

Integrated Multiple Species Aquaculture in the Protected Mangrove Areas in the Mekong Delta, Vietnam: A Case Study in Kien Giang

Thai Thanh Luom*

Institute of Technology and Training, Kien Giang University, Vietnam

ABSTRACT

The literature showed that aquaculture using a single species (shrimp) in allocated mangrove areas was common in many coastal provinces in the Mekong Delta, Vietnam. By contrast, integrated multiple species aquaculture, operated in the Kien Giang protected mangrove areas for years, was inadequately reported. The inadequate reporting caused the difficulty in fully understanding this special farming system and its role in improving local livelihood. The fully understanding of this farming system and its role in local livelihood improvement will be a technical reference in the Mekong Delta. This study used participatory action research for documenting the operation of the Kien Giang integrated multiple species aquaculture. As a result, the Kien Giang farming system is comprehensively documented, with release pattern, harvest seasonality, total incomes, threats, and its relevant lessons. The comprehensive documentation adds a new dimension to the literature in this regard. The Kien Giang farming and its relevant lessons should be circulated to ensure effective replication elsewhere in the Mekong Delta of Vietnam.

Keywords: Kien Giang; Integrated multiple species aquaculture; Angrove allocation; Mekong delta; Release; Harvest

INTRODUCTION

Mangrove aquaculture that uses mangrove functions in nutrient cycling has been popular throughout Southeast Asia [1,2]. This aquaculture type commonly involves farming of a single species, that was shrimp [1,3] fish [4], or oyster [5]. Mangrove aquaculture commenced in the Mekong Delta of Vietnam in the 1980s [6-8] was mainly operated using a single species such as shrimp, *Artemia*, mud crab or finfishes [9]. Shrimp farming was the most important and developed industry in the region because shrimp farming system generated enormous incomes and was promoted by the Government of Vietnam [6,7,9].

In 1992, coastal mangroves, including areas which had been used for shrimp farming, were officially established as coastal mangrove protection areas in the Mekong Delta of Vietnam [10]. According to the Vietnamese Law on Forest Protection and Development, coastal mangrove protection areas are administered by competent government agencies. Human activities in coastal mangrove protection areas need permission from competent government agencies [11]. Coastal mangrove protection areas are presently managed by provincial level Departments of Agriculture & Rural

Development [12]. Shrimp farming was not permitted in coastal mangrove protection areas in 1992.

In 2001, a policy, issued by the Vietnamese Prime Minister, permits provincial level Departments of Agriculture & Rural Development in the Mekong Delta of Vietnam to allocate protected mangroves under contracts to local communities for protection and for local livelihood improvement [13]. Under the 2001 allocation policy, local communities are contractually required to protect a certain percentage of allocated mangrove areas in return for the right to use a certain percentage of allocated forests for aquaculture for livelihood improvement. The percentage of allocated mangroves for protection and aquaculture development was different from province to province; for example, the percentage being 40 (use)/60 (protection) in Ca Mau province; 30 (use)/70 (protection) in Kien Giang province [14]. Shrimp farming was resumed as mangrove aquaculture in permitted areas of allocated mangrove areas in many provinces in the Mekong Delta [15]. Shrimp farming became a major livelihood activities in the region [7]. Shrimp farming and its relevant technical aspects were adequately reported; for example total income gained from shrimp farming [16], farming systems, access to investment sources for aquaculture [6,7,17] the best ratio between mangrove areas and shrimp farming [18]. Shrimp farming was substantially constrained by the limited access to mangrove

Correspondence to: Thai Thanh Luom, Institute of Technology and Training, Kien Giang University, Vietnam, Tel:+84 297 3628 777; E-mail: thai.thanhluomkgu@gmail.com

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areas, infrastructure, and market segments. Crop failure occurred due to regular occurrence of shrimp disease [7].

However, Kien Giang was reported to have applied Integrated Multiple Species Aquaculture (IMSA) (the Conservation and Development of Kien Giang Biodiversity Project) [19]. IMSA involved the farming of white leg shrimp (*Litopenaeus vanname*), mud crab (*Scylla serrata*), blood shell (*Tegillarca granosa*) and Barramundi fish (*Lates calcarifer*) in an integrated way [19]. The 2013 CDBRP report briefly described farming systems, production and yields, and reported high gross annual income gained from the IMSA. However, the IMSA operation and its lessons were not sufficiently reported.

Taking into consideration the issues discussed above, two questions remain as how the Kien Giang IMSA was operated and how this special farming technique improved local livelihood. Answers to these questions will be a technical reference in this regard in the Mekong Delta. Therefore, the study aims to document the Kien Giang IMSA operation, and to link the findings to the development of IMSA elsewhere in the Mekong Delta in the future.

