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Agricultural research on integrated rice–shrimp and mangrove–shrimp farming systems in the Mekong Delta of Vietnam

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Agricultural research on integrated rice–shrimp and mangrove–shrimp farming systems in the Mekong Delta of Vietnam

Dr Elizabeth Petersen
Principal Applied Economist, Advanced Choice Economics Pty Ltd
Adjunct Senior Lecturer, University of Western Australia

Dr Hua Hong Hieu
Freelance consultant
School of Social Sciences and Humanities, Can Tho University, Vietnam

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Foreword

The international partnerships that underpin research supported by the Australian Centre for International Agricultural Research (ACIAR) aim to improve the productivity and sustainability of agricultural, forestry and fisheries systems in partner countries. Through this research, Australia contributes to improving food security, food system resilience and the livelihoods of smallholder farmers in the Indo-Pacific region. Often, research findings are also relevant for the Australian agricultural innovation system, with flow-on benefits to rural industries and regional communities.

The full impact of research-for-development work in agriculture, forestry and fisheries is realised over decades and cannot be properly evaluated when the research first takes place. For more than 30 years, ACIAR has systematically undertaken independent impact assessment studies of its portfolio of research activities. These evaluations have consistently found high returns on investment, reflecting the quality of Australian agricultural science and our partnership model, which ensures a high level of engagement with in-country partners. The evaluation results also reflect the relevance and adoptability of research outputs.

This report assesses the impact of 2 rice–shrimp farming projects and a mangrove forestry project in the Mekong Delta that were supported by ACIAR from the mid-1990s. These projects aimed to investigate and support the ongoing sustainability and profitability of non-monoculture shrimp farming systems in the Mekong Delta. The projects commenced at a time when the rapid expansion of the shrimp industry in the region was imminent, and the potential for negative environmental impact was high.

The analysis suggests that almost 2 decades after the first project was initiated, the overall impact of the investment is very positive, with a benefit:cost ratio on ACIAR investment of 72:1 in the case of the rice–shrimp projects, and 13:1 in the case of the mangrove forestry project. The assessment shows that relationships developed between researchers, extension workers, local policymakers and farmers were core to the success of these projects.

By expediting the adoption of integrated shrimp farming systems in an environmentally sustainable way, these 3 ACIAR-funded projects have been proven to have had a positive and enduring impact on individual participants, institutions and smallholders, as well as contributing to the conservation of the coastal ecosystems of the Mekong Delta.

Andrew Campbell
Chief Executive Officer, ACIAR

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Summary

The purpose of this impact assessment is to identify the impact of 3 projects funded by the Australian Centre for International Agricultural Research (ACIAR) on integrated rice–shrimp and mangrove–shrimp farming systems in Vietnam's Mekong Delta. These projects operated from July 1995 to December 2002. A summary of their economic, value-chain, environmental, capacity, scientific, policy, gender and youth impacts is outlined in the tables in the following pages.

The first project, 'Assessment of the sustainability of rice–shrimp farming systems in the Mekong Delta Vietnam: a feasibility study' (ANRE/1993/036), was a precursor to the second project, 'An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta' (ASEM/1995/119). Together, these projects had a very high economic impact, achieved by facilitating the early introduction of shrimp production into traditional rice monocultures. These projects were conducted at a time when there were few profitable livelihood opportunities during the dry season and when shrimp production in the Mekong Delta was on the cusp of escalating. They facilitated the adoption of these systems about 3 years earlier than would have occurred without them, generating indicative economic benefits in the order of VND12,000 billion (AUD760 million). The combined benefit:cost ratio of these 2 projects is estimated to be 72:1, indicating that for every dollar invested in these projects by ACIAR, the equivalent of AUD72 (VND1.1 million) has been generated.

The third project, 'Mixed shrimp farming: mangrove forestry models in the Mekong Delta' (FIS/1994/012), had a very high environmental impact, as it played a significant role in preventing the destruction and degradation of mangrove forests in Vietnam's Mekong Delta. This, in turn, prevented erosion, provided habitat for bird and fisheries species, protected coastal communities from extreme weather events, and stored large reserves of blue carbon, helping to mitigate global climate change. These environmental impacts will be felt in the long term, mostly by local communities, but also by regional, national and global communities. Indicatively, this project's economic impact is estimated to be around VND1,900 billion (AUD120 million). The benefit:cost ratio of this project is estimated to be 13:1, reflecting a strong return on ACIAR's investment.

All 3 projects had high policy and capacity impacts. Without these projects, the policy reforms required for development of these integrated systems would have been substantially delayed, significantly reducing the economic impacts of the projects. Strong capacity building in all 3 projects catalysed the economic, environmental and scientific impacts of the projects. The projects enhanced the career trajectories of a large number of project participants, many of whom have since held, or currently hold, professional roles with high responsibilities, which have an ongoing and substantive impact in Vietnam.

Reasons for the success of the 3 projects include:

- timely facilitation of the integration of shrimp production into rice and mangrove monocultures when shrimp production was starting to escalate in the Mekong Delta
- dynamic and inclusive project leadership and participation from project partners, industry, government and farmers
- multidisciplinary teams and multifaceted project designs, which were novel for their time
- strong collaboration between researchers, extension workers, local policymakers and farmers
- innovative and entrepreneurial landholders, who were willing to take risks and make practice changes, driven by a need to establish sustainable incomes and opportunities for their families
- integration of scientific research and economic analysis within a livelihood/household context
- inclusion of government policy assessment as an objective of ASEM/1995/119
- continuous meetings and exchange between project participants, farmers and local policy staff.

Impact	'Assessment of the sustainability of rice–shrimp farming systems in the Mekong Delta Vietnam: a feasibility study' (ANRE/1993/036) and 'An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta' (ASEM/1995/119)	'Mixed shrimp farming: mangrove forestry models in the Mekong Delta' (FIS/1994/012)
Economic	**Very high**	**High**
	• Early introduction of sustainable shrimp livelihoods into traditional rice production areas of brackish water environments during the dry season when rice production and livelihood alternatives were not feasible • Improved rice production during the wet season through integration of shrimp production and improved locally adapted, short-duration, salt-tolerant rice varieties at a time when saline intrusion was increasing and income from rice production was decreasing • Introduction of integrated systems with reduced risk that are resilient to climate change (drought, flood and saline intrusion) for climate-vulnerable smallholders • Economic impacts indicatively in the order of VND12,000 billion (AUD760 million) • A combined benefit:cost ratio of about 72:1, reflecting a very high net return on ACIAR's investment	• Significant contribution to new annual income from sustainable shrimp livelihoods in areas dominated by mangroves, which had traditionally provided very little income for landholders • Improved livelihoods from mangroves, including increased and early incomes from improved thinning strategies rather than waiting until harvest • The project was a significant influence at the time and 30% of adoption of these systems is attributed to the project • Economic impacts in the order of VND1,900 billion (AUD120 million) • A benefit:cost ratio of about 13:1, reflecting a good net return on ACIAR's investment
Inclusive value chain	**Low**	
	The projects did not have a value-chain focus. Integrated rice–shrimp and mangrove–shrimp farming systems were just coming into existence and beginning to display signs of future potential. The constraint to the development of these systems was rigorous scientific production systems research. However, as shrimp are an export commodity and their production escalated during the time the projects were implemented, the introduction of shrimp production into traditional rice and mangrove systems contributed to the development of shrimp export value chains, including market intermediaries, and processing, trade and advocacy groups such as the Vietnam Association of Seafood Exporters and Producers (VASEP).	
Environmental	**Moderate**	**Very high**
	• Reduced need for fertiliser and chemicals during rice production, as shrimp production provides disease suppression and nutrient benefits • Reduced need for feed during shrimp production, due to production of rice straw • Economic and environmental benefit of extensive or semi-intensive shrimp production integrated with rice production at a time when many farmers were unsuccessfully adopting intensive shrimp monocultures • Alternative livelihood to fishing during the dry season, reducing pressure on over-exploited fishing resources • Reduced water and sediment pollution in ponds, rivers and canals through reduced water exchanged with the sediment-laden Mekong River	• Prevention of the destruction and degradation of mangrove forests in Vietnam's Mekong Delta at a time when intensive shrimp monoculture provided extremely high profits and was leading to the destruction or degradation of mangroves • The preservation of mangroves prevented erosion, provided habitat for bird and fisheries species, protected coastal communities from extreme weather events and stored large reserves of blue carbon, helping to mitigate global climate change • Environmental impacts are expected to be long-term • Local communities stand to benefit most from these environmental impacts, although they also impact regional, national and global communities

Impact	'Assessment of the sustainability of rice–shrimp farming systems in the Mekong Delta Vietnam: a feasibility study' (ANRE/1993/036) and 'An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta' (ASEM/1995/119)	'Mixed shrimp farming: mangrove forestry models in the Mekong Delta' (FIS/1994/012)
Capacity	**High**	
	• Strong capacity building of research, extension and policy staff at Can Tho University, the Research Institute for Aquaculture No. 2 and the Centre for South Western Forest Research and Experimentation, and the provincial and district staff of local departments of Agriculture and Rural Development • Indirect capacity building from the project catalysed among researchers, extension and policy staff • Improved technical skills and infrastructure for rice breeding and shrimp hatcheries • Specific capacity building of extension specialists through field schools • Many project participants enhanced their career trajectories as a result of the project, with a number of participants occupying professional roles with high-responsibility and high-impact in their local areas	
Scientific	**Moderate**	**Low**
	• Understanding of the integration of shrimp and rice production into the one system • The project's scientific impact was focused on development of knowledge unique for application in context, as intended • Scientific findings were small and are now largely out of date, but they formed a basis from which further significant scientific research developed • The project contributed to the development of rice-breeding capacity and encouraged local breeders to breed locally adapted, short-duration, salt-tolerant rice varieties, providing the impetus for project team members to later develop rice varieties specifically for rice–shrimp systems that have been widely adopted across the Mekong Delta (one of which was awarded the World's Best Rice in 2019)	• Transferred scientific knowledge from international project partners to Vietnamese project partners • New scientific knowledge on the integration of shrimp production and mangrove silviculture within one system, some of which is still used to inform policy and management • The project's scientific impact was focused on the development of knowledge unique for application in context rather than advancement of science, as intended • The level of published outputs and their scientific impact is low
Policy	**High**	
	• Project leaders and participants demonstrated to national, provincial and district government officials the suitability of integrated rice–shrimp farming systems for brackish water environments, and mangrove–shrimp farming systems for saline water environments in Vietnam's Mekong Delta • Research findings influenced policy reform associated with land use, infrastructure improvement and management regulations • Without this policy reform, there would have been delay in the development of these systems, and the economic benefits of the project would not have been realised • Landholders are still benefiting from policy reform instigated by the projects	

Impact	'Assessment of the sustainability of rice–shrimp farming systems in the Mekong Delta Vietnam: a feasibility study' (ANRE/1993/036) and 'An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta' (ASEM/1995/119)	'Mixed shrimp farming: mangrove forestry models in the Mekong Delta' (FIS/1994/012)
Gender and youth	**Low**	
	• Gender equity was not a focus • Most members of the project team in Vietnam were men, but several female international specialists provided a gender perspective to the projects • Vietnamese project teams were young, and investment in early-career researchers has led to significant capacity impacts • The projects helped provide alternative livelihoods to at-risk communities, facilitating improved opportunity for children of farming families to pursue an education • The project team worked equitably with women and men, and had a small impact on women who were predominantly involved in shrimp husbandry, processing, retail and export	

A rice shrimp pond in Hoa My commune, Cai Nuoc district, Ca Mau province, Vietnam
Photo: ACIAR

1 Introduction

In the late 1990s, ACIAR funded 3 projects to support the development of economically viable and environmentally sustainable rice–shrimp and mangrove–shrimp farming systems in several provinces within Vietnam's Mekong River Delta Region. These projects recognised the possibility for rapid and unregulated expansion of integrated rice–shrimp and mangrove–shrimp farming in the Mekong Delta and the ensuing environmental and economic sustainability issues. The projects sought to support these farming systems through applied research that could lead to improved government land-use policy and planning, improved extension services, increased farm productivity and increased farming household income. The intention and design of these projects was for applied research – science for application, not science for the furtherance of science.

The purpose of this impact assessment is to identify the impact of these 3 projects on land-use policy, rice–shrimp and mangrove–shrimp farming households, extension services and the economy in Vietnam. The assessment outlines the intended impact pathways of the projects (from next users through to final users of project outputs), their outcomes and effects, and describes them qualitatively and, where possible, quantitatively. The assessment is made in terms of economic, environmental, capacity, scientific, policy, and gender and youth impacts.

These projects operated from July 1995 to December 2002 with the University of Western Sydney, the Australian Institute of Marine Science and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) as commissioning organisations. Collaborating organisations included the Australian Bureau of Agricultural Resources Economics; the University of Sydney; Can Tho University; the Vietnamese Research Institute for Aquaculture No. 2; the Sub-Institute of Water Resources, Planning and Management; the Southern Institute of Water Resources Research; the Network of Aquaculture Centres in Asia-Pacific (NACA); and the International Rice Research Institute. The title, duration, goal and objectives of the 3 projects are summarised below.

'Assessment of the sustainability of rice–shrimp farming systems in the Mekong Delta Vietnam: a feasibility study' (ANRE/1993/036)

This project was smaller than the other 2 projects, starting in July 1995 with an 18-month duration. It was a feasibility study that was a precursor to ASEM/1995/119. The project goal was to assess the long-term economic viability and sustainability of integrated rice–shrimp farming systems in the Mekong Delta. The objectives of the project were:

- to obtain an overview of the Vietnamese economy and the relative importance of rice–shrimp farming within the national economy, in particular in the Mekong Delta
- to describe institutional structures and arrangements associated with the practice of integrated farming systems and the marketing of commodities
- to obtain baseline data about the range of integrated rice–shrimp farming systems in the whole of the Mekong Delta
- to identify and define the factors influencing sustainability of the rice–shrimp system
- to identify available information and establish areas where further information was required.

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

This project started in July 1997 and, with an extension, had a 5.5-year duration. The project goal was to determine appropriate on-farm management strategies and government policies for farming systems in the brackish water coastal region of the Mekong Delta that were aimed at ensuring the long-term economic and environmental sustainability of the farming systems. The objectives of this project were:

- to provide a bioeconomic assessment of the sustainability of current land-use practices in the brackish water coastal strip of the Mekong Delta, particularly rice–shrimp farming systems

- to provide an assessment of government policy options that might promote the sustainability of these farming systems, particularly land-use planning, management of waterways and other environmental policies
- to determine sustainable management strategies that could increase productivity and raise incomes in these farming systems over the longer term without creating adverse environmental impacts.

'Mixed shrimp farming: mangrove forestry models in the Mekong Delta' (FIS/1994/012)

This project started in July 1995 and, with an extension, had a 5-year duration. The project goal was to optimise the economic yield from mixed shrimp aquaculture–mangrove forestry farming systems in the Minh Hai province in a sustainable manner. The objectives of this project were:

- to investigate factors controlling the yields of shrimp and wood from existing shrimp farming–mangrove forestry systems in the Minh Hai province of Vietnam
- in cooperation with selected farmers and appropriate managers, to experiment with shrimp pond and mangrove forest management to evaluate different culture options
- to identify improved culture methodologies for these systems and quantify, where possible, their expected yields and costs
- to assist national and provincial authorities to transfer results of the project to the wider coastal farming community in the Mekong Delta.

Note that in 1996 the Minh Hai province was split into 2 provinces: Ca Mau and Bac Lieu.

2 Methodology

The impact assessment team included one team member in Australia, Dr Elizabeth Petersen of Advanced Choice Economics Pty Ltd and the University of Western Australia, and one team member in Vietnam, Dr Hua Hong Hieu of Can Tho University.

