. What is the reason to not plant mangroves?
6. According to you, what are the benefits of having mangrove planted?
7. What kind of material do farmers use in land preparation according to you?
    a. Before water entry?
    b. After water entry?
8. Is there any difference in positive impact between saponin and pesticide use?
9. Is there any difference in negative impact between saponin and pesticide use?
10. Is there any pollution in ponds/tambak managed by farmers? (yes/no)
11. If yes, explain .....
12. Is there any pollution in water canal surrounding ponds/tambak the farmers managed? (yes/no)
13. If yes, explain .....

Appendix 5. Staff questionnaire

Name : ..... (Male/Female)

Age : ..... years old

Address: .....

Phone : .....

Project titles

1. Technical capacity building and research support for the reconstruction of tsunami-affected, brackish water aquaculture ponds in Aceh (FIS/2005/009)
2. Aceh aquaculture rehabilitation project (FIS/2006/002)

ACIAR FISHERIES PROJECT ASSESSMENT

UJUNG BATEE BPBAP, ACEH

MARET 2017

A. GENERAL QUESTIONS

1. How long you have been working in Dinas Kelautan dan Perikanan? (years)
2. What is your current position?

B. ECONOMIC IMPACTS

Outcomes:

1. How large is the area of ponds in the kecamatan/district currently compared with after the tsunami (2005)? (ha)
2. How is the productivity of shrimp/fish at present (2016–2017) compared with after tsunami (2005)? (kg/cycle/ha)
3. What are the factors affecting pond productivity?
4. What is the current price of shrimp/fish compared with after the tsunami (2005)? (Rp/kg)
5. What are the returns for shrimp/fish farmers today compared with after the tsunami (2005)? (Rp/kg)
6. Why are the profits of shrimp/fish farmers changing? Is it due to changes in productivity, production costs, selling prices, or a combination of these factors?

C. SOCIAL IMPACTS

1. Is there any family member of shrimp/fish farmers involved in shrimp/fish farming? (yes/no)
2. Is there any labour outside the family members of shrimp/fish farmers involved in shrimp/fish farming? (yes/no)
3. How did they use the revenue from shrimp/fish ponds?
    a. the cost of producing shrimp/fish in the next season
    b. tuition fees
    c. house repair
    d. clothing
    e. others (specific): .....

Technology applied by farmers not training participants

4. Is there any other shrimp/fish farmer who follow or imitate the farming system that you did according to the guidance of Ujung Batee BPBAP/Dinas Kelautan dan Perikanan/extension workers in 2006–2010? (yes/no), how many people?

D. ENVIROMENTAL IMPACTS

1. What is the impact of shrimp/fish production activities to the environment?
2. Do the farmers plant the mangroves in the pond/tambaks? (yes/no)
   How many of the total farmers? How many of them plant the mangroves?
3. How many mangroves in each pond/tambaks?
4. What is the reason farmers plant mangroves?
5. What is the reason farmers do not plant mangroves?
6. According to you, what are the benefits of mangrove plants?
7. Is there any difference in positive impact between saponin and pesticide use?

8. Is there any difference in negative impact between saponin and pesticide use?
9. Is there any pollution in ponds/tambaks the farmers managed? (yes/no)
10. If yes, explain .....
11. Is there any pollution in water canal surrounding ponds/tambaks the farmers managed? (yes/no)
12. If yes, explain .....