MATERIALS AND METHODS

Site description

Kien Giang province, located in the Mekong Delta of Vietnam (Figure 1), has approximately 6951.8 ha of mangroves [20]. The Kien Giang mangrove areas are currently under direct management by two Management Boards: the Hon Dat-Kien-Ha-Management Board and the An Bien-An Minh Management Board (DARD 2010) [20]. The entire mangrove areas are technically divided into two belts that include the primary mangrove belt and the secondary mangrove belt. While the primary mangrove belt assists in providing protection of mangroves and improving resilience, the secondary mangrove belt is administratively used for allocating protected mangroves for coastal mangrove protection and for the IMSA to improve livelihoods [21].

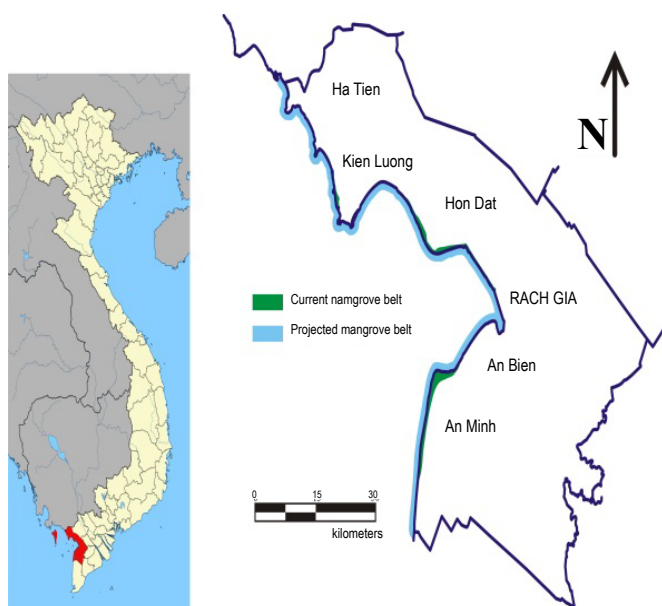


Figure 1: The map showing the location of Kien Giang Province in the Mekong Delta of Vietnam (left) and its mainland protected coastal mangrove belt (right) [8].

Mangrove allocation has been implemented using contracts (valid for almost 50 years) since 2005 (Kien Giang) Provincial People's Committee [22]. In these contracts, two Management Boards are contractors. Households and individuals, who applied for being involved in mangrove allocation, are contractees. Contractees are contractually required to protect the 70% of allocated mangrove areas to reserve the right to use the 30% permitted mangroves for the IMSA [22]. The 2005 policy was updated and replaced with the a decision issued in 2011 by the Kien Giang PPC [23]. The 2011 Kien Giang PPC continues to promote mangrove allocation. The IMSA is common in Kien Luong, An Bien, and An Minh districts. The communities in Hon Dat district do not practise the IMSA because the secondary mangrove belt was severely eroded [9]. In 2010, three allocation categories, that were applied, included mangrove areas less than 1 ha, between 1 and 3 ha, and more than 3 ha [20].

Methods

This study was undertaken using participatory action research [24]. Participatory action research is defined as a way of working together to improve a situation. The situation here in Kien Giang was inadequate recording of the Kien Giang IMSA. Therefore, participatory action research was best suited to comprehensively documenting the Kien Giang. Participatory action research methods included secondary data analysis (a desk-top review) [25], field visits [26], participatory community meetings [27], focus group interviews [27], semi-structured interviews [28] participatory diagramming [26], network diagramming [29], and thematic analysis [30].

Reports and documents related to the IMSA and mangrove protection in Kien Giang were collected, reviewed, and analyzed using secondary data analysis to obtain secondary data. Two semi-structured interviews were undertaken with staff working for government agencies in Kien Giang Province (DARD and Department of Natural Resources & Environment) for further secondary data. Two main open questions used in the semi-structured interviews with the government staff related the Kien Giang IMSA operation and law enforcement of the mangrove allocation policy. A semi-structured interview with government staff took approximately half an hour.

30 contractees were randomly selected from the mangrove allocation records filed in the offices of two Management Boards. They belonged to three allocation categories: 1 ha (12 contractees); 2 ha (8 contractees) and more than 3 ha (contractees). This random selection was undertaken before field trips were organized.

Five field visits were organized to ponds to gain primary data in relation to the IMSA. During the field visits, three focus group interviews were undertaken at three local houses, with support provided by the Women's Union, the Farmers' Union and two Management Boards. Each focus group interview was almost 2 hours long. Two main open questions used in the group focus interviews were how ponds were operated and what threats and/or lessons in relation to the IMSA operation were. In the focus group interviews, participatory diagramming was used for developing relationships among the primary data with regard to the operation of, and total incomes gained from, the IMSA.

The secondary and primary data were systematically diagrammed

and analyzed into themes using network diagramming. The themes, which were developed as a result of the network diagramming were pond construction and operation, release and harvest seasonality, income breakdowns, threats to the Kien Giang IMSA, and lessons learnt.