Five tasks were conducted to complete the impact assessment:

1. **Desktop literature review**. Project documentation and related publications were reviewed to research available data and information on the project, and their impact.
2. **Initial consultation of project partners**. Semi-structured interviews were conducted with 7 people, including project leaders and participants who are currently in Vietnam, England, Australia and Thailand (Appendix 1). The aim of this initial consultation was to:
   a. understand the types and magnitude of project outputs, outcomes and impacts
   b. determine next and final users of project outputs, outcomes and impacts
   c. understand the nature of value-chain, economic, environmental, capacity, scientific, policy, and gender and youth impacts
   d. determine further data collection requirements.
3. **Extended consultation with local officials**. As determined by the initial consultation, more detailed interviews of 4 provincial research, policy and extension officers were conducted within the project provinces of focus to discuss changes in their farming systems through time and the impacts attributable to the projects (Appendix 2). Due to COVID-19 travel restrictions, all interviews were conducted via videoconferencing. A summary of interviews conducted for the initial and extended consultation is provided in Table 2.1.
4. **Discounted cashflow analysis of quantifiable economic impacts of the projects**. This analysis is presented in 5.3 Economic impact. It involves:
   a. estimating current adoption of rice–shrimp and mangrove–shrimp systems in the Mekong Delta
   b. estimating the counterfactual – expected adoption of these systems in the absence of the projects
   c. estimating the adoption of these systems attributable to the projects
   d. estimating the economic profitability (gross margin) of these farming systems over time
   e. applying standard discounted cashflow analysis methodology to estimate the present value of the economic impact of the projects.
5. **Summarising findings in this impact assessment report.** This impact assessment report provides a summary of data and information generated from desktop literature review, the initial consultation with project partners, the extended consultation with local officials and discounted cashflow analysis. Background information is provided in Chapter 3, a list of next and final users is provided in Chapter 4, and the value-chain, economic, environmental, capacity, scientific, policy, and gender and youth impacts are presented in Chapter 5. An overview of the impacts is provided with a summary of reasons for project successes in Chapter 6.

Table 2.1 Summary of interviews conducted by project

Project	Number of people interviewed	Number of project participants interviewed	Number of local officials interviewed
ANRE/1993/036	1	1	0
ASEM/1995/119	4	2	2
FIS/1994/012	6	4	2
Total	**11**	**7**	**4**

3 Background

This chapter provides background information on the development of Vietnam's rice, shrimp and mangrove sectors over time, as well as the temporal and spatial development of integrated rice–shrimp and mangrove–shrimp systems.

Over half of Vietnam's rice production occurs in the Mekong River Delta Region (Figure 3.3), especially within the provinces of An Giang, Dong Thap, Kien Giang, Long An, Soc Trang and Vinh Long.

3.1 Rice sector

Rice is the commodity with highest value of agricultural production in Vietnam – VND281 trillion in 2019 (AUD17.6 billion) – and is the country's second-largest export commodity (FAO 2022). Vietnam is the world's third-largest exporter of rice, with exports valued at VND66 trillion (AUD4.1 billion) in 2020. The area of rice harvested in Vietnam has increased steadily over the last 60 years, from 4.7 Mha in 1960 to 7.2 Mha in 2020 (Figure 3.1). The value and quantity of production increased strongly from 1980 to 2015, largely due to significant yield increases that were facilitated in part by the Doi Moi socialist-oriented market reforms initiated in the late 1980s (Figure 3.2). Production has stagnated in recent years. With yields remaining high, this stagnation is largely due to the recent decline in harvested area (USDA 2020).

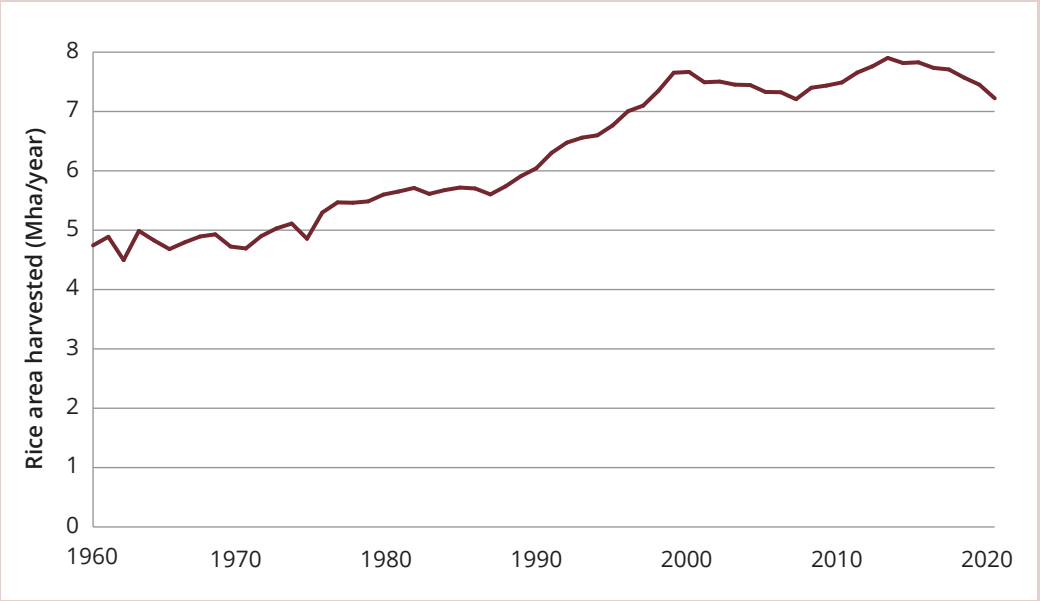

Figure 3.1 Rice area harvested per year in Vietnam, 1960–2020
Source: FAO 2022

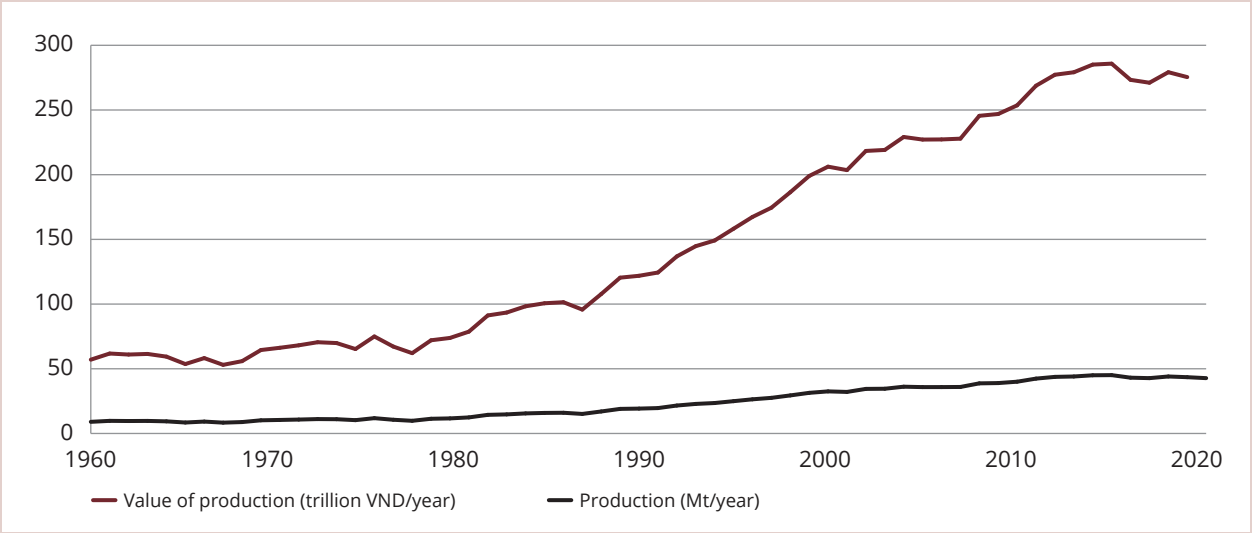

Figure 3.2 Rice production and value of production in Vietnam, 1960–2020
Source: FAO 2022

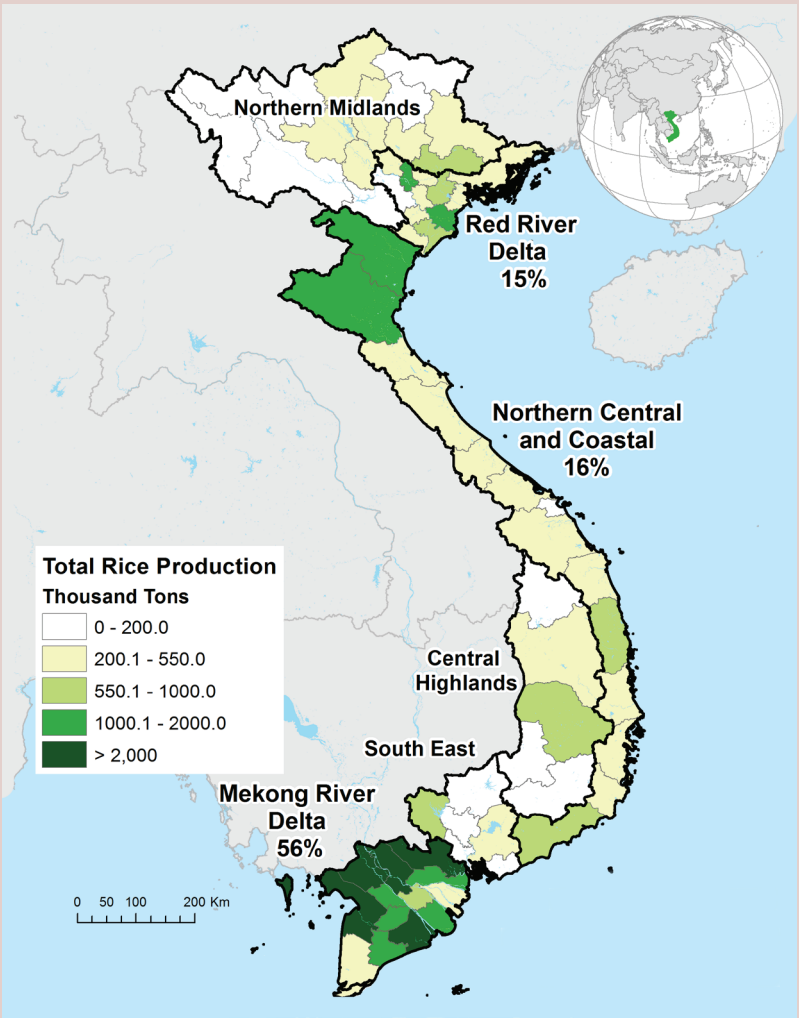

Figure 3.3 Rice-producing areas in Vietnam, 4-year average production, 2015–2018
Source: USDA 2022

3.2 Shrimp sector

Shrimp is the commodity with the third-highest value of agricultural production in Vietnam – VND152 trillion in 2019 (AUD9.5 billion) (FAO 2022; FishStatJ 2022). Production of shrimp in Vietnam started in the 1980s and increased slowly in the 1990s (Figures 3.4 and 3.5). It increased rapidly in the 2000s with the escalation in production of giant tiger prawn (*Penaeus monodon*) and then whiteleg shrimp (*Penaeus vannamei*). Whiteleg shrimp production experienced a sharp decline in 2008–2010 due to the emergence of white-spot disease. While there is no effective treatment of the disease, the development of control techniques to minimise its spread led to the escalation of production in Vietnam from 2010 to the present. Approximately 75% of total Vietnamese shrimp production comes from the Mekong Delta, especially from the provinces of Ca Mau, Bac Lieu and Soc Trang (World Bank 2014) (Figure 3.6).

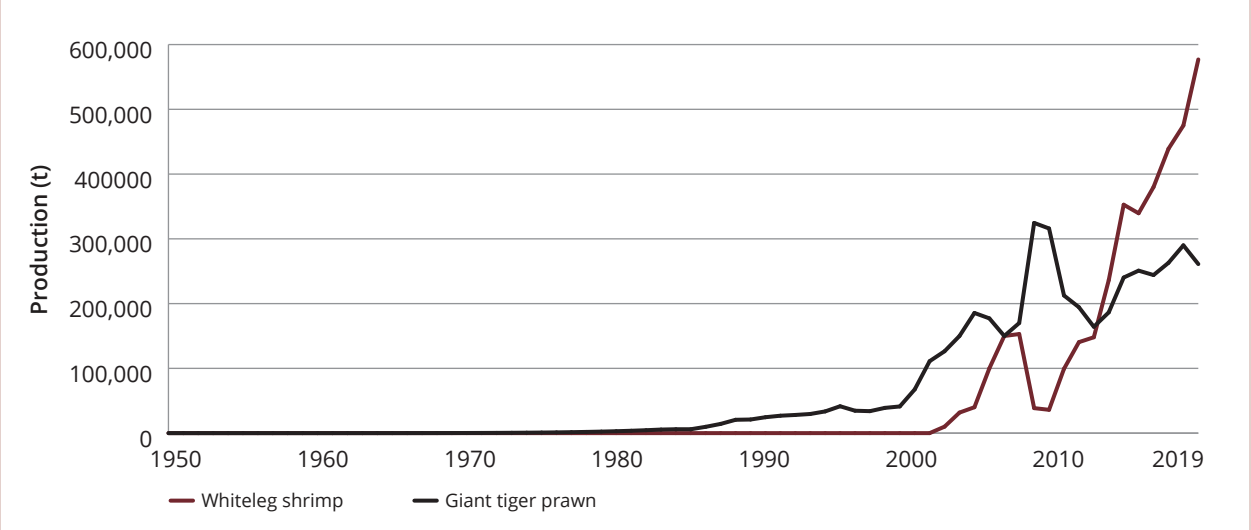

Figure 3.4 Production of various shrimp species in Vietnam, 1950–2019
Source: FishStatJ 2022

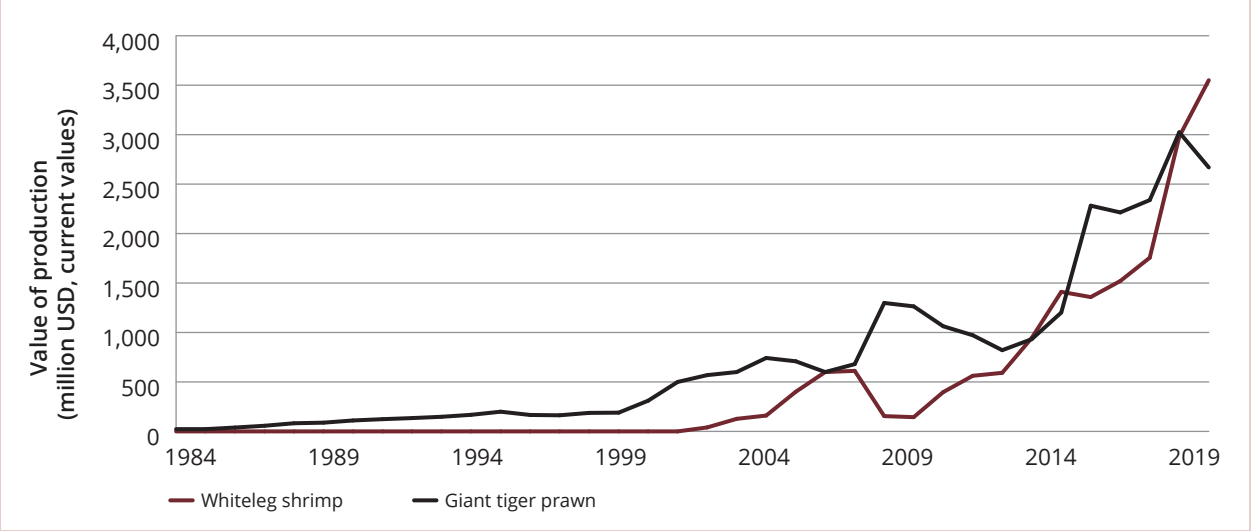

Figure 3.5 Value of production of various shrimp species in Vietnam, 1984–2019
Source: FishStatJ 2022

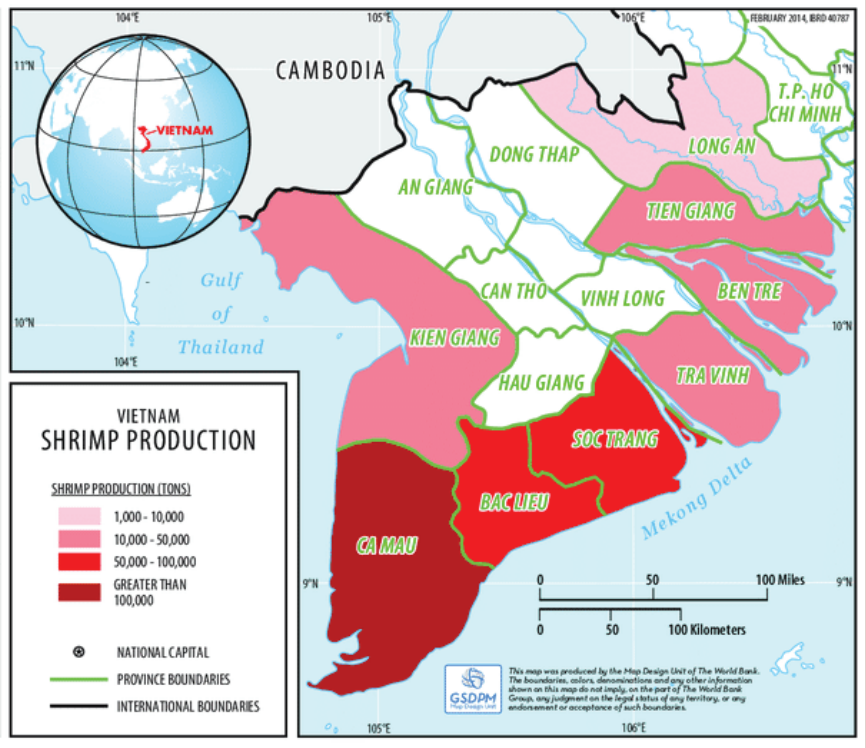

Figure 3.6 Principal shrimp growing areas in the Mekong Delta, Vietnam
Source: World Bank 2014

3.3 Rice–shrimp systems

Traditionally, farming activities in the Mekong Delta were dominated by rice production. Other livelihood alternatives were small in comparison to the dominance of rice, and included aquaculture, horticulture and livestock (Nhan et al. 2007). Farmers in the upper reaches of the Mekong Delta have access to fresh water all year round to grow 3 crops of rice per year, while those in the lower reaches of the Mekong Delta have saline intrusion, meaning that only one crop of rice is possible, during the dry season (Figure 3.7).