E. TECHNOLOGY TRANSFERRED IMPACTS

1. Preparation method
    a. How long did it take to dry ponds/tambaks?
    b. What is your opinion of the mud of ponds/tambaks? How many cycles did the farmers do to throw the mud?
    c. What is your opinion of soil tests? What kind of soil test did you give to the farmers?
    d. What is your opinion of the use of lime during preparation of ponds/tambaks? What kind of lime did you suggest?
    e. How did farmers do the water entry? Is there any use of filter? How many layers of filter should be used?
    f. How is the depth of water you suggested? (centimetre)
    g. Did you suggest any fertiliser for the preparation of the ponds/tambaks?
    h. What kind of materials did you suggest to eradicate wild fish?
    i. What is your opinion on pesticide use? Do you think it has a good or bad impact on your ponds/tambaks?
    j. Do you think farmers have used pesticides until now? If yes, what kind of pesticides do they use?
    k. Is there any difference in the impact of using saponins (natural pesticides) with toxic (artificial pesticides)?
2. How could you suggest spread the seed of
    a. shrimp ..... dense stocking..... /m^2
    b. milkfish ..... dense stocking..... /m^2
    c. others .....
3. How many times should farmers feed
    a. shrimp .....
    b. milkfish .....
    c. others .....
4. How do you manage water quality of your ponds/tambaks?
    a. Do you think farmers should change the water?
    b. How could you suggest continuously fertilisation?

5. What is your opinion about fish disease monitoring by farmers?
6. What is your opinion about postharvest treatment?
7. According to you, how should daily activities of the pond be recorded?
8. Is your farmers group still running?
9. How is the joint stocking process according to you? Is it still running until now?
10. How can the cultivation calendar system you know about be applied until now? When should shrimp and milkfish farming be done?
11. What do you think of the method of polyculture farming? Does it still apply? What kind of fish is used in polyculture?
12. Is there any pollution in ponds/tambaks the farmers managed? (yes/no)
13. If yes, explain .....
14. Is there any pollution in water canal surrounding ponds/tambaks the farmers managed? (yes/no)
15. If yes, explain .....

Appendix 6. Total production and costs of shrimp farmers in Aceh, 2005

Description	Unit	Volume (unit)	Price (Rp/unit)	Cost (Rp)
Purchase for pond rental	hectares	1	1,000,000	826,446
Pump	hours	33	15,000	409,808
Preparation/improvement	hectares	0.826446281	1,046,700	714,910
Shrimp/fish seeds	units	14,876	400	491,770
Artificial feed	kilograms	244	5,000	1,007,445
Fertiliser	kilograms	179	1,800	266,648
Dolomite	sacks	3	50,000	128,065
Saponin	kilograms	24	3,500	68,131
Probiotic	bottles	7	3,500	20,490
Additional feed	kilograms	100	6,400	528,926
Fuel cost	litres	33	7,000	191,244
Labour cost	working man days	7	50,000	273,205
Harvesting cost		22	60,000	1,104,228
Total cost				**6,031,316**
Shrimp production	**kilograms**	**185.54**	**50,000**	**7,666,826**
Profit				**1,635,510**

Appendix 7. Total production and costs of shrimp farmers in Aceh, 2006–2010

Description	Unit	Volume (unit)	Price (Rp/unit)	Cost (Rp)
Purchase for pond rental	hectares	1	1,000,000	1,000,000
Pump	hours	50	15,000	750,000
Preparation/improvement	hectares	1	675,000	675,000
Shrimp/fish seeds	units	19,600	50	980,000
Artificial feed	kilograms	136	6,400	875,375
Fertiliser	kilograms	205	1,800	369,000
Dolomite	sacks	1.3	75,000	100,000
Saponin	kilograms	49	3,500	171,250
Probiotic	bottles	2	3,750	7,500
Additional feed	kilograms	20	6,400	128,000
Fuel cost	litres	40	7,000	280,000
Labour cost	working man days	3.5	50,000	175,000
Harvesting cost		18	60,000	1,080,000
Total cost				**6,591,125**
Shrimp production	**kilograms**	**198**	**60,000**	**11,887,500**
Profit				**5,296,375**

Appendix 8. Total production and costs of shrimp farmers in Aceh, 2017

Description	Unit	Volume (unit)	Price (Rp/unit)	Cost (Rp)
Purchase for pond rental	hectares	0.33	1,000,000	333,000
Pump	hours	33	20,000	660,000
Preparation/improvement	hectares	1		2,266,700
Shrimp/fish seeds	units	18,750	60	1,125,000
Artificial feed	kilograms	365	6,400	2,336,000
Fertiliser	kilograms	9.5	1,800	17,100
Dolomite	sacks	2	150,000	300,000
Saponin	kilograms	17	5,000	85,000
Probiotic	bottles	4	4,000	16,000
Additional feed	kilograms	5	7,500	37,500
Fuel cost	litres			
Labour cost	working man days	5	50,000	250,000
Harvesting cost				1,800,000
Total cost				**9,226,300**
Shrimp production	**kilograms**	**201**	**85,000**	**17,050,000**
Profit				**7,823,700**