Fourteen participatory community meetings (325 contractees in total) were organized, with administrative support provided by the Women’s Union, the Farmers’ Union, DARD, two Management Boards, and the district level people’s committees. In these meetings, the themes were discussed and verified. Three additional semi-structured interviews conducted with staff working for Agro-Forestry Extension Centres in Kien Luong, An Bien and An Minh districts were organized to critically review, discuss, clarify, or justify the nature of the above identified themes. The themes were further discussed with two Management Boards for verification. The final results were presented in Results section. The methods used in this study are summarized in (Figure 2).

RESULTS

The Kien Giang IMSA operation

Pond design: Field visits revealed that ponds were mainly constructed on the seaward side in Kien Luong, An Bien and An Bien districts. Aquaculture techniques in Kien Luong are similar to those of An Bien district while An Minh district has ponds constructed perpendicular to its shoreline (Figure 3).

Release seasonality: The focus group interviews indicated that contractees in An Bien and An Minh districts had the same release seasonality. All contractees purchased juvenile blood shells and crabs, fingerlings of Barramundi fish and larvae of white leg shrimp elsewhere to start their IMSA. Different species were released at

different time in a year. Different releases assisted in preventing the predation of young blood shell by crabs that were previously released, and the predation of shrimp larvae and young crabs by naturally recruited fishes during the pond gate operation in An Bien and An Minh districts. Young blood shell and juvenile mud crabs were released twice a year. While shrimp larvae were released three times in a year, fingerlings of Barramundi fish were released once a year in An Bien and An Minh districts (Figure 4).

In Kien Luong district, Barramundi fish, crab and white leg shrimp were separately cultured. Juvenile crabs and shrimp larvae were cultured in one section, while fingerlings of Barramundi fish in different sections. IMSA was not a regular business activity for contractees in Kien Luong district because the Kien Luong contractees worked other jobs for incomes. Shrimp larvae and juvenile mud crabs were released twice a year, while fingerlings of Barramundi fish was released once a year (Figure 5).

All contractees interviewed in three districts shared the same release pattern. The contractees told that because no technical guidelines on IMSA were made locally available, contractees used their own knowledge or learnt farming techniques from other successful aquaculture operators, information sharing events or workshops organized in communities (Table 1).

Table 1: Release pattern in three categories in Kien Luong, An Bien and An Minh districts.

Farmed species	No. of individual released per m ²
Mud crab	1
White leg shrimp	50
Barramundi fish	1
Blood shell	100

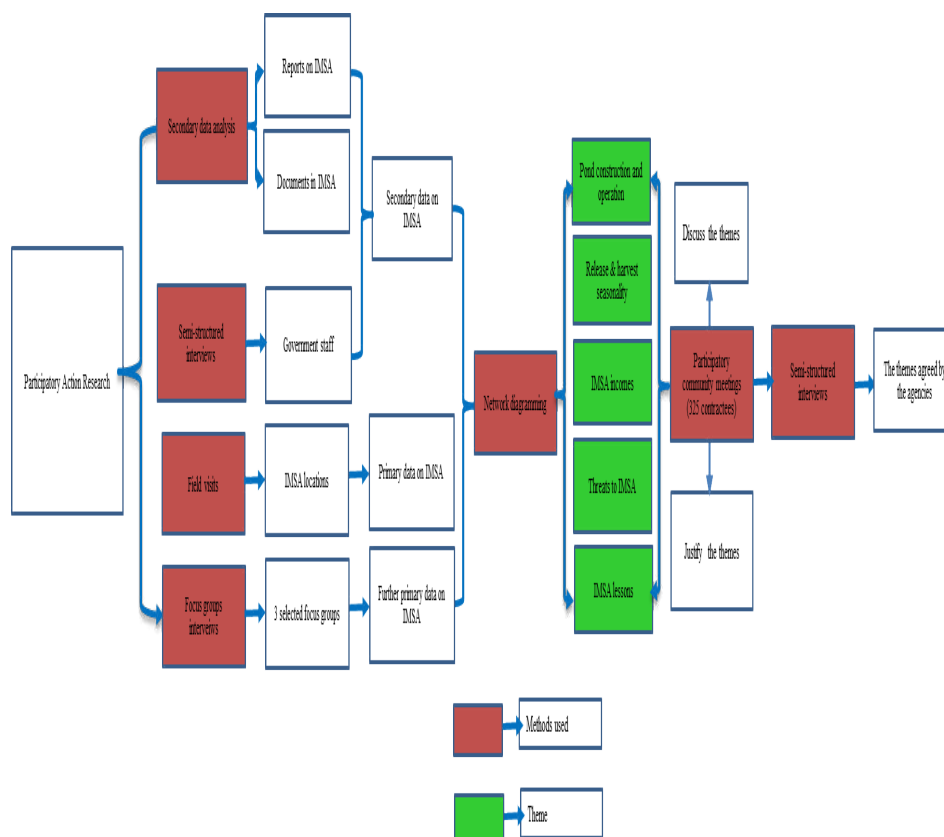


Figure 2: The diagram summarizes the methods used in the study.