With booming global demand for shrimp, declining rice prices, increasing saltwater intrusion and the natural incursion of shrimp postlarvae during seasonal saline intrusion, integrated rice–shrimp farming systems began to develop in the Mekong Delta in the late 1980s (Nhuong et al. 2002). In their simplest form, these systems involve rice cultivation during the wet season and shrimp cultivation during the dry season, although there are many variations. The Mekong Delta has a complex network of channels and sluice gates, and by opening the sluice gates in the dry season, farmers can allow saline water to enter irrigation channels and fill rice ponds for growing shrimp (Leigh et al. 2017). In the wet season, farmers rely on monsoon rains to desalinate the water and top soil layer in preparation for planting rice (Preston and Clayton 2003; Nhan et al. 2012).

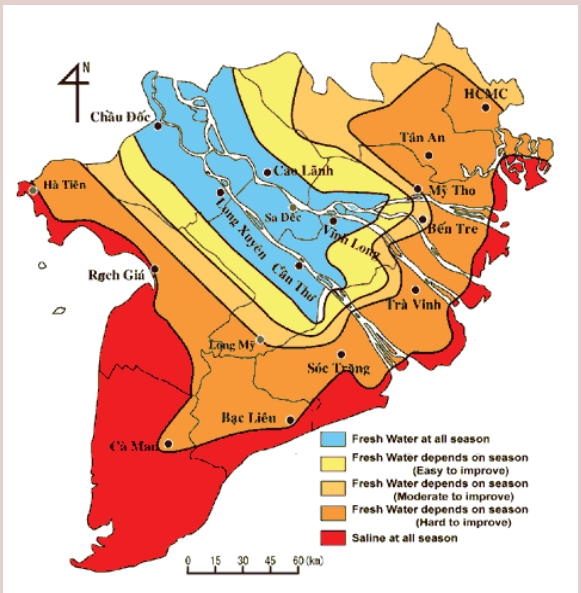

Figure 3.7 Seasonal saline intrusion in the Mekong Delta, Vietnam
Source: Nguyen and Ford 2010

These systems were met with initial reticence from the Vietnamese Government, due to the unknown impact of saline intrusion in the dry season on the build-up of salt in the soil and therefore on rice production during the wet season. Salt had always been antagonistic to agriculture, so there was understandable resistance to the introduction of brackish water systems in traditional rice-growing areas.

Trialling of integrated rice–shrimp farming systems started on pilot farms. When research results became available, it was observed that, with appropriate practices and technologies:

- saline intrusion did not lead to long-term build-up of salts in the soil
- there were additional benefits of using locally adapted, short-duration, salt-tolerant rice varieties
- use of improved extensive or semi-intensive systems avoided the problems of intensive shrimp farming (such as disease)
- shrimp production provided significantly higher profit than rice production.

Through a process of consultation, and demonstration of these findings with provincial extension and policy officials, agricultural land-use and management policy was reformed. In conjunction with a program of research and development activities to understand appropriate management and technologies required for the system, as well as extension and implementation activities, areas of rice–shrimp systems expanded rapidly. ANRE/1993/036 and ASEM/1995/119 played a significant role in these research, development, extension, implementation and policy reform pathways.

In 1984, the area of rice–shrimp systems was estimated to be 5,000 ha (Xuan and Matsui 1998), in 2000 it was estimated to be 40,000 ha (Brennan et al. 2002; Preston and Clayton 2003), in 2014, 153,000 ha (USAID 2016), and in 2016, 160,000 ha (Tuan et al. 2016). It is speculated that the area will continue to rise to about 250,000 ha by 2030 (Tuan et al. 2016) (Figure 3.8).

Rice–shrimp systems are commonly found in Soc Trang, Ca Mau, Kien Giang, Ben Tre and Tra Vinh provinces. Giant tiger prawn is currently the shrimp species most commonly cultured in these systems. Farmers also stock other aquatic food species, such as mud crab (Leigh et al. 2017). These aquatic food species are cultivated using improved extensive systems, with improved seed and low stocking and feed intensities. These integrated rice–shrimp systems are economically viable and environmentally sustainable due to low input use. They are resilient to problems faced by other agricultural industries in the region, such as drought, flood, saline intrusion and rising sea levels resulting from climate change. Due to the relatively high profitability of shrimp production compared with rice production, many farmers have tried switching to intensive, or even super-intensive, shrimp monoculture systems without reaching the expected increase in profits due to issues such as disease outbreaks (consultation processes; Preston and Clayton 2003).

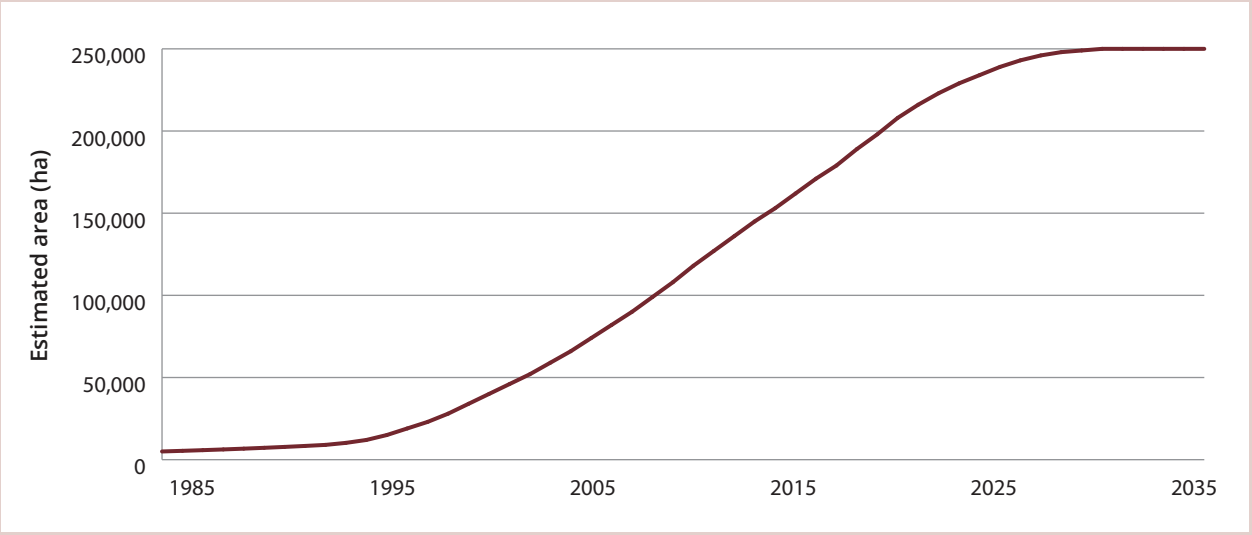

Figure 3.8 Estimated area of rice–shrimp systems in the Mekong Delta, Vietnam, 1985–2035
Source: Author estimates using Xuan and Matsui 1998, Brennan et al. 2002, Preston and Clayton 2003, USAID 2016 and Tuan et al. 2016

3.4 Mangroves

Mangroves are intertidal wetlands occurring along tropical, subtropical and warm-temperate coastlines (Nguyen et al. 2021). Approximately 70% of Vietnam's mangroves are in the Mekong Delta, and 50% are within the Ca Mau province (Tuan et al. 2016). They provide significant benefits to coastal communities by preventing erosion, providing habitat for bird and fish species, protecting coastal communities from extreme weather events, and storing large reserves of blue carbon, thus helping to mitigate global climate change (Nagelkerken et al. 2008; Koch et al. 2009; Atwood et al. 2017; Ouyang et al. 2018; Hochard et al. 2019). They provide habitat and nursing grounds for commercial and non-commercial fish species, food, medicine and building materials, and fuel for local communities. Vietnamese mangroves are home to some of the most productive and biologically important ecosystems of the world, dominated by *Rhizophora* and *Avicennia* genera (Veettil et al. 2019).

Mangroves were reported to cover over 400,000 ha in the 1940s – approximately 1.2% of the country (Hong and San 1993) – but this dramatically declined to about 73,000 ha by the 1990s (FAO 2015). Most of this decline occurred in the period 1962 to 1975 due to aerial spraying of herbicides during wartime (Nguyen et al. 2021). In later years, conversion to aquaculture and coastal development have been the dominant drivers of mangrove loss or degradation, estimated at 161,000 ha from 1953 to 1995 (Phillips et al. 1993; Minh et al. 2001; Veettil et al. 2019).

The dramatic decrease in mangrove cover has led to initiatives by the Vietnamese Government and non-government organisations to preserve and replant mangrove ecosystems. About 200,000 ha of mangroves reforestation and restoration activity has been conducted with government and non-government organisation funds (Hai et al. 2020). Current mangrove coverage is approximately 240,000 to 270,000 ha (FAO 2015; MARD 2020). The distribution of mangrove forests by province includes Ca Mau (71%), Tra Vinh (10%), Ben Tre (9%), Bac Lieu (5%) and Soc Trang (4%) (Luat and Thuy n.d.). The change in mangrove area in Ca Mau between 1999 and 2018 as a result of these plantings is shown in Figure 3.9.

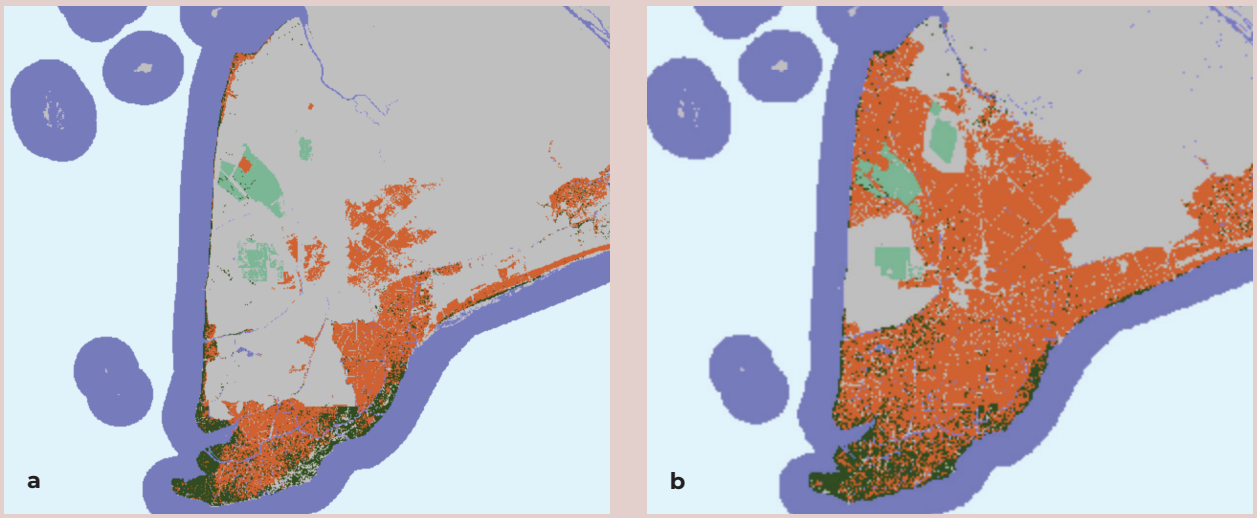

Figure 3.9 Areas of mangroves (dark green), wetlands (teal) and ponds (orange) in Ca Mau in (a) 1999 and (b) 2018
Source: Aronson 2022

3.5 Mangrove–shrimp systems

Integrated mangrove–shrimp farming systems have developed mainly in Indonesia and Vietnam and include water canals between platforms planted with mangroves. Improved extensive or semi-intensive farming systems are used, where farmers stock shrimp through tidal water exchange and hatchery sources, and feed and chemical inputs are very low (Johnston et al. 2000; Primavera et al. 2000; Bosma et al. 2016). They are a form of low-input sustainable aquaculture (Ahmed et al. 2018).

Mangrove–shrimp systems are environmentally sustainable, as they allow farmers to generate income while maintaining areas of mangroves. Farmers can gain profits without the negative environmental impacts experienced by industrial intensive shrimp farming systems, with relatively low investment costs, low risk of crop failure, low incidence of disease and high profits (Ha et al. 2012b, 2014; Joffre et al. 2015). They are nature-based farming models, so shrimp products can be certified as organic, opening increased access to discerning international markets and higher prices (Jonell and Henriksson 2015).

Mangrove–shrimp systems contribute significant value to household livelihoods in the Mekong Delta (Nguyen KAT et al. 2016; Nguyen HQ et al. 2020). Shrimp culture is the focus of income generation from these systems, as profits are high and income is annual. Mangroves provide significant benefits for shrimp production. Income from the thinning and harvest of mangrove wood is generated from 5 years (for firewood and light construction materials) to 20 years (for heavy construction material), so mangroves provide a smaller proportion of income than shrimp.

The current area of integrated mangrove–shrimp farming systems is approximately 50,000 ha (Osborne 2018; Seafood-tip 2021), and is estimated to have increased rapidly between 2000 and 2010 (Figure 3.10). Integrated mangrove–shrimp systems are mostly found in Ca Mau (Figure 3.11) and make up around 15% of the shrimp farming area in this province (Ha et al. 2012a).