Notes
Profit growth (2005 to 2006–2010): 224% in 5 years, or 44.8% per year
Profit growth (2005 to 2017): 378% in 12 years, or 31.5% per year

Appendix 9. Economic benefit of feed technology disseminated through social media, 2017

No.	Name	Group	Topic/commodity	Location	Follower	Establishment (years)	Benefit (Rp)
1	Ibnu Sahidhir	Art Aquaculture	Feed technology and fish farming	Indonesia	70,000	8	6,720,000,000
2	Khoirul Anam	Paguyuban Budidaya Lele (Catfish Farming Association)	Catfish	Probolinggo	9,568	8	918,528,000
3	Jaja Jamaludin	Consortium for Sovereignty and Selfreliance	Fish feed and feed processing machine	Bogor	242	4	11,616,000
4	Julian S. Nugraha	Regancy Farm Nusantara Limited Partnership	Fish feed	Lampung Timur	35	3	1,260,000
5	Wari Siswoyo	Indonesian Catfish Group	Catfish	Bandung	250	4	12,000,000
6	Julian (Zuka)	Natural Water System	Catfish and fish feed	Lamongan	1,724	4	82,752,000
7	Ahmad Jauhari	Higienic Catfish Farming Discussion Forum	Probiotic/catfish	Banda Aceh	15,866	8	1,523,136,000
8	Rahman Qutub	Asosiasi Pembudidaya Lele Seluruh Indonesia (Indonesian Catfish Farmers Association)	Catfish and shrimp	Tasikmalaya	2,263	5	135,780,000
9	Sholihin	Sangkuriang Catfish Community	Catfish	Bogor	18,095	8	1,737,120,000
10	Bayu R. Widodo	Tanjung Jaya Mina Limited Partnership	Seafood	Pemalang	4	1	48,000
11	David	Together Progress Catfish	Catfish	Purwakarta	24,213	8	2,324,448,000
						Total	**13,466,688,000**

Source: Interview with Ibnu Sahidir, BPBAP Ujung Batee.

Appendix 10. Financial net present value of Muhammad Faikal's fish farming and fish feed business, 2007–2017

Year	Tilapia feed (IDR)	Carp feed (IDR)	Catfish feed (IDR)	Tilapia farming (IDR)	Carp farming (IDR)	Catfish farming (IDR)	Fish farm profit sharing (IDR)	Total (IDR)
2007	0	0	0	0	0	0	0	
2008	0	0	0	0	0	0	0	
2009	0	0	0	0	0	0	0	
2010	0	0	0	0	0	0	0	
2011	0	0	0	0	0	0	0	
2012	0	0	0	0	0	0	0	
2013	0	0	0	0	0	0	0	
2014	20,400,000	20,400,000	18,000,000	106,920,000	173,745,000	141,900,000	61,627,500	
2015	20,400,000	20,400,000	18,000,000	106,920,000	173,745,000	141,900,000	61,627,500	
2016	20,400,000	20,400,000	18,000,000	106,920,000	173,745,000	141,900,000	61,627,500	
2017	20,400,000	20,400,000	18,000,000	106,920,000	173,745,000	141,900,000	61,627,500	
NPV	**47,011,660**	**47,011,660**	**41,480,876**	**246,396,406**	**400,394,160**	**327,007,576**	**142,020,151**	**1,251,322,490**

Notes
Financial value is based on the total profit earned by Mr Faikal's business
Year 0 is 2006 when the ACIAR project started. Discount rate of 6% started in year 1—that is, 2007

Appendix 11. Economic net present value of Muhammad Faikal's fish farming and feed business, 2007–2017