Harvest seasonality: Each species was seasonally harvested in a year. In most cases, both farmed species and natural recruited species were commercially harvested. In other cases, natural recruitments continued to be farmed to provide an additional food source, or were commercially harvested for daily income, depending on their harvest seasonality. Contractees in An Bien district shared harvest seasonality with those in An Minh district (Figure 6).

In Kien Luong district, contractees harvested farmed species and



Figure 3: Common mangrove aquaculture pond designs in Kien Giang, Vietnam.

(1) Pond design in Kien Luong district. In (1) (a) is pond area, (b) is protected mangroves. (Source: “Kien Luong coast.” 10012’21.14” N and 104041’25.80” E. E. Google Earth. 22 October 2011. [Accessed 21 December 2014]).

(2) Pond design in An Bien district. In (2), (a) is pond area, (b) is protected mangroves. (Source: “An Bien coast.” 9048’41.27” N and 104053’33.14” E. E. Google Earth. 22 October 2011. [Accessed 21 December 2014]).

(3) Pond design in An Minh district. In (3) (a) is pond area, (b) is protected mangroves, (Source: “An Minh coast.” 9042’12.69” N and 104052’06.74” E. E. Google Earth. 22 October 2011. [Accessed 21 December 2014]).

natural recruited species for commercial purposes. Commercial harvest of the species was frequently undertaken at the end of the year (Figure 7).

Incomes generated from the Kien Giang IMSA

All contractees earned considerable incomes generated from the IMSA regardless of the total area in Kien Luong, An Bien, and An Minh districts (Figures 8 af and Table 2). They earned 100% harvest, especially for the first three years. In rare cases, they earned a minimum 20% gain or lost their harvests, especially when their ponds were damaged by water contamination with highly concentrated heavy metals or abrupt changes in salinity or pH in pond water environments, especially during the periods of heavy rains or fast flooding. The aquaculture incomes were considered as annual saving amounts, which were usually spent on education, health and comforts.

Contractees in three districts gained daily income differently. Contractees in An Bien and An Minh districts gained daily income from harvests of commercially important marine products; for example, fiddler crabs, mud crabs or fishes for commercial purposes. The daily income, harvest of natural recruitments, was calculated as approximately 7 USD per person, and was used to pay daily family expenses such as food, drink, rice and domestic travel. By contrast, the Kien Luong contractees did not earn daily income from the IMSA. They worked as daily labourers and were paid approximately 5 USD a day per person as a daily income source.

Threats to the Kien Giang IMSA

Following threats to the Kien Giang IMSA operation were identified in participatory community meetings, and focus group interviews. Shrimp larvae and juvenile crabs, when being released, were often killed by their predators, which came into ponds through opening gates in Kien Luong, An Bien and An Minh districts. This killing caused a substantial economic loss. Roots of *Derris Elliptica* were normally used to eradicate predators of shrimp larvae and juvenile crabs before the species were released to ensure good harvests.

During pond operation, gates were opened to allow the passage of saline water and wild larvae. In certain months in the raining season, as soon as the gates were closed, farmed species died in aquaculture ponds in An Bien and An Minh districts. In other cases, shrimp and blood shell died in Kien Luong, An Bien and An Minh districts. Semi-structured interviews with staff working for Agriculture and Aquaculture Extension Centres in An Bien and An Minh districts revealed that after extension staff was contacted

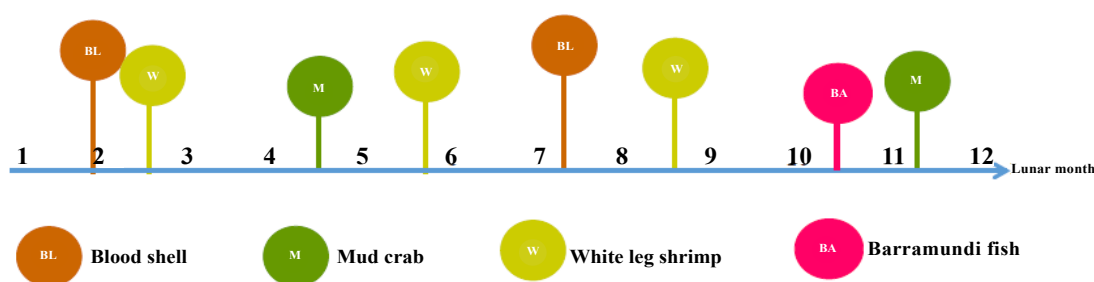


Figure 4: Release seasonality in An Bien and An Minh districts.