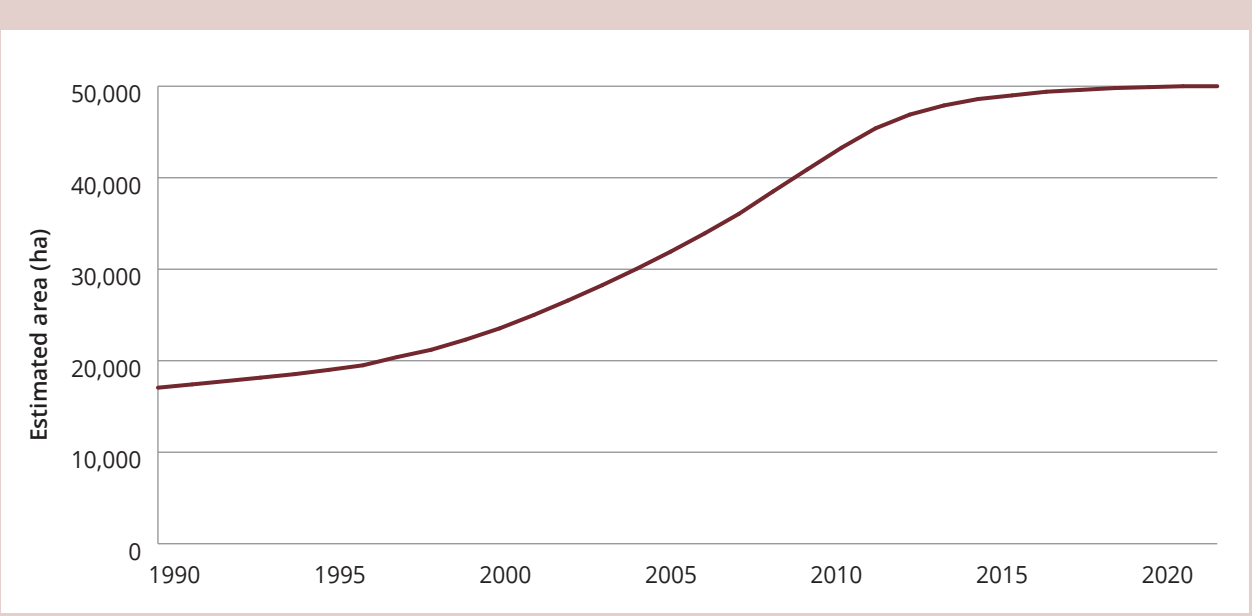

Figure 3.10 Estimated area of integrated mangrove–shrimp farming systems in the Mekong Delta, Vietnam, 1990–2020

Source: Author estimates

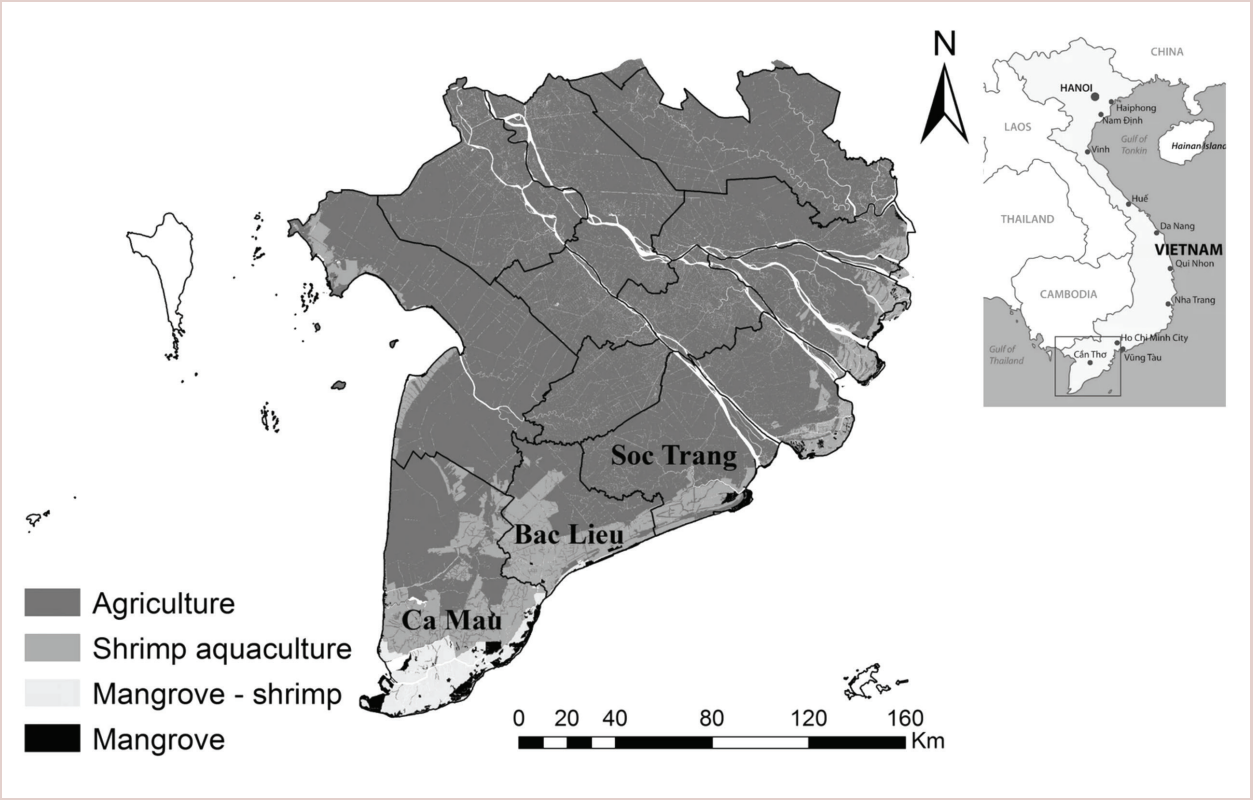

Figure 3.11 Mekong Delta region of Vietnam, showing the concentration of mangrove–shrimp systems in Ca Mau
Source: Joffre et al. 2018

4 Next and final users

4.1 Next users

As 20 to 25 years have passed since the completion of the 3 projects, the knowledge from these projects has been dispersed widely throughout Vietnam and internationally. This list is not considered to be complete or definitive.

Industry

- Vietnam Association of Seafood Exporters and Producers

Research

- Can Tho City Institute for Socio-economic Development Studies
- Can Tho University
- Centre for South Western Forest Research and Experimentation

Government

- Centre for Agricultural Extension in the various provinces of Vietnam's Mekong Delta, especially Agricultural Extension Center of Ca Mau
- Department of Agriculture and Rural Development in the various provinces of Vietnam's Mekong Delta
- Fisheries Sub-department of Ca Mau
- Mekong Delta Agricultural Extension Project
- Mekong River Commission
- Ministry of Fisheries
- Provincial People's Committee in the various provinces of Vietnam's Mekong Delta
- Research Institute for Aquaculture No. 2
- Sub-Institute for Fisheries Research, Ca Mau

International

- Canada International Development Agency
- German Agency for International Cooperation
- Network of Aquaculture Centres in Asia-Pacific
- VVOB, Belgium
- World Bank Coastal Wetlands Protection and Development Project

4.2 Final users

Final users of ANRE/1993/036 and ASEM/1995/119 are current and potential rice–shrimp farmers in brackish water coastal regions of the Mekong Delta.

Final users of FIS/1994/012 are current and potential mixed shrimp aquaculture–mangrove forestry farmers and government officials in Ca Mau and Bac Lieu.

5 Impact assessment

5.1 Impact of ANRE/1993/036

The integration of shrimp farming into traditional rice-growing areas of the Mekong Delta in Vietnam was an innovative development at the time these projects commenced. The influx of saline water into the freshwater canal system during the dry season was initially expected to be detrimental to rice monocultures, which are the dominant agricultural crop in the area. In his master thesis, Dr Tran Thanh Be initially identified the potential opportunity of integrating rice and shrimp cultivation, thereby creating a new cash income source from aquatic organisms while maintaining, or potentially augmenting, rice cultivation. Dr Vo Tong Xuan (at that time, Head of the Mekong Delta Development Research Institute, Can Tho University) took Dr Tran Thanh Be's work to ACIAR, and ACIAR initiated the feasibility study 'Assessment of the sustainability of rice–shrimp farming systems in the Mekong Delta Vietnam: a feasibility study' (ANRE/1993/036).

The project goal of ANRE/1993/036 was to assess the long-term economic viability and sustainability of integrated rice–shrimp farming systems in the Mekong Delta. The feasibility study surveyed 100 farmers and quantified various aspects of rice–shrimp systems, such as rates of sedimentation and salinisation and their impact on rice production, numbers of seedstock available, impacts of agrochemicals on shrimp production and rates of algae formation. One of the main findings was an agreed direction for further research and associated priorities, which led to the development of the larger project, 'An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta' (ASEM/1995/119). The biggest impact of the feasibility study was that it led to the larger project, which in turn had a diverse and widespread impact in the region. With this in mind, the impact assessment of ANRE/1993/036 will be considered within the impact assessment of ASEM/1995/119.

5.2 Impact pathways

ASEM/1995/119

The impact pathway taken by ASEM/1995/119 was novel for its time. The project operated during a time when direct engagement with industry was rare and extension processes were supplementary to applied research. ASEM/1995/119 engaged an impact pathway that defied this paradigm by using novel influencing activities that are now considered to be important processes for change. These included:

- farmer-driven and place-based experimentation and learning
- cooperation between researchers, local and regional government staff and farmers throughout the project
- demonstration sites for farmer extension activities
- employment of the 'farmer school' extension system and demonstration of the triple-bottom-line benefits of the technology in the context of other household activities
- adaptive learning in response to emerging issues.

Research for ASEM/1995/119 involved the cooperation of farmers, local government agencies and researchers in the provinces of Soc Trang and Bac Lieu throughout the project. The earliest adoption was through on-farm research collaboration, where an influential farmer was selected to provide the experimental site and was trained in farming techniques during the experimental period. This farmer became a champion of these systems and a source of advice for other farmers. The project then directly involved 10 farmer families in the rice–shrimp field experiments and 400 households in survey processes. The research considered the role of rice–shrimp systems within the wider context of other household activities and the cumulative impact of potential growth of these systems geographically from local to regional scales.

Project staff from Can Tho University and the local agricultural extension service made direct use of the research sites as 'demonstration' fields for farmer extension activities. Farmers received extension advice from various sources, including the extension service and Can Tho University staff. Monthly farmer meetings were conducted in Soc Trang, in which project participants, local government staff and extension staff participated. This collaboration led to the development of best-management practices for integrated rice–shrimp farming that were imparted to farmers via a 'farmer school' extension system, which included videos, CDs and extension leaflets designed specifically for farmers. Extension materials were widely distributed to farmers and extension officers in the region.

Project team members understood that they had to engage provincial government agencies in order to conduct research and extension activities, and that policy reform was needed for widescale adoption of integrated rice–shrimp systems. The project provided support to the provincial Departments of Agricultural and Rural Development and the local authorities for sustainable development of rice–shrimp farming systems through improved planning, land-use management and extension services. Departmental staff were trained in understanding rice–shrimp farming systems management and conducting field monitoring and research activities. This encouraged local policymakers to adopt policies that facilitated the adoption of integrated rice–shrimp systems. In some areas in the Mekong Delta, land was zoned as suitable only for integrated rice–shrimp farms.

FIS/1994/012

At the time that FIS/1994/012 was conducted, applied research rarely engaged with industry, and extension processes were generally conducted as a separate project or by a separate organisation than those conducting the research. FIS/1994/012 focused mostly on developing technical outputs, so impacts were mostly generated for project participants. When the project received a costed variation, it entered an extension phase. This extension phase included:

- preparing extension materials for government agencies, extension officers and farmers, based on the technical outputs from the project
- training a core group of extension officers to a high level of competence
- building research expertise in research institutions, especially the Research Institute for Aquaculture No. 2
- engaging with provincial government staff to encourage a policy shift to integrate recommendations into enterprise district and provincial government policy
- developing linkages with other existing and planned new projects in the lower Mekong Delta provinces, so that other projects could build on the results and experience of the project and maximise spillover benefits.

Extension materials, training, capacity building, engagement and project linkages were developed to a limited extent through these processes. The dominant impact pathway for FIS/1994/012 was through new technical knowledge developed by the project team that was transferred through the new and subsequent projects that team members participated in.

5.3 Economic impact

ASEM/1995/119

Sources of economic impact

The most critical impact of ASEM/1995/119 was to provide assurance to the Vietnamese central and provincial government agencies that the introduction of shrimp production in rice paddies during the dry season would not adversely affect rice production in the same paddies during the wet season. At the time the project commenced, the government was concerned that growing shrimp in the dry season would result in salinisation of the soil during the wet season. Salt was considered to be an enemy of agricultural production. The concern was that when the rain came at the end of the dry season, there would be residual salt in the soil, preventing rice production. The project was able to show that this wasn't the case – that by using appropriate technology and management techniques, the rain flushes out almost all of the salt in the soil.

This project was instrumental in influencing government mindset that brackish water farming systems have significant potential. This mindset continues to this day, as evidenced in the Vietnamese Government's latest 10-year plan, which gives very high priority to integrated rice–shrimp farming systems and has set ambitious targets for shrimp exports (Government of Vietnam 2013). Introducing shrimp into the farming system gave smallholders a source of income during the dry season at a time when farmers had no significant agricultural alternatives, especially with a changing climate leading to increasing saline incursion. It allowed farmers to manage risk associated with rice monocultures with a system that is resilient to drought, flood and salinisation.

The project was able to show the mutual benefits from integrating shrimp and rice production. For example, shrimp production has pest management benefits for rice production, as miniscule amounts of salt in the soil dissuades the brown planthopper (*Nilaparvata lugens* (Stål)), a significant rice pest, from eating the rice crop.

Over time, the Vietnamese Government's initial aversion to introducing shrimp production in traditional rice-growing areas would have changed without this project, but it did bring forward the government's confidence in these systems by a number of years. From interviews conducted during the consultation processes, it is estimated that the project accelerated the adoption of these systems by about 3 years. Shrimp production in the Mekong Delta escalated during the 2000s. Without ASEM/1995/119, there would have been significant doubt about the viability of rice–shrimp farming systems during this critical time of growth in the shrimp industry.

While the major economic impact of the project was to facilitate the early integration of shrimp into rice-producing farming system, the project also had an impact on increasing rice yields. The project's research on the rice component identified a rice variety suited to salinised field conditions and, more importantly, encouraged local project members to develop locally adapted, salt-tolerant, short-season rice varieties. With this encouragement, researchers did develop this capacity. Local rice varieties bred specifically for integrated rice–shrimp systems are currently being used throughout the Mekong Delta. These rice varieties minimise the risks associated with increasing saline intrusion, where use of traditional varieties would have caused farmers to suffer economic losses.

The activities of this project were centred in 2 provinces: Bac Lieu (Gia Rai district) and Soc Trang (My Xuyen district). The project's impacts were initially experienced in these provinces but subsequently grew to all provinces with brackish water rice–shrimp production: Ca Mau, Bac Lieu, Soc Trang, Kien Giang, Tra Vinh, Ben Tre and Tien Giang.

Estimating the adoption impact of the project

Based on the consultation process undertaken to inform this impact assessment, it is assumed that the major economic impact of the project was to bring forward the adoption of integrated rice–shrimp systems by 3 years. Figure 5.1 shows the estimated impact of the project on adoption of these systems, where the brown line is the actual adoption of these systems through time (with the project), and the black line is the counterfactual, the estimated adoption of these systems in the absence of the project. The adoption impact of the project is the difference between these 2 lines as shown in Figure 5.2.

Estimating the gross margins of rice–shrimp systems

The value of the project's adoption impact is determined by the profitability of integrated rice–shrimp farming systems compared with rice monocultures over this time period. The increase in profits made on farms by introducing integrated rice–shrimp systems is the profit made during the shrimp phase and increases in rice yields due to rotational benefits from the shrimp (such as improved pest management). The project also had economic impacts of encouraging local researchers to develop locally adapted, short-duration, salt-tolerant rice varieties.

