Lessons from Ecosystem Approach to Aquaculture (EAA) Best Practices for Sustainable Fisheries Development in Indonesia

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Abstract. This study examines the application of the concept developed in the last decade, namely the Ecosystem Approach to Aquaculture (EAA). This approach balances social goals with human state and their interactions with ecosystem. The EAA is a strategy for integrating activities within the wider ecosystem in such a way that it promotes sustainable development, equity, and resilience of interlinked social and ecological systems. Case studies in three locations, namely Pinrang, Aceh Besar and South Lampung, were conducted to draw lessons in order to formulate a general framework for wider application in this country. The potential application of the concept was examined based on the following aspects: (i) ecosystem sustainability, (ii) justice welfare, and (iii) good governance. Data were collected through surveys guided with previously designed questionnaires, invlolving 179 respondents selected purposively from exixting shrimp cultivator. Data were analyzed using Principal Component Analysis (PCA) using the Stata software. Results showed that there was a difference between weights determined in the technical guidelines and those resulting from PCA, which was indicated by various existing conditions in research location. This is a significant finding that is relevant in in developing EAA in Indonesia.

Keywords: Ecosystem management, environmentally friendly, shrimp cultivator, sustainability, welfare.

1 Introduction

A sustainable development is where ecological, economic, and social goals are integrated [1], which supported by the governance goals [2]. This notion is adopted for the fishery sector, a primary sector in the Indonesian economy. Following the 'sustainable' concept, fisheries development goals are determined by various arrangements related to human and fish resources through fisheries management [3, 4]. At the global level, the agreed reference

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for implementing sustainable fisheries management is the Code of Conduct for Responsible Fisheries (CCRF) [5]. The code states that fisheries management must ensure the 'quality', 'diversity' and 'availability' of fish resources in sufficient quantities for current and future generations. The basic principle adopted in this case is that fisheries management is applied by considering the dynamic interaction between abiotic and biotic ecosystem components as a unitary function and process, utilization, and policy formulation. Responsible fisheries management is one of the keys to responding to the challenges of sustainable fisheries development [6].

The notion introduced above is then extended to aquaculture. Aquaculture itself is defined by FAO as a controlled cultivation of aquatic organisms including fish, molluscs, crustaceans, and aquatic plants aimed at increasing production, owned and operated by individuals and business entities. Indonesia adopted this FAO definition where the equivalent of the word "aquaculture" is "fish farming" which is defined as "activities to raise, raise, and/or breed fish and harvest the results in a controlled environment including transportation, storage, processing, and preservation activities [7].

Aquaculture is defined as the farming of aquatic organisms, including fish, mollusks, crustaceans and aquatic plants. Farming entails some form of intervention in the rearing process to enhance production such as regular stocking, feeding, protection from predators, etc. and also implies individuals or corporate ownership of the stock being cultivated [7–9]. One of the ways to implement responsible and sustainable fisheries management is through an ecosystem approach [10–17]. The ecosystem approach is an internationally agreed regime in implementing sustainable fisheries development. The ecosystem approach in aquaculture is known as the Ecosystem Approach to Aquaculture (EAA). The EAA builds on the conceptual work carried out to develop the ecosystem approach to fisheries [18].

Indonesia's shrimp production in 2018 reached 911.86×10^3 t with a value of IDR 63.49×10^{12}. The provinces of Aceh, South Lampung and South Sulawesi are some of centers shrimp production with a fairly large contribution in Indonesia [19]. For Indonesia, one of the promising aquacultures is giant tiger prawn [*Penaeus monodon* (Fabricius 1798)] farming. This is true because fish farming for this species has a number of advantages. First, it can generate high economic value [21], given the increasingly high local and export demand [22, 23]. Second, from the social side, farming is the main source of livelihood for many coastal communities [24]. Third, it is one of the possible ways to provide animal protein for consumers in the country. This background then underlies the policy of the Ministry of Maritime Affairs and Fisheries, which pays great attention to the acceleration of exports and aquaculture that considers local aspects. One example of a concrete form of the policy is the aquaculture village development program.

The challenge faced in its implementation is environmental degradation. The data show that in many locations, the success of aquaculture has come at a cost in terms of environmental damage. One of the triggers of environmental damage due to aquaculture is the application of excessive production inputs that poison the soil and water where aquaculture is developed. Another trigger is bad management, namely management that is not in accordance with natural or ecological capacities. This damage can be treated of course, but the costs may not be commensurate with the benefits derived from implementing aquaculture.

EAA is expected to be able to compromise the interests of reaping benefits while avoiding the damage caused by aquaculture. Brugere *et al.* [25] stated that the EAA in planning processes has raised awareness of the usefulness of holistic and participatory approaches in aquaculture and helped to steer the sector towards greater sustainability. The application of EAA will balance human social interests and their interactions with ecosystems, which in the context of the discussion of this paper will be a strategic step to integrate aquaculture activities in the wider ecosystem. The question is how a sustainable aquaculture development

approach can be promoted and applied in Indonesia. Based on this, the purpose of writing this paper is to identify the relevant factors for the development of EAA in Indonesia.