Year	Tilapia feed (IDR)	Carp feed (IDR)	Catfish feed (IDR)	Tilapia farming (IDR)	Carp farming (IDR)	Catfish farming (IDR)	Fish farm profit sharing (IDR)	Total (IDR)
2007	0	0	0	0	0	0	0	
2008	0	0	0	0	0	0	0	
2009	0	0	0	0	0	0	0	
2010	0	0	0	0	0	0	0	
2011	0	0	0	0	0	0	0	
2012	0	0	0	0	0	0	0	
2013	0	0	0	0	0	0	0	
2014	84,000,000	84,000,000	90,000,000	528,000,000	336,000,000	525,000,000	180,000,000	
2015	84,000,000	84,000,000	90,000,000	528,000,000	336,000,000	525,000,000	180,000,000	
2016	84,000,000	84,000,000	90,000,000	528,000,000	336,000,000	525,000,000	180,000,000	
2017	84,000,000	84,000,000	90,000,000	528,000,000	336,000,000	525,000,000	180,000,000	
NPV	**193,577,424**	**193,577,424**	**207,404,382**	**1,216,772,376**	**774,309,694**	**1,209,858,897**	**414,808,765**	**4,210,308,962**

Notes
Economic value is based on the total returns earned by Mr Faikal's business
Year 0 is 2006 when ACIAR project finished. Farm and feed fish business started in year 1—that is, 2007

Appendix 12. Costs and income of vannamei shrimp farm in Jangkalubi village, Jangka district, Bireuen regency, 2005

Item	Volume	Unit	Price (Rp/unit)	Value (Rp)	% of total cost
Costs of production					
Pond rent	—	—	—	1,350,000	51.39
Water pump irrigation	—	—	—		0.00
Pond maintenance	—	—	—		0.00
Seed	15,000	shrimp	30	450,000	17.13
Saponin	50	kilograms	3,500	175,000	6.66
Urea (50 kg @IDR2,000)	—	—	—	100,000	3.81
Triple superphosphate (TSP) (50 kg @IDR3,000)	—	—	—	150,000	5.71
Feed	—	—	—		0.00
Growth hormone	6	pack	17,000	102,000	3.88
Harvest labour	—	—	—	300,000	11.42
Total cost				**2,627,000**	**100.00**
Production	**100**	**kilograms**	**45,000**	**4,500,000**	**171.30**
Profit				**1,873,000**	**71.30**

Notes
Pond area size was 7,000 m^2, with rent at IDR4,000,000 per year in 2005
This pond was operated by Mr Jamaludin

Appendix 13. Costs and income of vannamei shrimp farm in Jangkalubi village, Jangka district, Bireuen regency, 2015

Item	Volume	Unit	Price (Rp/unit)	Value (Rp)	% of total cost
Costs of production					
Pond rent	0.33	year	6,000,000	2,000,000	14.92
Water pump irrigation	3	times	150,000	450,000	3.36
Pond maintenance	1	units	500,000	500,000	3.73
Seed	3,000	shrimp	45	1,350,000	10.07
Saponin	50	kilograms	3,500	175,000	1.31
Lime	4	sacks	50,000	200,000	1.49
Urea (nitrogen) fertiliser	30	kilograms	2,500	75,000	0.56
Multiple (nitrogen, phosphorous, potassium) fertiliser	50	kilograms	3,500	175,000	1.31
Feed	500	kilograms	15,600	7,800,000	58.19
Growth hormone	6	pack	30,000	180,000	1.34
Harvest labour	—	—	—	500,000	3.73
Total cost				**13,405,000**	**100.00**
Production	**300**	**kilograms**	**60,000**	**18,000,000**	**134.28**
Profit				**4,595,000**	**34.28**

Notes
Pond area size is 7,000 m^2, with rent at IDR6,000,000 per year in 2016
This pond was operated by Mr Jamaludin

Appendix 14. Costs and income of milkfish farming in Kareung village, Jangka district, Bireuen regency, July 2005