Estimated gross margins of extensive shrimp production in the Mekong Delta are shown in Figure 5.3. These gross margins are estimated using shrimp yields from Brennan et al. (2002) and Leigh et al. (2017), international shrimp prices from **www.indexmundi.com**, consumer price indices for 1992 to 2000 from **tradingeconomics.com** and for

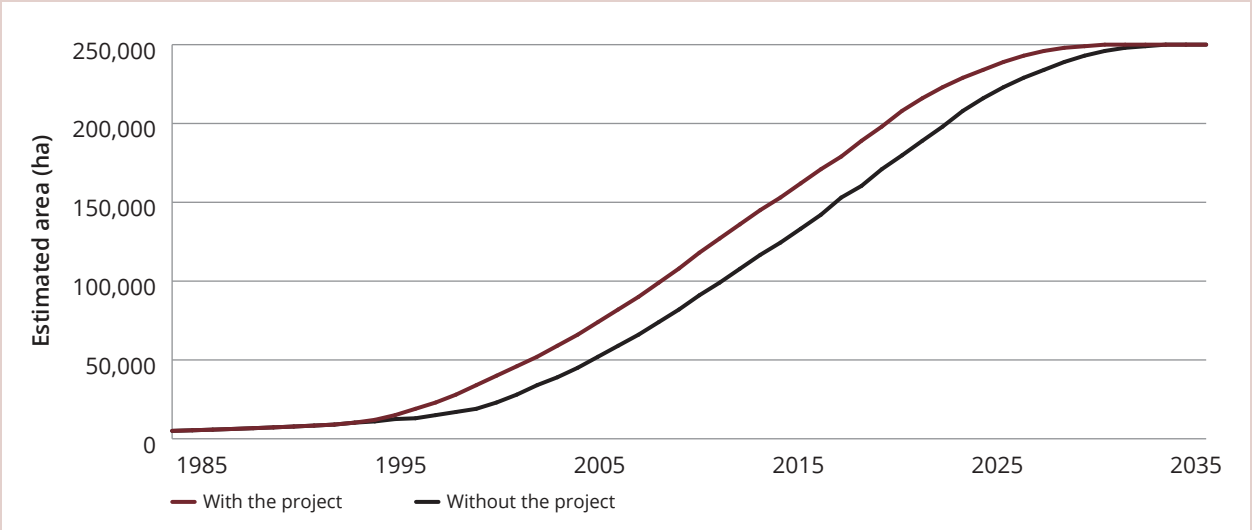

Figure 5.1 Estimated area of rice–shrimp systems in the Mekong Delta, Vietnam, with and without ASEM/1995/119 (including ANRE/1993/036), 1985–2035

Source: Author estimates

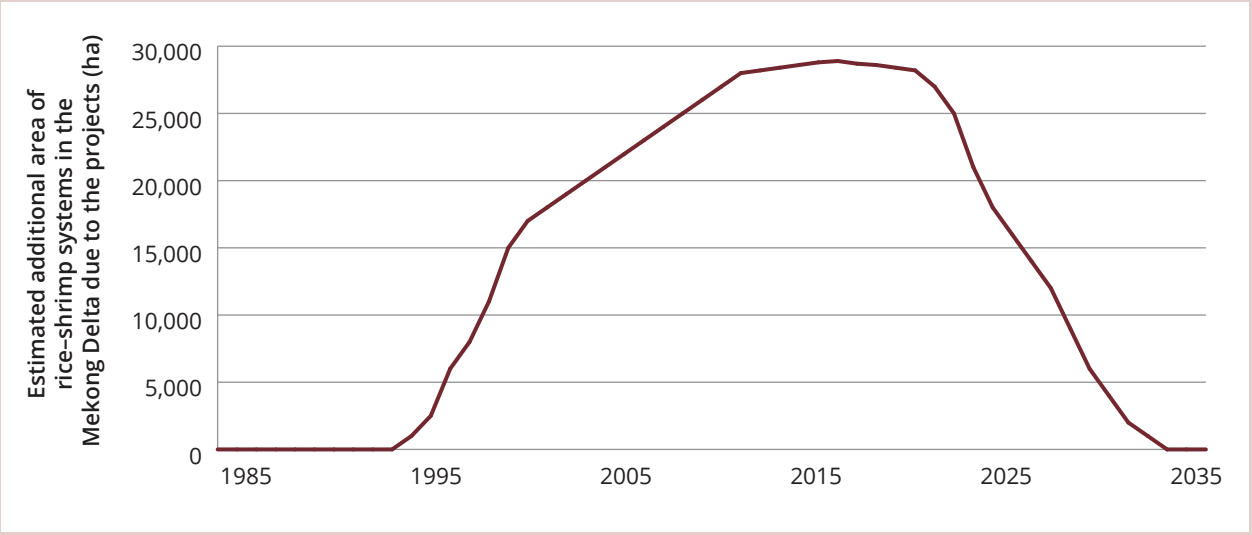

Figure 5.2 Estimated additional area of integrated rice–shrimp systems in the Mekong Delta, Vietnam, due to ASEM/1995/119, 1985–2035

Source: Author estimates

Figure 5.3 Estimated gross margin of shrimp production in the Mekong Delta, Vietnam, 1992–2021, real 2022 values

Source: Author estimates

2001 to 2021 from FAO (2022), and conversion of international to farmgate price and proportion of costs in gross revenue from Brennan et al. (2002). The trend in gross margin largely reflects shrimp prices, which increased quickly from the early 1990s to 2000, then declined to 2010 and has remained relatively steady over the last 12 years.

Indicative value of the project's adoption impact

Multiplying estimates of the gross margin of shrimp production (Figure 5.3) by the estimated area of adoption attributable to the project (Figure 5.2) provides an estimation of the value of the adoption impact (Figure 5.4). Because the area of these systems is still expanding today, 20 years after the cessation of the project, the benefit of generating early adoption of these projects is still being generated, and this is expected to continue until about 2035.

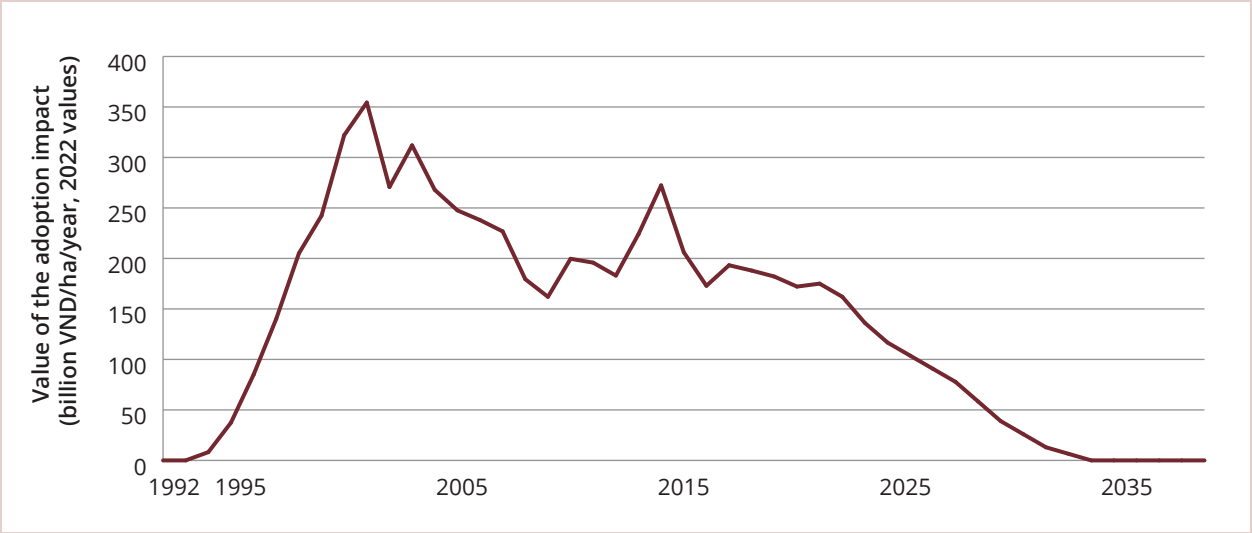

Figure 5.4 Estimated value of the adoption impact due to ASEM/1995/119, 1992–2038, real 2022 values
Source: Author estimates

Discounted cashflow analysis of the project's economic impact

Standard discounting cashflow analysis is used to estimate the project's economic impact. Equations used are shown in Appendix 3. All values are converted from nominal (current) monetary values to real (2022) values. The time value of money is accounted for using a standard 5% compound/discount rate.

Results of the discounted cashflow analysis are presented in Table 5.1 for the indicative benefits generated up until 2022, as well as the indicative benefits until 2035. The total indicative economic impact is estimated to be about AUD760 million (VND12,000 billion). This is the sum of the present values from 1992 to 2022. The project cost of ANRE/1993/036 was AUD112,900 in 1995. The project cost of ASEM/1995/119 was AUD997,525 in 1997. The cost of the project extension of ASEM/1995/119 was AUD194,825 in 2000. Adjusting these values to account for inflation, and compounding them to present values, the combined cost of these projects was equivalent to a present value of AUD11 million (VND170 billion). The indicative net benefit of the project (the difference between the present value of the benefits and costs) is estimated to be AUD750 billion (VND12,000 billion). The ratio of total benefits to costs is 72, meaning that for every dollar invested by ACIAR, the project has generated about 72 dollars. This benefit:cost ratio is expected to increase when considering future benefits of the project to 2035, and represents a very large return on ACIAR's investment.

Table 5.1 Discounted cashflow analysis of the indicative economic impact of ASEM/1995/119 (including ANRE/1993/036), 1992–2022, present values

	AUD million	VND billion
1992–2022		
Total indicative benefits	764	11,977
Total costs	11	167
Net indicative benefit (benefits minus costs)	754	11,810
Indicative benefit:cost ratio (benefits divided by costs)		72
1992–2035		
Total indicative benefits	811	12,701
Total costs	11	167
Net indicative benefit (benefits minus costs)	800	12,534
Indicative benefit:cost ratio (benefits divided by costs)		76

A sensitivity analysis was conducted on key assumptions of the discounted cashflow analysis, and the resulting benefit:cost ratios are presented in Table 5.2. Three key assumptions were considered:

1. the discount rate – a low discount rate of 3% and a high discount rate of 7%
2. the length of time the project brought forward the Vietnamese Government's confidence in integrated rice–shrimp systems – a shorter length of time of 2 years and a longer length of time of 4 years
3. the shrimp gross margin – where gross margins are reduced by 20% and increased by 20%.

Based on this sensitivity analysis, it is estimated that the project's benefit:cost ratio may range from 51 to 89.

Table 5.2 Benefit:cost ratio with low, standard and high values for key assumptions of the discounted cashflow analysis, 1992–2022

	Level of each key assumption		
Key assumption	**Low**	**Standard**	**High**
Discount rate (3%, 5%, 7%)	85	72	62
Length of early introduction (2 years, 3 years, 4 years)	51	72	89
Shrimp gross margin (0.8, 1, 1.2)	58	72	86

FIS/1994/012

Sources of economic impact

FIS/1994/012 commenced at a time when land-use policies were changing in Vietnam to prevent the continued decline of mangrove deforestation. The area of mangroves had declined quickly from the mid-1940s to mid-1990, after which reforestation and restoration activities gained momentum and the area of mangrove forest started to increase. The major economic benefit of this project was to facilitate landholders to earn a profitable livelihood without degrading or deforesting mangrove areas on their land. The project transferred scientific knowledge from international project collaborators to Vietnamese partners, promoted the adaptation of this knowledge to local conditions and engaged with policymakers to instigate policy reform to enable the development of these systems. The annual income from shrimp production offset the longer-term nature of income from mangrove thinning and harvest.

The project trained farmers in appropriate mangrove management to facilitate organic shrimp production. For example, the project helped farmers manage mangrove density and thinning to prevent excessive leaf fall affecting water quality and to increase sunshine, which is required to oxygenate water for shrimp growth. Mangroves have scope for absorption of nutrients and organic matter, and shrimp eat leaf and organic food from mangroves, leading to improved water quality discharged into canals. The project helped develop water quality standards in these systems for certification of organically produced shrimp, such as farm certification from the Aquaculture Stewardship Council, increasing export market access and generating higher export prices. The price for certified shrimp is, on average, 10% higher than for uncertified shrimp.

Estimating the adoption impact of the project

FIS/1994/012 had a significant influence in the development of integrated mangrove–shrimp systems. Based on the consultation process undertaken to inform this impact assessment, it is estimated that 30% of the benefits from development of integrated mangrove–shrimp systems can be attributed to the project (Table 5.3), with a very low likelihood that other projects would have been funded in the absence of FIS/1994/012. This attribution is estimated from talking with several people, including Dr Vo Nguon Thao, who attributes the development of the systems to 3 main projects as well as farmers' experiences.

Figure 5.5 shows estimates of the actual area of integrated mangrove–shrimp farming systems within the Mekong Delta (brown line), and 2 hypothetical counterfactuals:

- adoption through time without any research, due to farmers' experience only (black line)
- estimated adoption through time with experience and FIS/1994/012 research only (orange line).

The indicative increase in adoption due to FIS/1994/012 is shown in Figure 5.6.

Estimating the gross margins of mangrove–shrimp systems

The profitability of integrated mangrove–shrimp farming systems through time is estimated by the gross margin (Figure 5.7). The gross margin from integrated mangrove–shrimp farming is calculated as the shrimp gross margin calculated in Figure 5.3, doubled to consider year-round shrimp production (not just during the dry season), and multiplied by the proportion of the farm used for shrimp production (62%, Lai et al. 2022). Ninety per cent of the total gross margin of the mangrove–shrimp enterprise is assumed to be from shrimp, and a further 10% from mangroves (Trang et al. 2022).

Table 5.3 Attribution of development of integrated mangrove–rice systems across sources

Source	Major contribution	Years	Attribution (%)
FIS/1994/012	• Determining optimal ratio between mangroves and shrimp ponds by land area • Project recommendations adopted in Ca Mau	1994–1999	30
General management program of coastal zone (German Agency for International Cooperation)	• Developing mangrove seeds • Techniques of monitoring and restoring mangroves in Ca Mau and Bac Lieu • Restoring mangrove co-management in communities	Unknown	20
Mangrove restoration project through raising sustainable mangrove–shrimp system (MAN) at Nhung Mieng Protected Mangrove	• Training and improvement in aquaculture processing techniques (SNV the Netherland) • Helping farmers understand the value of integrated mangrove–shrimp systems, and providing training for implementation	2016–2020	40
Other factors and experience from farmers			10
Total			**100**

Source: Dr Vo Nguon Thao (personal communication, 2022)

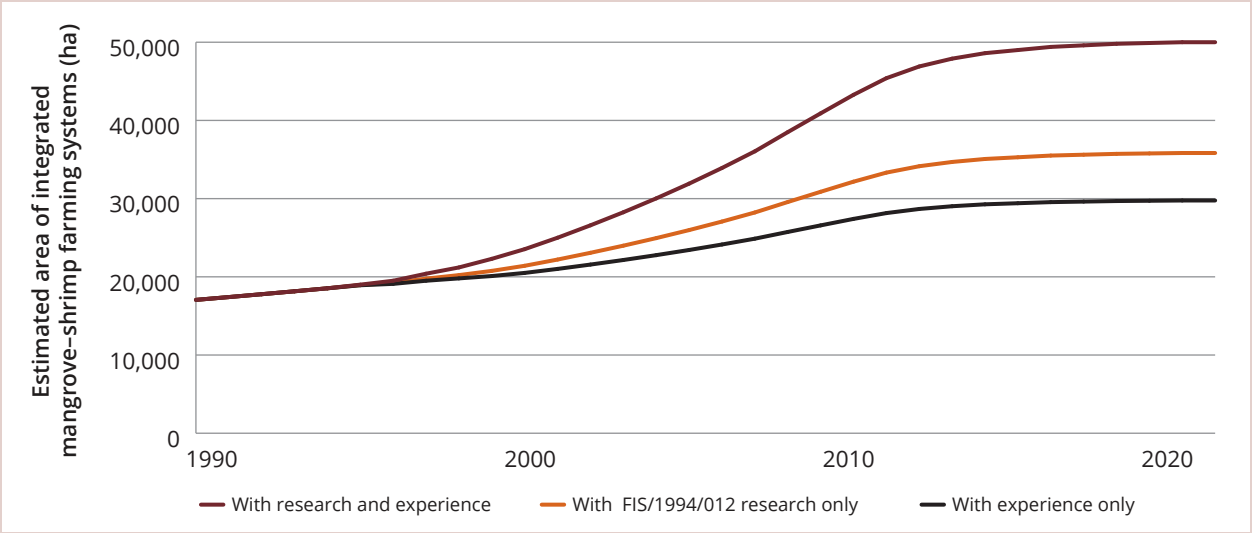

Figure 5.5 Estimated area of integrated mangrove–shrimp systems in the Mekong Delta, Vietnam, with and without research and experience, 1990–2021