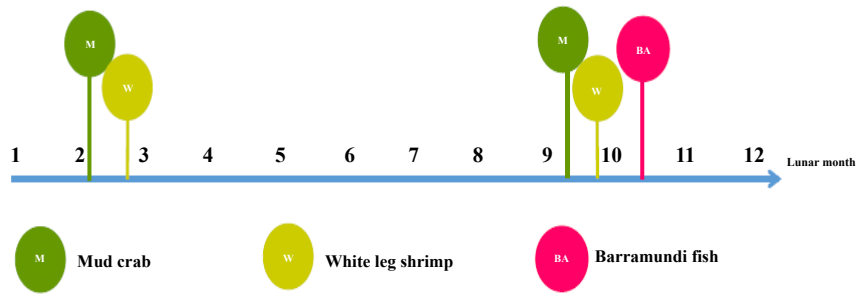


Figure 5: Release seasonality in Kien Luong district.

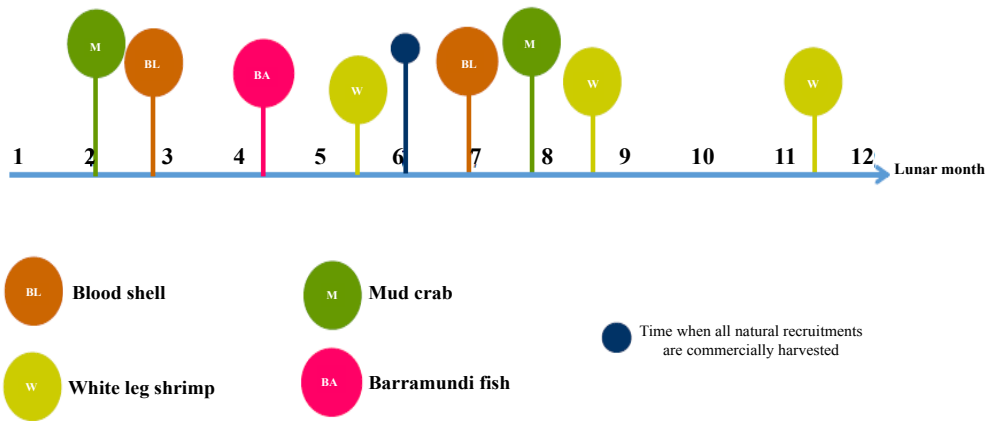


Figure 6: Harvest seasonality in An Bien and An Minh districts.

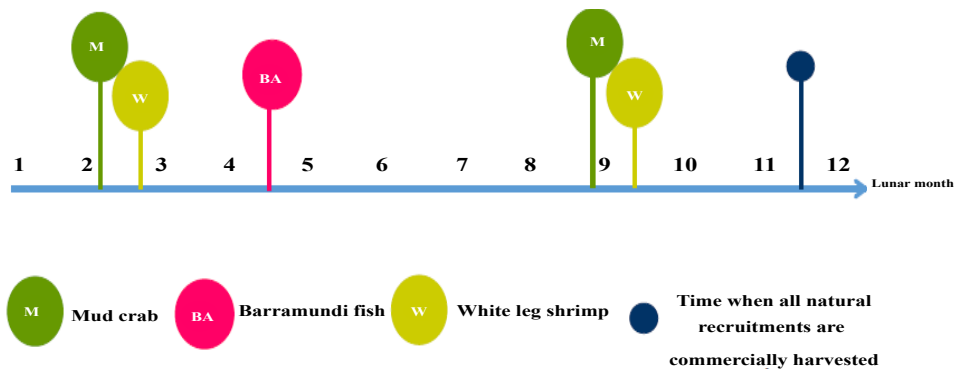


Figure 7: Harvest seasonality in Kien Luong district.

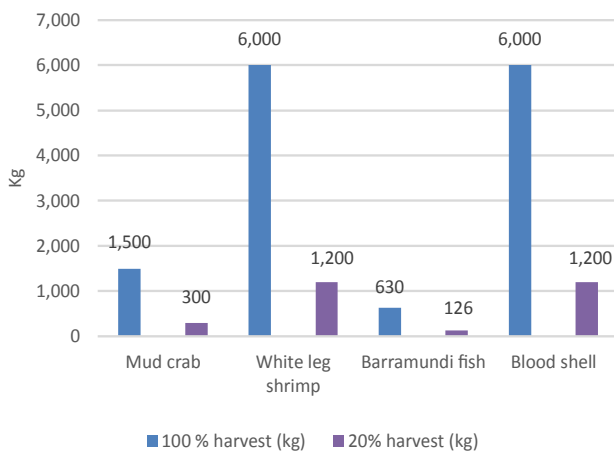


Figure 8a: Yield per harvest in Dong Hung A, An Minh district and Rach Dung, Kien Luong; Yield per harvest for 1 ha pond in Dong Hung A, An Minh.