2 Methodology

2.1 Research area

The research was conducted in 2019 in three District (Pinrang, Aceh Besar, South Lampung). The three locations were chosen because they are aquaculture production centers in each province and locations that have initiated the EAA implementation.

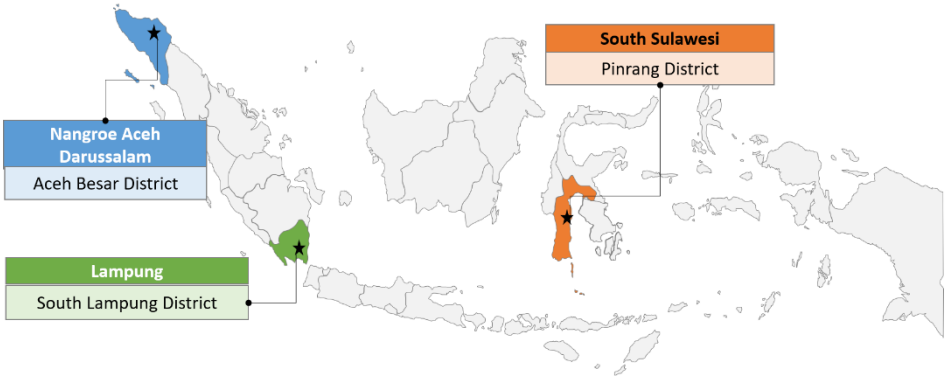


Fig. 1. Research locations.

Based on data from Ministry of Maritime Affairs and Fisheries [26], the provinces of Aceh, South Lampung and South Sulawesi are included in the top ten provinces of Indonesia's shrimp production centers with a contribution of 21.37 %. The selection of this location is also supported by statistical data which shows that the area of ponds from the three provinces reaches 2 103 244 378 m^2 which consists of simple, semi-intensive and intensive ponds. The distribution of ponds area in Aceh, Lampung and South Sulawesi Province is shown in Table 1.

Table 1. Ponds area in Aceh, Lampung, and South Sulawesi Province, 2018.

Province	Simple ponds	Semi-intensive ponds	Intensive ponds
Aceh	497.872.117	89.584.997	31.740.264
Lampung	208.017.245	115.580.911	61.451.844
South Sulawesi	1.033.051.501	57.422.240	8.523.259

2.2 Data collection

The data collected includes primary and secondary data. Primary data were collected using a surveys technique guided by previously designed questionnaires. The survey was carried out through interview involving 179 respondents selected purposively from existing shrimp cultivators. The data taken includes respondent characteristics, business characteristics, shrimp cultivator perception and EAA indicators. Data were also complemented with field notes taken through field observation. While secondary data were taken from various relevant references.

2.3 Data analysis

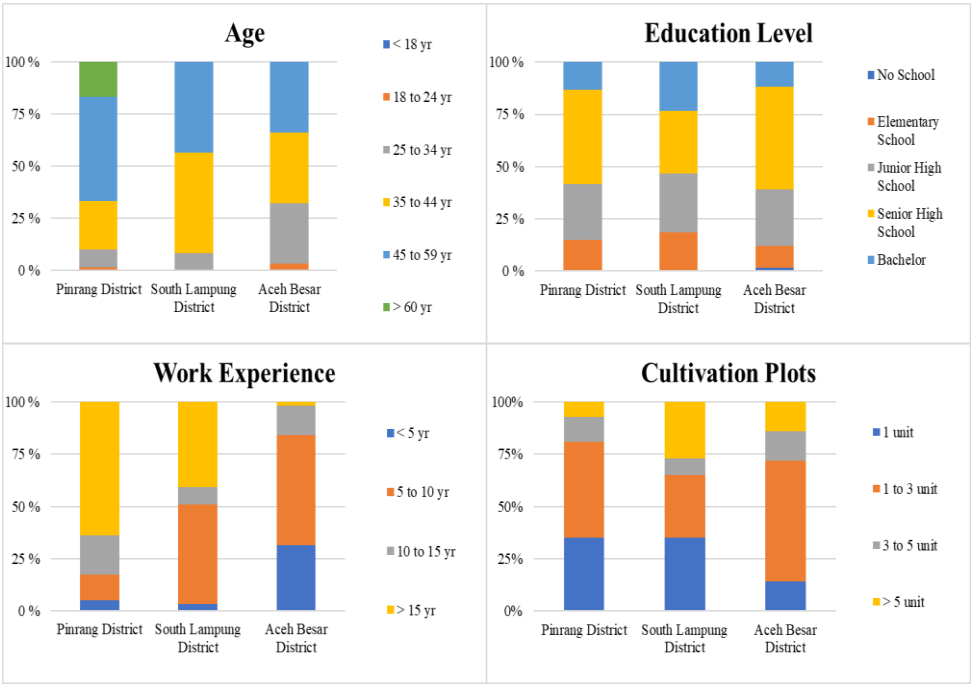
Data were analyzed using a descriptive analysis approach. Determination of factors that influence the success of EAA implementation was done using the Principal Component Analysis (PCA) with the Stata software. The analyzed factors covered three domains, namely ecosystem sustainability, justice welfare, and good governance.