Source: Author estimates

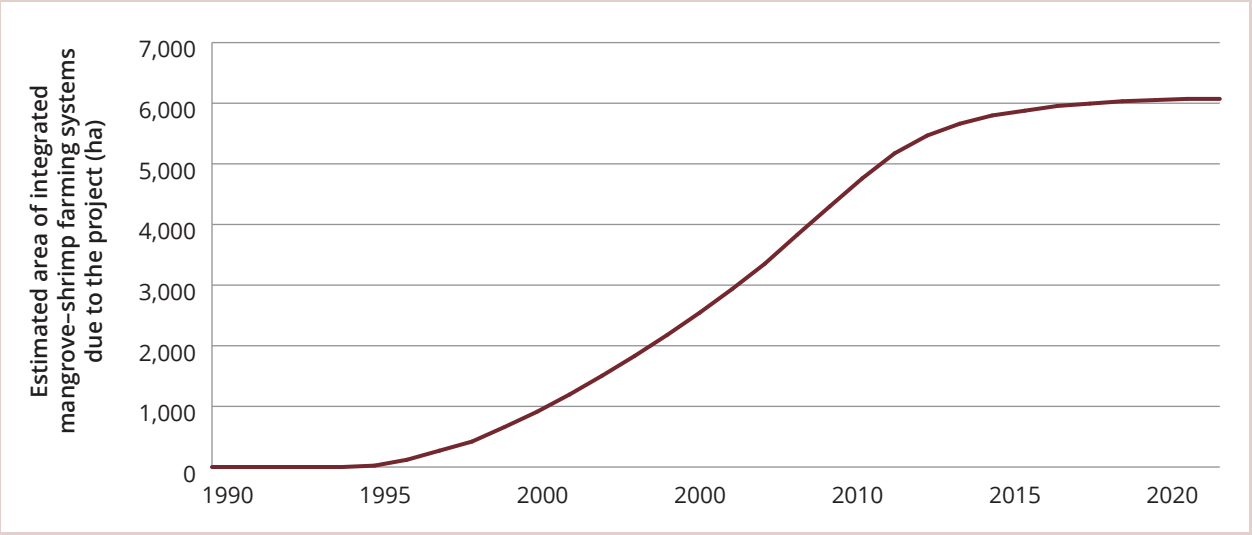

Figure 5.6 Estimated additional area of integrated mangrove–shrimp systems in the Mekong Delta, Vietnam, due to FIS/1994/012, 1990–2021

Source: Author estimates

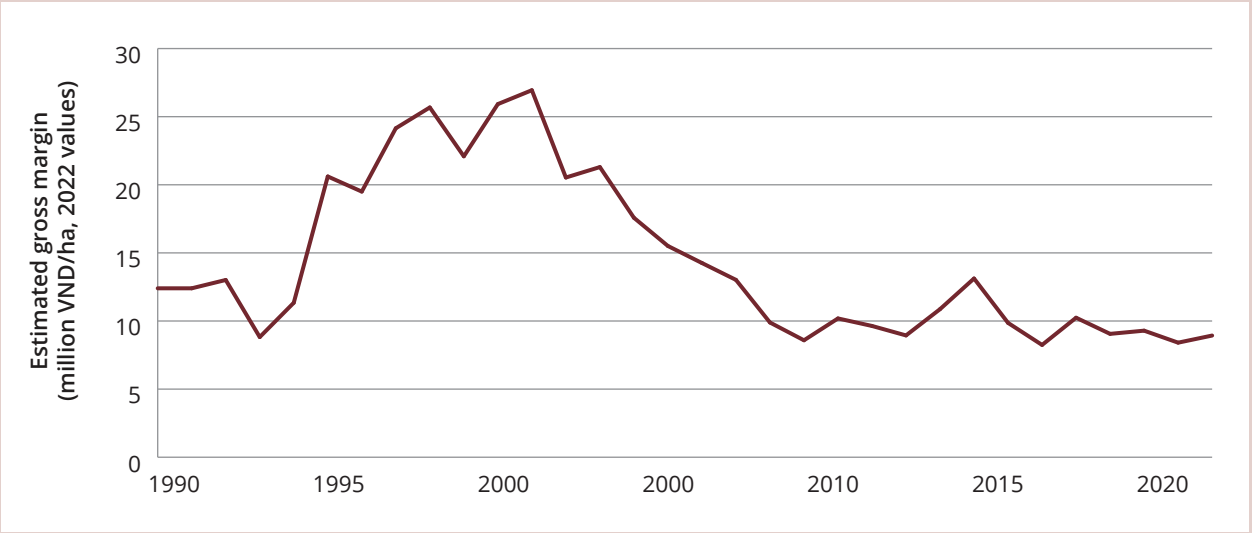

Figure 5.7 Estimated gross margin of integrated mangrove–shrimp farming systems in the Mekong Delta, Vietnam, 1990–2021, real 2022 values

Source: Author estimates

Indicative value of the project's adoption impact

Multiplying the estimates of the gross margin of mangrove–shrimp systems (Figure 5.7) by the estimated area of adoption attributable to the project (Figure 5.6) provides an estimation of the value of the adoption impact (Figure 5.8).

Figure 5.8 Estimated value of the adoption impact due to FIS/1994/012, 1990–2021, real 2022 values
Source: Author estimates

Discounted cashflow analysis of the project's economic impact

Standard discounting cashflow analysis is used to estimate the project's economic impact, as described earlier. Equations used are shown in Appendix 3. Results are presented in Table 5.4. The total indicative benefit of the project is estimated to be about VND1,900 billion (AUD120 million). The project cost of FIS/1994/012 was AUD963,380 in 1995. Adjusting these values to account for inflation, and compounding it to a present value, the cost of the project was equivalent to a present value of AUD9 million, or VND140 million. The indicative net benefit of the project is estimated to be VND1,700 trillion, or AUD110 million. The ratio of total benefits to costs is 13, meaning that for every dollar invested by ACIAR, the project has generated 13 dollars in return. This represents a strong return to ACIAR's investment, comparable with other agricultural research projects. For example, Alston et al. (2020) found that over the past 5 decades, CGIAR's investment in agricultural research has returned a benefit:cost ratio of 10:1.

A sensitivity analysis was conducted on key assumptions of the discounted cashflow analysis, and the resulting benefit:cost ratios are presented in Table 5.5. Three key assumptions are considered:

1. the discount rate – a low discount rate of 3% and a high discount rate of 7%
2. the area of integrated mangrove–rice systems attributable to the project – a low attribution of 20% and a high attribution of 40%
3. the shrimp gross margin – where gross margins are reduced by 20% and increased by 20%.

Based on this sensitivity analysis, it is estimated that the project's benefit:cost ratio may range from 9 to 18.

Table 5.4 Discounted cashflow analysis of the indicative economic impact of FIS/1994/012 (present values)

1995–2022	AUD million	VND billion
Total indicative benefits	121	1,891
Total costs	9	143
Net indicative benefit (benefits minus costs)	112	1,747
Indicative benefit:cost ratio (benefits divided by costs)	13	

Table 5.5 Benefit:cost ratio with low, standard and high values for key assumptions of the discounted cashflow analysis

	Level of each key assumption		
Key assumptions	Low	Standard	High
Discount rate (3%, 5%, 7%)	17	13	10
Attribution (20%, 30%, 40%)	9	13	18
Shrimp gross margin (0.8, 1, 1.2)	11	13	16

5.4 Inclusive value-chain impact

None of the projects had a value-chain focus. Integrated rice–shrimp and mangrove–shrimp systems were just coming into existence and beginning to display signs of future potential. The nascent nature of these systems meant that the bottleneck to their development was scientific understanding of these production systems. This was required before value-chain issues could be addressed. However, as the project progressed and these systems began to flourish, there were significant flow-on benefits along the value chain.

Both ASEM/1995/119 and FIS/1994/012 recommended the use of hatchery-sourced shrimp seed that was bred for growth and quality in local conditions. At the inception of these projects, shrimp hatcheries were located at significant distance from these farming systems. ASEM/1995/119 recommended establishing a local network for the supply of shrimp seed to overcome the significant difficulties experienced in the Mekong Delta as a result of inadequate supplies of good-quality postlarvae shrimp. ASEM/1995/119 stimulated the movement of hatcheries to closer locations, and the subsequent growth in number and production of hatchery-produced shrimp seed.

The projects showed that farmers could not rely on water extraction to catch wild shrimp seed and, in the case of ASEM/1995/119, that this water extraction created sedimentation that affected rice production in the wet season. This, along with improved survival and growth rates from hatchery-produced seeds, led to accelerated use of hatchery seed in the Mekong Delta.

Shrimp production within the Mekong Delta escalated as the projects concluded, and the nominal value of these exports increased from USD0.66 trillion in 2000 to around USD3.5 trillion now (Figure 5.9). These exports include live, fresh and frozen shrimp, as well as several processed shrimp products, such as smoked, shelled, dried, salted, brined and preserved shrimp. This increase in production, processing and exports had a significant impact on value-chain participants, including processors, traders and their intermediaries, due in part to this project. The Vietnamese Association of Seafood Exporters and Processors (VASEP) was established in 1998 and developed a significant role in improving the value, quality and capacity of Vietnamese seafood exports and processing, thereby enhancing production during this time. Due to the project's role in enhancing shrimp production, processing and exports at the time, it had a noteworthy impetus to the establishment and function of VASEP and other industry groups.

At the time of these projects, women and men shared responsibility for farming activities, with a high proportion of women involved in shrimp husbandry. In addition, women were important stakeholders in the value chain. They were involved in selling shrimp to traders, acted as market intermediaries between the farmer and processors, retailers and exporters, and engaged in processing activities in shrimp companies. Although not their focus, the projects had a small and positive impact on the livelihood of women in these roles.

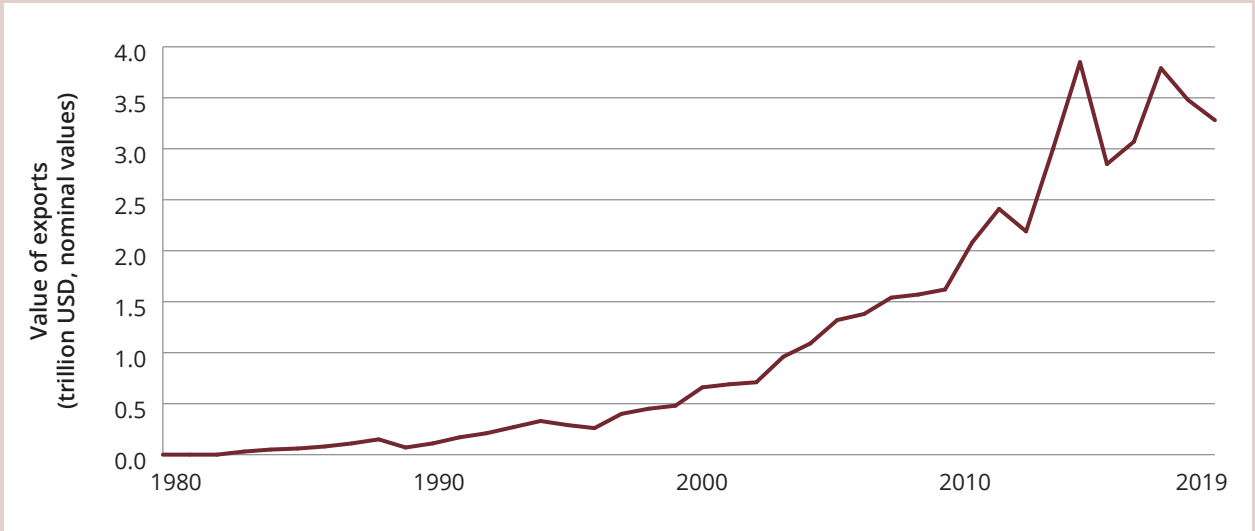

Figure 5.9 Value of exports of shrimp and shrimp products from Vietnam, 1980–2019, nominal values
Source: FishStatJ 2022

5.5 Environmental impact

These projects were the catalysts for the development of 2 nascent farming systems (rice–shrimp and mangrove–shrimp systems) that promote stewardship and sustainability of the Mekong Delta environment. These systems are resilient to drought, saline intrusion and floods, and provide significant livelihood alternatives for smallholder farmers. They maintain soil and water quality and contribute to maintaining function and values of ecosystem services. The projects provided initial technical research to enhance the environmental sustainability of systems. Farmers and research and extension staff continue to further develop the technologies and management strategies first developed through these projects.

ASEM/1995/119

ASEM/1995/119 was conducted when rice monocultures were the traditional farming system and shrimp production was about to escalate. The project had significant environmental impact, as the integration of these 2 monocultures has several mutual environmental benefits.

Reduced need for fertiliser, chemicals and shrimp feed

The rice phase of these systems provides disease breaks and nutrient benefits to the shrimp phase, and vice versa, leading to reduced fertiliser, pesticide and other chemical requirements. In recent years, farmers of integrated rice–shrimp systems have diversified the aquatic species cultivated in these systems. Different types of shrimp are reared, such as giant freshwater shrimp, as well as different types of aquatic species, such as mud crab. The diverse range of aquatic species has led to a more limited use of pesticide for rice cultivation (Leigh et al. 2017). Straw from rice production improves the soil and provides food and nutrients to shrimp production, and shrimp production provides nutrients for rice production, reducing the need for fertiliser for rice and feed for shrimp.

As these systems started to develop and a high profit margin for shrimp culture was realised, many farmers moved away from integrated rice–shrimp systems towards intensive shrimp monocultures. The project warned against this, arguing that this would lead to problems associated with disease outbreaks (Preston and Clayton 2003). These problems did become a reality, leading to the dominant use of extensive or semi-extensive shrimp phases within the rice–shrimp systems to this day. Farmers employ low pesticide rates for rice to prevent the pesticides harming or killing the shrimp. Moreover, miniscule amounts of salt in the soil after shrimp production has suppressed the brown planthopper, a significant rice pest. Rice yields have increased despite reduced use of fertiliser, pesticides and other chemicals.

Reduced pressure on fish resources

The Mekong River Delta has a high population density, with strong reliance on fishing as a source of livelihoods for local communities. Rice–shrimp systems provide an alternative livelihood to fishing during the dry season for people who live on rivers and canals. Reducing the pressure on fishing has meant that these systems have reduced the destruction of natural fish habitat due to fishing.

Reduced water pollution in ponds, rivers and canals

When integrated rice–shrimp systems first started to develop, they were reliant on high levels of water exchange for recruitment of natural shrimp into rice ponds during the dry season. The Mekong River is a sediment-laden water body, and water exchange was resulting in the sedimentation of rice paddies. The project was instrumental in promoting hatchery-reared stocking of postlarvae shrimp, combined with low water exchange, thereby limiting the sedimentation of ponds and taking pressure off wild stocks of seed shrimp.

The project recommended that farmers checked water quality and water levels in and outside ponds before bringing in irrigation water (Preston and Clayton 2003). ASEM/1995/119 designed new irrigation gates and recommended one flush in and one sluice out per week (rather than one per day) so that ponds were not accumulating sediment from the Mekong River.

FIS/1994/012

Maintenance of mangrove forest ecosystems

The biggest impact of FIS/1994/012 was its success in preventing the destruction of significant areas of mangrove forests in the Mekong Delta. The project began when the economic benefits of shrimp aquaculture were beginning to be realised, and there was intense pressure on farmers who owned or leased land with mangroves to cut down the mangroves in favour of shrimp monoculture.

The project showed the economic benefits of maintaining mangroves by integrating them into mangrove–shrimp systems, and trained farmers in the management of integrated forestry and aquatic enterprises. It provided a lucrative livelihood while preventing the destruction of large areas of mangroves. This protection of mangroves prevented erosion, provided habitat for bird and fisheries species, protected coastal communities from extreme weather events and stored large reserves of blue carbon, thus helping to mitigate global climate change. These benefits are not short-term but will continue in the medium to long term. Local communities will benefit

most from these environmental impacts, although benefits will also be realised for the regional, national and global community.

FIS/1994/012 showed that the greater the ratio of mangrove area in the mangrove–shrimp system, the greater the environmental benefits, especially for water quality. It helped developed ratios for optimal mangrove to shrimp pond density based on farm size to balance the environmental benefits of the mangroves with the economic benefits of the shrimp.

Reduced water pollution

Integrated mangrove–shrimp systems support extensive or semi-intensive shrimp production, where shrimp stocking densities are lower than in extensive shrimp monocultures, and where shrimp source food organically from the leaf and organic matter provided by the mangrove forests. Shrimp discharge is assimilated by the mangroves, maintaining water quality in the shrimp ponds and canals. The management of mangrove forests has a significant impact on water quality.