Item	Volume	Unit	Price (Rp/unit)	Value (Rp)	% of total cost
Costs of production					
Pond rent per season	—	—	—	1,350,000	58.32
Paddle wheel rent	—	—	—		0.00
Pond maintenance	—	—	—		0.00
Seed	—	—	—	500,000	21.60
Saponin	25	kilograms	3,000	75,000	3.24
Organic fertiliser	30	kilograms	4,000	120,000	5.18
Feed	—	—	—		0.00
Harvest labour	—	—	—	270,000	11.66
Total costs				**2,315,000**	**100.00**
Production	**450**	**kilograms**	**6,000**	**2,700,000**	**116.63**
Profit				**385,000**	**16.63**

Notes
Pond size was 15,000 m^2, with rent at IDR5,000,000 per year
This pond was operated by Mr Muhammad Isa

Appendix 15. Costs and income of milkfish farming in Kareung village, Jangka district, Bireuen regency, 2015

Item	Volume	Unit	Price (Rp/unit)	Value (Rp)	% of total cost
Costs of production					
Pond rent	—	—	—	3,700,000	34.87
Paddle wheel rent	—	—	—	1,500,000	14.14
Pond maintenance	—	—	—	1,600,000	15.08
Seed	8,000	milkfish	100	800,000	7.54
Saponin	25	kilograms	6,000	150,000	1.41
Nitrogen, phosphorous, potassium	50	kilograms	8,000	400,000	3.77
Feed	150	kilograms	6,400	960,000	9.05
Harvest labour	—	—	—	1,500,000	14.14
Total costs				**10,610,000**	**100.00**
Production	**1,200**	**kilograms**	**14,000**	**16,800,000**	**158.34**
Profit				**6,190,000**	**58.34**

Notes
Pond size was 15,000 m^2, with rent at IDR11,000,000 per year
This pond was operated by Mr Muhammad Isa

Appendix 16. Costs and income of vannamei shrimp farming in Kareung village, Kuala Raja district, Bireuen regency, 2005

Item	Volume	Unit	Price (Rp/unit)	Value (Rp)	% of total cost
Costs of production					
Pond rent	—	—	—	0	0.00
Seed	10,000	shrimp	44	440,000	15.44
Saponin	20	kilograms	6,000	120,000	4.21
Feed	150	kilograms	10,600	1,590,000	55.79
Harvest labour	—	—	—	600,000	21.05
Transport to the market	—	—	—	100,000	3.51
Total cost				**2,850,000**	**100.00**
Production	**67**	**kilograms**	**77,000**	**5,159,000**	**181.02**
Profit				**2,309,000**	**81.02**

Notes
No pond rent (own pond). Shrimp harvested with size of 40 shrimps per kilogram
This farmer's own pond of 2000 m^2 was operated by Mr Muhammad Chairil

Appendix 17. Costs and income of tilapia farming in Kareung village, Kuala Raja district, Bireuen regency, 2015

Item	Volume	Unit	Price (Rp/unit)	Value (Rp)	% of total cost
Cost of production					
Pond rent	—	—	—	1,200,000	29.93
Seed	8,000	tilapia	100	800,000	19.95
Saponin	25	kilograms	6,000	150,000	3.74
Nitrogen, phosphorous, potassium	50	kilograms	8,000	400,000	9.98
Feed	150	kilograms	6,400	960,000	23.94
Harvest labour	—	—	—	500,000	12.47
Total cost				**4,010,000**	**100.00**
Production	**400**	**kilograms**	**14,000**	**5,600,000**	**139.65**
Profit				**1,590,000**	**39.65**

Notes
Pond size was 3,000 m^2, with rent at IDR3,500,000 per year
This pond was operated by Mr Muhammad Chairil

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No.	Author(s) and year of publication	Title	ACIAR project numbers
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88	Clarke M. 2015	ACIAR-funded crop–livestock projects, Tibet Autonomous Region, People's Republic of China	LPS/2002/104, CIM/2002/093, LPS/2005/018, LPS/2005/129, LPS/2006/119, LPS/2008/048, LPS/2010/028, C2012/228, C2013/017
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