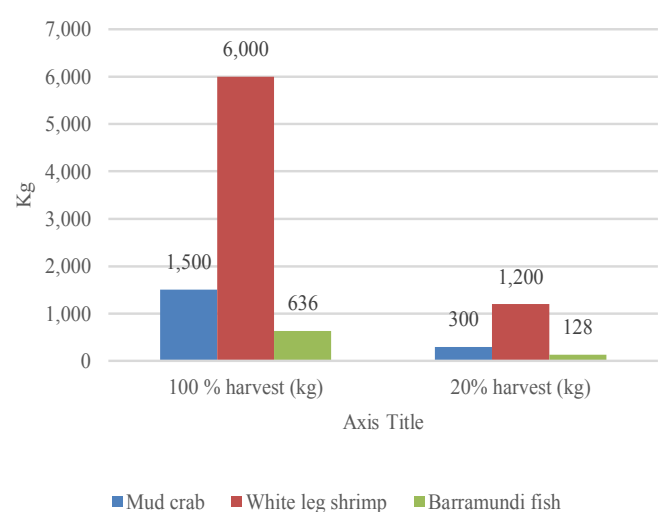


Figure 8b: Yield per harvest for 1 ha in Rach Dung, Kien Luong.

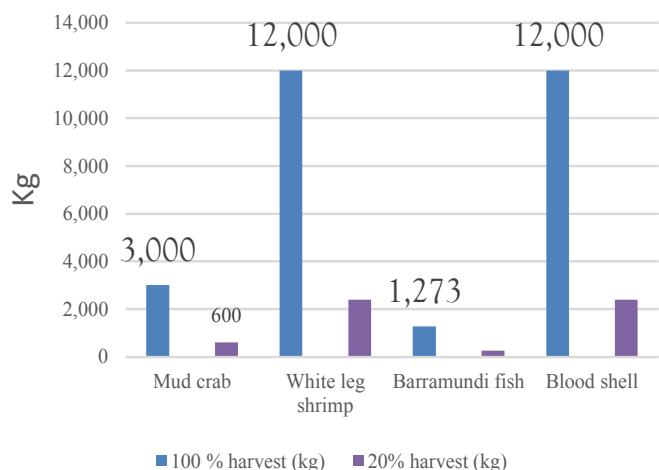


Figure 8c: Yield per harvest for 2 ha pond in Dong Hung A, An Minh.

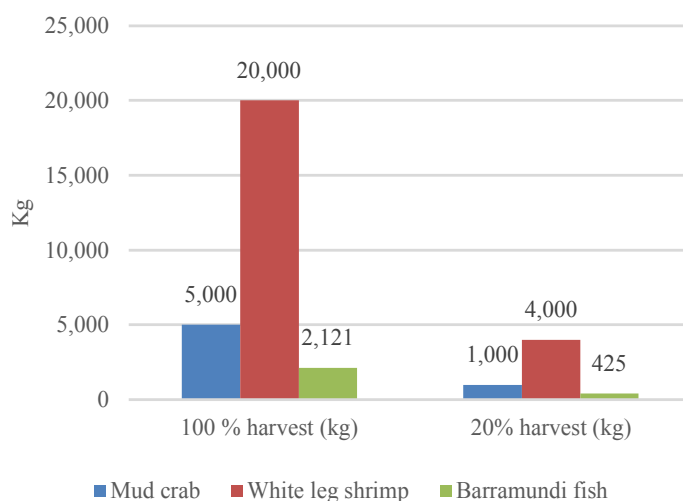


Figure 8f: Yield per harvest for 3 ha in Rach Dung, Kien Luong.

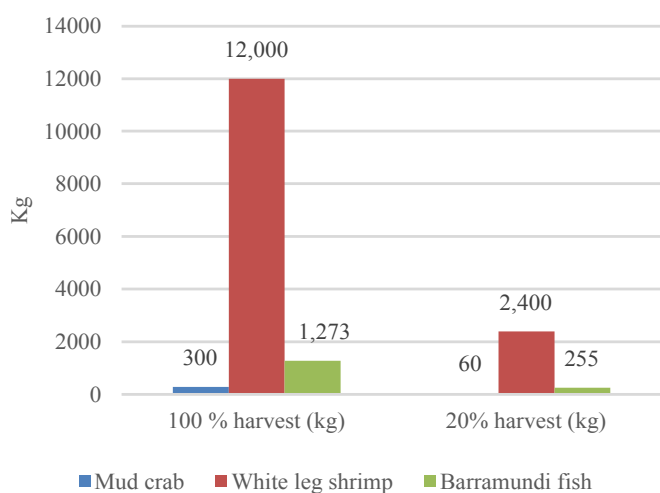


Figure 8d: Yield per harvest for 2 ha in Rach Dung, Kien Luong.