5.6 Capacity impact

ASEM/1995/119

ASEM/1995/119 had a significant capacity-building impact, directly during the project and indirectly since its completion. The project had direct capacity-building impacts through technical training of approximately 200 farmers and 25 extension staff and local officials. This capacity building occurred through numerous workshops and meetings over the project's lifetime, where stakeholders developed technical knowledge of management practices to develop the integrated rice–shrimp systems in the Mekong Delta. The project facilitated field schools that were effective in building capacity of agricultural extension specialists.

However, the largest capacity-building impact of the project was the indirect impacts that it catalysed. After the project was completed, the local provincial researchers, extension and policy officers it had trained conducted follow-up training programs. Local farmers adopted the information and knowledge from the project, continued to trial and implement these systems, and facilitated the diffusion of this information and knowledge to other farmers within Soc Trang and Bac Lieu and beyond.

Of particular impact was the project's emphasis on encouraging provincial researchers to develop locally adapted short-duration, salt-tolerant rice varieties, which led to significant improvement in rice-breeding capacity. The project also recommended the development of a local system of shrimp hatcheries, which led to significant improvement in shrimp-breeding capacity.

The project produced 2 doctorate degrees in economics, one master degree in shrimp science, one master degree in soil science and one master degree in agricultural economics. It provided the opportunity for a number of lecturers from Can Tho University to obtain scholarships to study in Australia. These connections indirectly led to further capacity-building opportunities. For example, through Dr Tran Thanh Be's connection with fellow project member, Dr Donna Brennan, at Sydney University, Dr Be obtained a partial scholarship for postgraduate study in Australia. The project helped another participant, Dr Le Xuan Sinh, to receive an ACIAR scholarship to conduct his PhD studies in Australia. Dr Sinh later became an Associate Professor at Can Tho University.

The project was a catalyst for many of its stakeholders working for provincial governments and Can Tho University to continue improving their knowledge and positions after completion of the project. A number of project participants have held, or currently hold, positions of high responsibility in Vietnam, and have made significant contributions in their areas of expertise.

Within Can Tho University:

- Nguyen Thanh Phuong is now a professor and is a chair of the committee of Can Tho University
- Tran Ngoc Hai is now a professor and is a vice rector of Can Tho University
- Tran Thanh Be has his doctorate and held the positions of Director of the Mekong Delta Development Research Institute, Can Tho University, and Director of Can Tho City Institute for Socio-economic Development Studies before his retirement. Since his retirement, Dr Be has held the position of Secretary of the Editorial Board of Can Tho University's Journal of Science.

At the provincial level:

- Tran Tan Phuong has his doctorate and is the Vice Director of the Department of Agriculture and Rural Development in Soc Trang
- Nguyen Phuong Hung is Director of the Centre for Seed within the Department of Agriculture and Rural Development in Bac Lieu (see case study).

FIS/1994/012

Capacity impacts are probably one of the most important impacts of this research project. They contributed to the social and adaptive learning processes of many project participants.

The project leaders were the leading mangrove specialists at the time, and they were keen to build the capacity of project collaborators, actively involving them in writing publications. They had a dominant impact, especially on understanding mangrove silviculture and its integration with shrimp production.

Case study: ASEM/1995/119 capacity building – Nguyen Phuong Hung

Nguyen Phuong Hung was a staff member of the Centre for Agricultural Extension in Bac Lieu when ASEM/1995/119 commenced in 1995. He participated in the project between 1997 and 2002. Mr Hung is now Director of Seed within the Department of Agriculture and Rural Development in Bac Lieu. This project helped Mr Hung further his career, which has had a flow-on benefit to agriculture in the Mekong Delta.

Mr Hung is an agricultural engineer. While participating in the project, he learned farming techniques of integrated rice–shrimp systems, new methods and skills in agricultural extension and different pathways to access information for developing these skills. After finishing his involvement in the project in 2002, Mr Hung was promoted to Head of the Office of Media and Training at the Bac Lieu Centre for Agricultural Extension.

Due to working on ASEM/1995/119 and gaining experience in collaborative research with international research organisations, Mr Hung was able to participate in a project titled Participatory Technology Development between 2002 and 2005. This was a collaboration between the Mekong Delta Development Research Institute of Can Tho University and the VVOB organisation of Belgium (VVOB is a non-profit organisation commissioned by the Flemish and Belgian governments to contribute to the quality of education in developing countries). This collaboration implemented the Mekong Delta Agricultural Extension Project. According to Mr Hung, the knowledge and skills he developed while working on ASEM/1995/119 provided the foundation for him to participate in the Mekong Delta Agricultural Extension Project, which in turn allowed him to further update and improve his knowledge and skills in participatory farming extension.

With this additional experience, in 2005 Mr Hung was appointed Vice Director of the Centre for Agricultural Extension of Bac Lieu. In 2006 and 2007, he participated in a World Bank–funded agricultural extension project where he continued to learn new methods and skills for agricultural extension with experts from Can Tho University.

Thanks to knowledge and skills learned from ASEM/1995/119 and the Mekong Delta Agricultural Extension Project, between 2010 and 2014, Mr Hung participated in a rice–shrimp farming system project funded by the German Agency for International Cooperation. He contributed his knowledge and skills on the system's farming techniques to this project and continued to learn new knowledge and skills.

In 2020, Mr Hung was appointed Director of the Centre for Seed within the Department of Agriculture and Rural Development in Bac Lieu. This is a position of significant responsibility and allows him to have an impact on the seed sector in Bac Lieu.

ASEM/1995/119 gave Mr Hung a foundation of skills and knowledge in integrated rice–shrimp farming systems and agricultural extension that has allowed him to continue to develop this capacity, participate in international projects and programs with different organisations, achieve a high level of career mobility and contribute to sustainable economic development in Vietnam's Mekong Delta.

FIS/1994/012 had a significant impact in developing capacity of researchers in a number of organisations, such as the Research Institute for Aquaculture No. 2 in Ho Chi Minh City, the Centre for South Western Forest Research and Experimentation, and the provincial Departments of Agricultural and Rural Development.

Dr Vu Anh Tuan is a good example of this capacity building. Towards the end of his participation in the project, he received a scholarship from ACIAR to study for his PhD in Australia. The experience he developed from working on the project and then completing his PhD allowed him to consult on other projects related to mangrove restoration and mangrove–shrimp systems in several provinces in the Mekong Delta, such as the projects of mangrove restoration funded by the German Agency for International Cooperation in Bac Lieu and Tra Vinh. Dr Tuan is now Asia Aquaculture Technical Manager at Olmix Group.

The project helped to build capacity for many extension staff and farmers in Ca Mau. Dr Vo Nguon Thao was an agricultural engineer within the Centre for Applied Research of Forest Techniques in Minh Hai while participating in the project. He is now the director of the Centre for South Western Forest Research and Experimentation in Ca Mau (see case study).

The project also increased capacity in capital (equipment) that continued to grow through time, stimulating technical capacity and human capital.

Dr Barry Clough, project leader and leading mangrove specialist, has lived in Vietnam since the project concluded, acting as a conduit between the project and subsequent related projects and programs across provinces and agencies.

Case study: FIS/1994/012 capacity building – Dr Vo Nguon Thao

Dr Vo Nguon Thao completed a degree in engineering and forestry in 1992 at the Agriculture and Forestry University in Ho Chi Minh City. He started working at the Centre for Applied Research of Forest Techniques in Minh Hai province. In 1993, he participated in a project focused on social forestry funded by the Vietnamese Ministry of Agriculture and Rural Development. This project initiated the first model of social forestry where local people received forest land area for planting and managing forestry. He organised trials of integrated agroforestry models at experimental farms and evaluated the effectiveness of each model.

During 1994 and 1995, Dr Thao participated in FIS/1994/012. He led research into understanding mangrove growth rates at different typographical levels in Ca Mau. He learned methods for sampling soil and water in different typographical locations, such as in rivers, oceans and shrimp ponds of different water levels. He learned and practised the analysis of indicators of soil and water quality (the physics and chemistry of soil and water). He learned methods to implement trials in mangroves, such as measuring biomass growth in mangrove areas and evaluating optimal ratios of mangrove to shrimp areas in mangrove–shrimp systems. He also developed techniques of mangrove forest thinning for different types of mangrove and different types of thinning products.

In 1997, Dr Thao was appointed Vice Head of Office at the Centre for Applied Research of Forest Techniques in Minh Hai. He bought his skills and knowledge of working on mangroves to melaleuca from 2006 to 2009. He was the melaleuca research project leader at the provincial level in the Mekong Delta, where he implemented skills and techniques he had developed in FIS/1994/012. This included evaluating growth rates of melaleuca at different ages and evaluating soil and water management in melaleuca forests.

From 2000 to 2003, Dr Thao studied a Master of Science in Environmental Sciences at Can Tho University. He bought the knowledge and skills he developed while working on FIS/1994/012 directly into this master thesis.

In 2007, Dr Thao was appointed Vice Director of the Centre for Applied Research of Forest Techniques at Minh Hai. In 2009, he was appointed the Director of the Centre for Forest Experiment Research in South West Ca Mau (the same institute, but under a changed name). While working in this position, Dr Thao completed his PhD in the environment of land and water at Can Tho University. The knowledge and skills he developed during FIS/1994/012 helped him write his doctoral thesis on natural forest areas in Ca Mau.

Dr Thao developed capacity during FIS/1994/012 that provided a foundation for his future studies and career. He has not deviated from his work on mangrove forests in Vietnam, but has continued to develop skills and knowledge in this field, and is bringing his expertise to develop forestry research in South West Ca Mau in his current role of Director of the Centre for Forest Research and Experimentation.

5.7 Scientific impact

ACIAR assesses scientific impact as either the **advancement of science** through the production of highly credible quality science research or the **development of knowledge unique for application in context**.

The scientific impact of the 3 projects was focused on developing knowledge unique for application in the specific context rather than the advancement of science.

ASEM/1995/119

ASEM/1995/119 had a scientific impact by producing basic scientific research about the integration between shrimp and rice monocultures. It explored the factors and techniques that led to maximum profitability of these systems. Key scientific findings focused on the interactions between shrimp and rice systems, such as:

- understanding land preparation for integrated rice–shrimp systems, including methods for flushing salt from the soil after shrimp production and before starting the rice season
- developing techniques to breed locally adapted, short-duration, salt-tolerant rice varieties
- management techniques associated with extensive shrimp production, including stocking densities and feeding regimes
- solutions for adjusting the seasonal calendar to manage the impacts of climate variability.

While the direct scientific results from this project were small and are now out of date, the project was a catalyst for significant research in the region. After completion of the project, Soc Trang's Department of Agriculture and Rural Development continued the research in collaboration with Can Tho University, by using provincial government and other project funding. Several international projects have also continued

the project, such as a project funded by the Canada International Development Agency on rice–shrimp farming systems. ACIAR has extended its research on integrated rice–shrimp farming systems in Vietnam (for example, 'Climate change affecting land use in the Mekong Delta: adaptation of rice-based cropping systems' (SMCN/2009/021), and 'Improving the sustainability of rice–shrimp farming systems in the Mekong Delta, Vietnam' (SMCN/2010/083)).

ASEM/1995/119 encouraged local researchers to develop locally adapted, short-duration, salt-tolerant rice varieties. Mr Ho Quang Cua, a local leader of this project, started a program of rice breeding specifically to develop rice varieties for rice–shrimp farming systems. To quote Dr Tran Thanh Be, international project collaborators continued to encourage local breeders by saying, 'You can develop local rice varieties, you can, you can!'. And Mr Cua did. He developed a number of rice varieties, most notably ST24 and ST25, which are currently used throughout Vietnam's Mekong Delta. In 2017, ST24 was in the top 3 of the World's Best Rice award, and in 2019 ST25 was awarded the World's Best Rice at the 11th Annual World Rice Conference (Tuoi Tre News, 2019). It is the first time that Vietnam has won the award. Basic research from ASEM/1995/119, and encouragement from project partners, led in part to Mr Cua's successful rice-breeding program, and this is arguably the biggest scientific impact of the project.

The ASEM/1995/119 final report lists 3 direct project publications that were published in peer-reviewed international journals, although more may have been published after completion of the project (Table 5.6).

The majority of scientific findings of the project are published in a monograph prepared by the project: Preston N and Clayton H (eds) (2002) *Rice–shrimp farming in the Mekong Delta: biophysical and socioeconomic issues*, ACIAR Technical Report No. 52e, Australian Centre for International Agricultural Research, Canberra.

The final report also lists 4 databases, 5 conference presentations, and a Vietnamese language video/CD-ROM titled *A guide to farming shrimp as rotational crop in rice paddies*.

FIS/1994/012

The strength of FIS/1994/012 was not so much the development of new scientific knowledge as the transfer of scientific knowledge from international project partners to Vietnamese project partners. The project provided Vietnamese collaborators with scientifically rigorous experimentation techniques as well as evidence-based scientific information concerning mangrove silviculture and how it can be integrated with shrimp and other aquatic food production. Project participants collected rigorous data to monitor water quality and made recommendations for management practices based on economic and environmental outcomes, including the timing of shrimp stocking, postlarvae shrimp stocking densities, improved brood stock for hatcheries, shrimp feed species, diversification of aquatic food species, diversification of wood species such as redwood species and coconuts (the latter providing additional benefit of nutritious food for farming families), mangrove planting density, thinning strategies and harvest ages.

The scientific technologies and management practices were adapted to Vietnamese conditions and were instrumental in forest management policy reform at the provincial level. The scientific technologies and management practices were used by project participants beyond mangrove–shrimp systems in the replanting and management of other forest species in the Mekong Delta, such as melaleuca.

Project leader, Dr Barry Clough, prepared a list of known publications from the project (Table 5.7).

Table 5.6 List of ASEM/1995/119 publications and available altmetrics

Publication	Paper views	Citations
Brennan DC, Clayton H and Tran TB (2000) 'Economic characteristics of rice–shrimp farms in the Mekong Delta, Vietnam' *Journal of Aquaculture Economics and Management,* 4(3–4):127–139.	217	14
Brennan D (2002) 'Savings and technology choice for risk averse farmers', *Australian Journal of Agricultural Economics*, 46:501.		2
Tran TB, Dung LC and Brennan DC (1999) 'Environmental costs of shrimp culture in the rice growing regions of the Mekong Delta', *Aquaculture Economics and Management,* 3(1):31–43.	283	5

Table 5.7 List of FIS/1994/012 publications and available altmetrics

Publication	Paper views	Citations
Alongi DM, Dixon P, Johnston DJ, Tien DV and Xuan TT (1999) 'Pelagic processes in extensive shrimp ponds of the Mekong Delta, Vietnam', *Aquaculture*, 175:121–41.	65	29
Clough B (2001) 'Mangrove-based small-scale shrimp aquaculture', in IIRR, IDRC, FAO, NACA and ICLARM, *Utilizing different aquatic resources for livelihoods in Asia: a resource book*, IIRR.		
Clough B, Johnston D, Xuan TT and Phillips M (2002) 'Case study 7: Silvofishery farming systems in Ca Mau Province, Vietnam', in Macintosh DJ, Phillips MJ, Lewis III RR and Clough B, *Annexes to the thematic review of coastal wetland habitats and shrimp aquaculture, case studies 7–13*, report prepared for the World Bank, NACA, WWF and FAO Consortium Program on Shrimp Farming and the Environment, work in progress for public discussion, published by the Consortium.		20
Clough B, Tan DT, Phuong DX and Buu DC (2000) 'Canopy leaf area index and litter fall in stands of the Mangrove *Rhizophora apiculata* of different age in the Mekong Delta, Vietnam', *Aquatic Botany,* 66:311–20.	16	64
Clough B, Tuan VA, Lu T, Johnston D, Phillips M and Chanratchakool P (2002) *Mixed shrimp-mangrove farming practices: a manual for extension workers*, ACIAR and Ministry of Fisheries, Vietnam.		
Johnston D and Keenan CP (1999) 'Mud crab culture in the Minh Hai Province, South Vietnam', in Keenan CP and Blackshaw A (eds) *Mud crab aquaculture and biology*, ACIAR Proceedings no. 78, ACIAR.		
Johnston DJ, Lourey M, Tien DV, Luu TT and Xuan TT (2002) 'Water quality and plankton densities in mixed shrimp–mangrove farming systems in Vietnam', *Aquaculture Research,* 33:1–14.		
Pednekar SS, Nguyen HT, Le Thong P and Dan TH (2002) 'Case study 8: mixed shrimp farming–mangrove models in the Mekong Delta – socio-economic study component', in Macintosh DJ, Phillips MJ, Lewis III RR and Clough B *Annexes to the thematic review on coastal wetland habitats and shrimp aquaculture, case studies 7–13*, report prepared for the World Bank, NACA, WWF and FAO Consortium Program on Shrimp Farming and the Environment, work in progress for public discussion, published by the Consortium.		
Tuan VA, Clough B, Lu T, Johnston D, Phillips M and Chanratchakool P (2002) *Mixed shrimp–mangrove farming practices: a manual for farmers*, ACIAR and Ministry of Fisheries, Vietnam.		
Van Trong N (1999) 'Mixed shrimp farming–mangrove forestry models in the Mekong Delta: ACIAR PN 9412', in *Mud crab aquaculture and biology*, ACIAR Proceedings no. 78, ACIAR.		