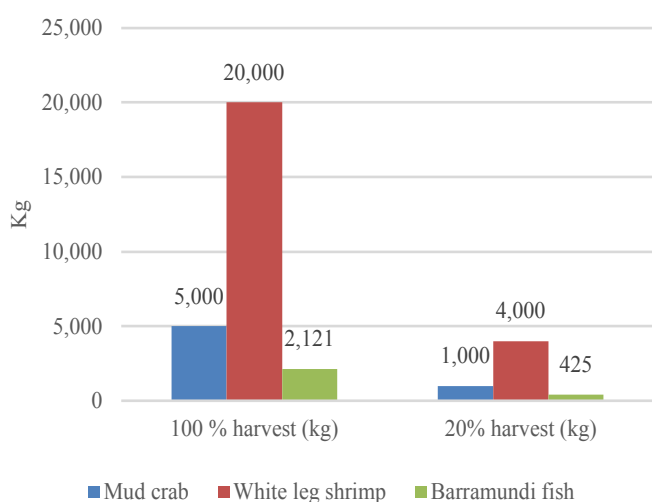


Figure 8e: Yield per harvest for 3 ha pond in Dong Hung A, An Minh.

for assistance, they collected water samples from pond areas for analysis. The analysis results showed that the saline water and sediment was contaminated with metals reaching harmful limits recorded nationally including Cu (1.02 mg/L), Zn (1.3 mg/L), Hg (0.009 mg/L) and Fe (1.66 mg/L). The contaminated sea water was reported to come from elsewhere in Rach Gia City, the capital of Kien Giang Province during the raining season or from rice

Table 2: Investment cost and market price in Kien Luong and An Minh districts.

Farmed species	Cost per individual in November 2013 (USD)	No. of mature individual per kg	Market price per kg of mature individual as at July 2014 (USD)
Mud crab	0.019	2	4.69
White leg shrimp	0.002	25	7.03
Barramundi fish	0.028	0.5	3.52
Blood shell	0.002	50	2.34

farming areas located landwards. Likewise, pond water was quickly diluted with rain water, especially on heavy raining days or fast flooding events. Changes in salinity in saline water decreased the concentration of dissolved oxygen in aquaculture water in An Bien and An Minh districts, which quickly killed farmed species. In the dry season, high temperatures increased respiration associated problems for farmed species, especially shrimp species in An Bien and An Minh districts (Figure 9).

Additionally, shrimp quickly died due to temperature increase in water environments. In the dry season when saline water became saltier or pH levels fluctuated, blood shell died in Kien Luong district (Figure 10).

Lessons with regard to the Kien Giang IMSA operation

The Kien Giang IMSA entirely depended on mangrove nutrient cycling in ponds as the only important food source for farmed species. However, the focus group interviews revealed that a few contractees in An Bien and An Minh districts, who farmed IMSA on allocated mangrove areas of 1 ha, encountered harvest failure. The contractees wished to maximize incomes by releasing species at high density and regularly feeding the farmed species using diets. As a consequence, a substantial number of individuals, especially shrimp species died. The semi-structured interview with staff working for the Centre for Agro-Forestry Extension in An Minh district revealed that regular feeding using diets, when not fully consumed by farmed species, resulted in excess nutrients being accumulated in ponds, which stimulated mass growth of algae or of nuisance plants. The excess nutrients and mass growth of algae and nuisance plants were still evident during field visits.

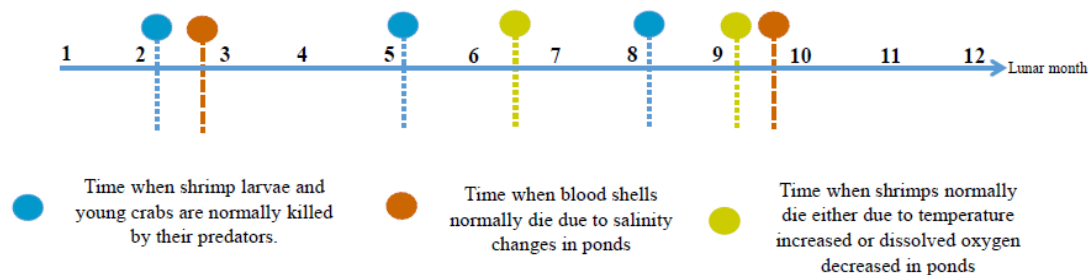


Figure 9: Seasonal events threatened IMSA in An Bien and An Minh districts.

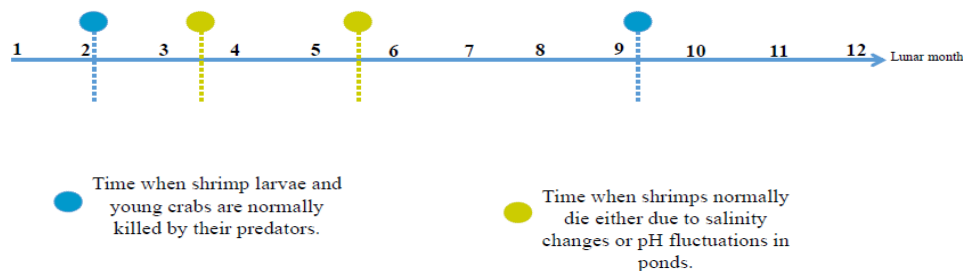


Figure 10: Seasonal events threatened IMSA in Kien Luong district.

The staff collected water sampling for analysis on request made by contractees. The analysis results revealed that a substantial number of individuals, especially shrimp species died as a consequence of eutrophication or reduced dissolved oxygen in pond water environments.

In addition, farmed species did not fully grow within an expected time frame as a consequence of highly competitive interactions of oxygen and food among the farmed species. Un-fully grown species were sold at a substantially low price because the farmed species did not meet commercial standards.

Contractees could not gain access to markets for sale of their harvests because they lived quite far from market places. They quite often undertook commercial transactions of their harvests with middle men who came onto their farms. During commercial transactions, middlemen tried hard to bargain with contractees over the price of harvests. As a consequence, harvests were commercially transacted at prices which excessively below market prices.

Each contractee had a maximum of four labourers who were their family members or relatives in assisting in operating the IMSA. Their labour days on aquaculture operation was not considered as an investment because they needed to do so to maintain their ponds. In some circumstances, contractees were close relatives. Therefore, the exchange of labour days among close relatives was daily work, especially during pond gate operation, release, and harvest seasonality. In addition, contractees could not tell total labour days they spent on operating the IMSA because they did not have a habit of documenting their labour days and total labour days exchanged.

DISCUSSION

The Kien Giang IMSA and its value

The Kien Giang IMSA has been repeatedly applied in Kien Giang since the 1980s. This study showed that contractees did not

record total labour days. Likewise, [8] reported that contractees did not have a habit of documenting total income drawn from this aquaculture model. As a consequence, the Kien Giang IMSA was inadequately recorded. Inadequate recording of the Kien Giang IMSA is a significant problem to thoroughly understand the Kien Giang IMSA and its role in improving local livelihoods. The inadequate recording led to possible presumption among the wider local communities that it was difficult to balance demands for local livelihoods with the need for coastal mangrove protection, especially for allocation areas less than 1 ha in Kien Giang in 2010 (DARD 2010). This reason could presumably explain the low uptake of contractees (only 40%) who implemented IMSA, as reported by [20].

The study showed that the participatory action research methods greatly assisted in comprehensively documenting the Kien Giang IMSA operation, lessons learnt and all income sources. Therefore, the comprehensive documentation of the Kien Giang IMSA helps overcome the challenge posed by the inadequate recording in this regard.

The literature showed that that single species farming (shrimp farming) in allocated mangroves became common in many coastal provinces in the Mekong Delta [6,7,16,18]. Meanwhile, the IMSA was applied in Kien Giang for years and there was no adequate documentation of this aquaculture model. Therefore, the finding of this study added a new dimension to the literature. Besides, The Kien Giang IMSA has established an example of diversifying income sources that are generated from mangrove aquaculture. Total annual incomes gained from the Kien Giang IMSA were much higher than those of mangrove shrimp farming in Ca Mau province, the Mekong Delta of Vietnam, as reported by [16], and [31]. Total annual incomes also positioned contractees in Kien Giang Province well above the poverty line in comparison to the Vietnam poverty line in rural areas, which was approximately 35 USD per person per month (700,000 VND) [7,32] indicated

that there was the risk of crop failure due to regular occurrence of shrimp diseases in shrimp farming. Meanwhile, the Kien Giang IMSA seasonally rotated farming crops and this seasonal rotation substantially assists in diversifying incomes, effectively using the allocated mangroves, and minimizing crop failure. Threats and lessons related to the Kien Giang IMSA have been identified and need to be properly dealt to avoid the same problems in the future. As suggested by [33], monitoring and recording are necessary for contractees in Kien Giang.

CONCLUSION AND RECOMMENDATION

The Kien Giang IMSA operation and its lessons are comprehensively documented using the participatory action research methods. The findings of this study add a new dimension to the literature with respect to mangrove aquaculture. The IMSA lessons should be circulated to ensure effective IMSA replication elsewhere in the Mekong Delta of Vietnam. Species farmed in allocated mangroves should not be regularly fed using diets because regular feeding using diets could possibly result in eutrophication that reduces dissolved oxygen in the water. In case diet feeding is needed to achieve higher harvest amounts, water exchange and air exposure measures must be established to ensure water quality. Daily recording of daily inputs, incomes, and threats should be established to ensure the effectiveness of operating the IMSA. Market links should be strongly developed to increase the exposure of the Kien Giang IMSA products.

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