5.8 Policy impact

ASEM/1995/119

ASEM/1995/119 had a strong policy impact. The project was able to demonstrate to policy officials the potential for integrating shrimp production (during the dry season) with rice production (during the wet season) in brackish water environments by using appropriate technologies and practices.

The provincial government was initially hesitant to support these systems due to concerns that saline water used for shrimp production would salinate the soil, reducing subsequent rice yields. The project understood that to achieve widescale adoption of these systems, the provincial governments needed to be convinced that rice production would be unaffected or even augmented by the introduction of shrimp production during the dry season. The project was successful in doing this, leading to change in provincial policies. The government's planning processes changed to allow the shift in land use from rice monocultures to integrated rice–shrimp systems. This policy shift occurred first in Bac Lieu and Soc Trang, the provinces in which the project was focused.

In Bac Lieu, after being convinced of the feasibility and sustainability of integrated rice–shrimp systems, the provincial government introduced a revised version of Decision 09/NQ-CP, dated 6 September 2000, to allow farmers to convert the purpose of land use from exclusively agricultural purposes to include aquacultural purposes. As a result, the area of rice–shrimp systems in Bac Lieu increased from 20,000 ha in 2005 to 22,100 ha in 2010, and 39,600 ha in 2020.

The project also influenced earlier versions of the national Resolution No.120/NQ-CP, dated 17 November 2017, on sustainable and climate-resilient development of the Mekong River Delta to allow integrated rice–shrimp systems rather than consecutive rice or sugarcane systems.

The project was successful in establishing integrated rice–shrimp farming systems in brackish water environments in Soc Trang and Bac Lieu. Can Tho University and the Department of Agriculture and Rural Development in Soc Trang continued the research after ASEM/1995/119 and facilitated the extension of these farming systems outside the project's focus areas to other districts within Soc Trang and Bac Lieu, and beyond to Ca Mau, Kien Giang, Ben Tre and Tra Vinh provinces. The policy reforms that started in Bac Lieu and Soc Trang later spread into other provinces, such as Ca Mau and Kien Giang. Kien Giang now has the largest area of integrated rice–shrimp systems and the area of these systems is still expanding.

It is expected that the potential for integrated rice–shrimp systems would have become known over time, and this policy shift would have occurred at some stage, but the project facilitated this shift about 3 years earlier than would have otherwise happened.

Policies regarding land use were not the only government regulations that changed due to ASEM/1995/119. In 2000, policies regarding the program of building sluice gates and establishing institutional arrangements for improved water coordination and distribution for both brackish and fresh water were also revised and practised. These policy reforms helped increase the efficiency of water distribution activities in brackish water areas to facilitate the expansion of rice–shrimp systems. In 2020, the Bac Lieu provincial government built reservoirs to control fresh water, specifically for the rice phase of the integrated rice–shrimp systems.

The national and provincial governments remain supportive of integrated rice–shrimp systems to this day. In 2021, the Ministry of Agriculture and Rural Development held a workshop for developing integrated rice–shrimp farming systems in the brackish water zones in the Mekong Delta. The purpose of this workshop was to facilitate the adaptation of coastal communities in the Mekong Delta to climate change. These systems have been supported by Resolution 62, dated 2019, facilitating both the projection of rice land and the expansion of integrated rice–shrimp systems through infrastructure and training developments.

In early 2022, the Bac Lieu Department of Agriculture and Rural Development facilitated a workshop with the theme 'Developing the model of "Fragrant rice-clean shrimp" in the Mekong region', which was supported by the Ministry of Agriculture and Rural Development.

According to the Ministry of Agriculture and Rural Development:

> *the coastal provinces of the Ca Mau peninsula have advantages in the production of organic agricultural products thanks to the rice–shrimp, mangrove–shrimp, rice–fish ecosystems… If there is a good irrigation system, it can increase 100,000 hectares of rice–shrimp area rotation and consolidate the existing rice–shrimp area of about 150,000 hectares. Rice products in this region can enter the market segment of specialty rice with the highest price in the world market today' (MARD 2022).*

Rice–shrimp systems are expected to continue to expand to about 250,000 ha by 2030 in coastal provinces in the Mekong Delta (Tuan et al. 2016). There are still significant policy developments that could be made at the provincial level to facilitate this, including further infrastructure development (such as more sluice gates and improving rural roads), enhancement of breeding programs for rice varieties with adaptation to high-salinity, brackish water conditions and facilitating improved vertical and horizontal market integration through agricultural cooperatives and improved market access.

FIS/1994/012

FIS/1994/012 also had a strong impact on policy reform at the provincial level. When the project commenced, the Ca Mau provincial government was under pressure to generate livelihoods through shrimp production, which was on the cusp of rapid expansion. The government was also concerned about protecting mangroves that were threatened by the expansion of shrimp monocultures. FIS/1994/012 showed the benefits of integrated mangrove–shrimp culture and demonstrated that farmers could protect mangrove forests and generate livelihoods by raising shrimp and other aquatic foods. These benefits were acknowledged by the provincial government, which revised local policies to allow mangroves to be used in agricultural production in Ca Mau. This revision of local policies prevented further destruction of mangroves and facilitated the generation of strong and secure livelihoods for vulnerable landholders. Other provincial governments followed Ca Mau's lead and revised their policies.

Policy reform was not isolated to land use. It also included regulations regarding the most suitable ratio between the area of mangrove (60%) and area of shrimp ponds (40%) within integrated mangrove–shrimp systems to maximise protection of mangroves while still facilitating strong economic returns. Project findings were translated into local government regulations relating to mangrove growth and management, such as the optimal density of mangrove forest, the characteristics of soil and topography of land and associated management techniques.

Another policy reform that can be, in part, attributed to FIS/1994/012 was the issuing of green certificates to farmers by the Ca Mau provincial government. Green certificates allowed farmers to obtain loans from banks for their investment in aquaculture.

Farmers are heavily influenced by the policy directives of provincial governments, and FIS/1994/012 provided initial impetus to allow changes to these directives to be made so that farmers could adopted integrated mangrove–shrimp systems. Adoption of these systems has grown since the project's conclusion. These systems are likely to develop further with relaxation of provincial policy rules regarding mangrove management, densities and times of thinning.

5.9 Gender and youth impact

Enhancing gender equity was not a focus for any of the 3 projects, but they did offer equal opportunities for engagement with men and women. While most members of the project team in Vietnam were men, with a number of female international specialists, the project team was young, and investment in early-career researchers has led to significant capacity impacts.

The projects helped developing livelihoods for landholders from integrated rice–shrimp systems and from mangrove–shrimp systems where there were few livelihood alternatives, especially in the dry season and without destroying or degrading mangrove habitats. The additional climate-resilient livelihood opportunities have had a significant positive impact on the social resilience of these communities, especially as impacted communities are especially vulnerable to the effects of climate change, such as drought, floods and saline intrusion. The livelihoods provided strong, reliable income streams to these vulnerable communities, increasing opportunities for children to be supported by their families to attend school. As such, these projects have played a role in facilitating the education of the next generation.

6 Conclusion and reasons for project impacts

An overall impact assessment of the projects is provided in Table 6.1.

ANRE/1993/036 and ASEM/1995/119 had a very high economic impact by facilitating the early introduction of shrimp production into traditional rice monocultures during the dry season at a time when there were few profitable livelihood opportunities, and when shrimp production was just starting to escalate in the Mekong.

FIS/1994/012 had a very high environmental impact, as it played a significant role in preventing the destruction and degradation of mangrove forests in Vietnam's Mekong Delta, in turn preventing erosion, providing habitat for bird and fisheries species, protecting coastal communities from extreme weather events and storing large reserves of blue carbon, thus helping to mitigate global climate change. These environmental impacts will be felt in the long term, mostly by local communities, but also by regional, national and global communities.

All 3 projects had high policy and capacity impacts. Without these projects, the policy reforms required for development of these integrated systems would have been substantially delayed, significantly reducing the economic impacts of the projects. The strong policy and capacity-building impacts of all 3 projects catalysed their economic, environmental and scientific impacts. They enhanced the career trajectories of a large number of project participants, many of whom have held, or currently hold, professional roles with high responsibility and have an ongoing and substantive impact in Vietnam.

Reasons for the success of these projects are provided below:

- demonstration of substantially higher profits from shrimp compared with rice monoculture and mangrove silviculture
- project timing coincided with the value of shrimp production in the Mekong Delta escalating during and after their implementation
- dynamic and inclusive project leadership and participation from project partners, industry, government and farmers
- multidisciplinary team and multifaceted design, which integrated the skills of a broad range of international and national experts within a range of Vietnamese research institutions and across multiple Vietnamese Government agencies
- strong collaboration between researchers, extension workers, local policymakers and farmers
- innovative and entrepreneurial nature of stakeholders who were willing to take risks and make practice change, driven by a need to establish sustainable incomes and opportunities for farming families
- integration of evidence-based and rigorous scientific research and economic analysis within a livelihood/household context
- inclusion of government policy assessment as an objective of ASEM/1995/119
- continuous meetings and exchange between project participants, farmers and local policy staff, meaning that policy change didn't occur through the one-off writing of a policy brief, but by continuous engagement with influential policymakers over time.

Table 6.1 Summary impact assessment

Impact	ANRE/1993/036 and ASEM/1995/119	FIS/1994/012
Economic	**Very high**	**High**
Inclusive value chain	**Low**	
Environmental	**Moderate**	**Very high**
Capacity	**High**	
Scientific	**Moderate**	**Low**
Policy	**High**	
Gender and youth	**Low**	

Dan Churchill visiting an integrated rice–shrimp farming system in Ca Mau
Photo: Jana Langhorst

7 Appendices

Appendix 1: People interviewed for initial consultation

Name	Institution during project	Current affiliation	Reason for interview
Dr Tran Thanh Be	Can Tho University	Officially retired but active as Secretary of Editorial Board of Can Tho University Journal of Science	Project member (Vietnam, ASEM/1995/119)
Dr Barry Clough	Australian Institute of Marine Science, Australia (AIMS)	Officially retired but active as a mentor of students and providing language tuition	Project leader (Australia, FIS/1994/012)
Dr Michael Phillips	Network of Aquaculture Centres in Asia-Pacific, Thailand (NACA)	Consultant in advisory services to aquaculture and business applications	Project leader (Thailand, FIS/1994/012)
Dr Nigel Preston	CSIRO, Australia	Retired	Project leader (Australia, ASEM/1995/119)
Mr Barney Smith	ACIAR	Retired	Research Program Manager for the Fisheries Program (Australia, FIS/1994/012)
Dr N Sriskandarajah	University of Western Sydney, Hawkesbury	Retired	Project leader (Australia, ANRE/1993/036)
Dr Vu Anh Tuan	Research Institute for Aquaculture No. 2, Vietnam	Asia Aqua Technical Manager, Olmix Group	Project member (worked directly with Barry Clough) (Vietnam, FIS/1994/012)

Appendix 2: Provincial research, extension and policy officials interviewed for extended data collection

Name	Specialisation and project	Province
Mr Ho Quang Cua	Policy and extension specialist in Vietnam for ASEM/1995/119	Soc Trang
Mr Nguyen Phuong Hung	Policy and extension specialist in Vietnam for ASEM/1995/119	Bac Lieu
Mr Nguyen Van Trung	Aquaculture and policy specialist in Vietnam for FIS/1994/012	Ca Mau
Dr Vo Nguon Thao	Forestry specialist in Vietnam for FIS/1994/012	Ca Mau

Appendix 3: Discounted cashflow analysis calculations

ASEM/1995/119

$$Total\ indicative\ benefits = \sum_{t=-1}^{-30} \frac{Total\ impact_t}{(1+i)^t} \quad (1)$$

$$Total\ impact_t = (Rice\ impact_t + Shrimp\ impact_t) * Area\ of\ impact_t \quad (2)$$

$$Rice\ impact_t = 20\% * net\ rice\ income_t \quad (3)$$

$$Shrimp\ impact_t = Shrimp\ yield_t * Farmgate\ shrimp\ price_t - Cost\ of\ production_t \quad (4)$$

where: t = 0 for 2022, –1 for 2021 through to –30 for 1992

i = discount/compound rate (%, assumed to be 5%)

$Area\ of\ impact_t$ = area of integrated rice–shrimp farming systems attributable to the project in year t (hectares)

$Net\ rice\ income_t$ = rice gross margin attributable to the project in year t (VND/ha)

$Shrimp\ yield_t$ = expected yield of shrimp attributable to the project in year t (kg/ha)

$Farmgate\ shrimp\ price_t$ = Farmgate shrimp price attributable to the project in year t, adjusted for inflation (VND/kg in 2022 values)

$Cost\ of\ production_t$ = Variable and fixed costs of production in year t, adjusted for inflation (VND/kg in 2022 values)

$$Total\ costs = \sum_{t=-22}^{-27} \frac{Project\ costs_t}{(1+i)^t} \quad (5)$$

where: $Project\ costs_t$ = funding provided by ACIAR to conduct the project in year t

$$Net\ indicative\ benefit = Total\ indicative\ benefits - Total\ costs \quad (6)$$

$$Indicative\ benefit{:}cost\ ratio = \frac{Total\ indicative\ benefits}{Total\ costs} \quad (7)$$

FIS/1994/012

$$Total\ indicative\ benefits = \sum_{t=-1}^{-30} \frac{Total\ impact_t}{(1+i)^t} \quad (8)$$

$$Total\ impact_t = (Mangrove\ impact_t * Mangrove\ coverage + Shrimp\ impact_t * Mangrove\ coverage\ coverage) * Area\ of\ impact_t \quad (9)$$

$$Mangrove\ impact = \frac{Shrimp\ impact_t}{0.9} \quad (10)$$

$$Shrimp\ impact_t = (Shrimp\ yield_t * Farmgate\ shrimp\ price_t - Cost\ of\ production_t) * Number\ of\ rotations \quad (11)$$

where: t = 0 for 2022, –1 for 2021 through to –27 for 1995

i = discount/compound rate (%, assumed to be 5%)

Mangrove coverage = Proportion of farm in mangroves (assumed to be 38%)

Shrimp coverage = Proportion of farm in shrimp (assumed to be 62%)

$Area\ of\ impact_t$ = area of integrated mangrove shrimp farming systems attributable to the project in year t (ha)

$Shrimp\ yield_t$ = expected yield of shrimp attributable to the project in year t (kg/ha)

$Farmgate\ shrimp\ price_t$ = Farmgate shrimp price attributable to the project in year t, adjusted for inflation (VND/kg in 2022 values)

$Cost\ of\ production_t$ = Variable and fixed costs of production in year t, adjusted for inflation (VND/kg in 2022 values)

Number of rotations = Number of shrimp rotations, assumed to be 2 per year

$$Total\ costs = \sum_{t=-22}^{-27} \frac{Project\ costs_t}{(1+i)^t} \quad (12)$$

where: $Project\ costs_t$ = funding provided by ACIAR to conduct the project in year t

$$Net\ indicative\ benefit = Total\ indicative\ benefits - Total\ costs \quad (13)$$

$$Indicative\ benefit{:}cost\ ratio = \frac{Total\ indicative\ benefits}{Total\ costs} \quad (14)$$

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