The stages of analysis carried out were as follows: i) Data collection in the field (interviews using a questionnaire reinforced by the results of discussions and field observations by researchers); ii) Data validation and verification was carried out on the data that has been collected so that it could be used for analysis purposes; iii) Data entry was carried out after changing the data into ordinal forms in accordance with the order with a predetermined interval scale so that it can be analyzed using the principal component analysis method (PCA - Principle Component Analysis); and iv) Calculations were carried out using Stata software after obtaining the coefficients from the PCA for the indicators that had been grouped according to their principles and domains.

3 Result and discussion

3.1 Respondent characteristics

The characteristics of shrimp cultivators in the study area were seen from several aspects, namely age, education, length of work, area, household income and additional work (Figure 2).



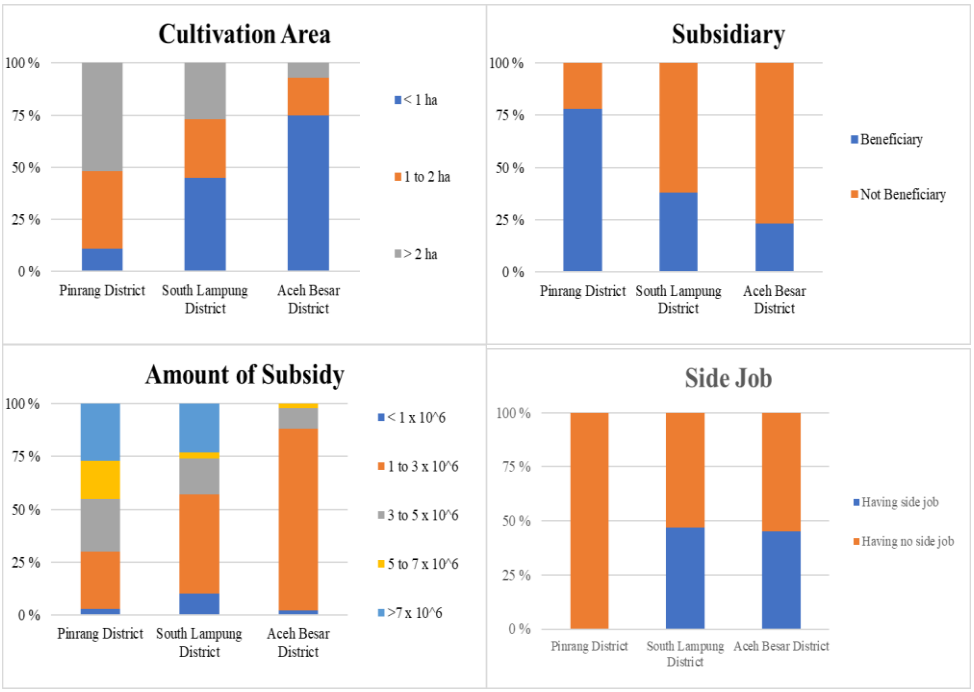


Fig. 2. Characteristics of respondents of shrimp farmers in research locations, 2019.

Regarding the total ownership of cultivated pond, the selected respondents to shrimp farmers in Pinrang Regency owned relatively a greater number of plots than other locations. South Sulawesi is one of the centers of aquaculture production and has the largest pond in Indonesia. In addition, South Sulawesi also still has potential shrimp farming area for its development [27]. Meanwhile, the location in Aceh Besar Regency has relatively narrow area.

The high and low age of a person is indicated to affect the success of the business. Most of them fall into the category of productive age, young people's interest in shrimp farming is low regeneration of farmers. It is need to notice that young people no interest in catching shrimp [28].

Most of the cultivators have fulfilled the 9 yr primary school requirement. Education can influence the adoption of aquaculture technology and aquaculture management policy programs. The experience of cultivation business was found relatively longer at the Pinrang Regency location compared to other locations location. Business experience was also fund as a determining factor in the level of aquaculture adoption and the implementation of aquaculture management policy programs. Cultivation business in one cycle for 3 mo to 4 mo.

The results of the status of recipients of financial assistance, it was found that respondents in Aceh Besar received relatively less assistance than other regions. Meanwhile, the area in Pinrang Regency was the area that received the biggest amount of financial assistance.

3.2 Busines characteristics

There are assumptions held by this study that the more dominant the source of livelihood from aquaculture, especially shrimp cultivator in livelihood structure of the fish farmer's household. Then readiness shrimp cultivator for EAA implementing. One of the important problems faced in economic development is how to deal with trade of between environment

sustainability and fulfillment development needs [29, 30]. Shrimp farming increased the people's income in a reasonable way that could be projected to the elevated socio-economic status of the coastal communities [31].

Figure 3 shows that under normal conditions the costs, revenues and profits obtained from farming in the research location are positively correlated with plot size. Furthermore, it is also shown that there are differences in the income of farmers in each location, which is caused by differences in shrimp prices and operational costs. The results related to this aspect of the business generally show that profitability affects the level of farmer adoption of the EAA introduced to farmers.

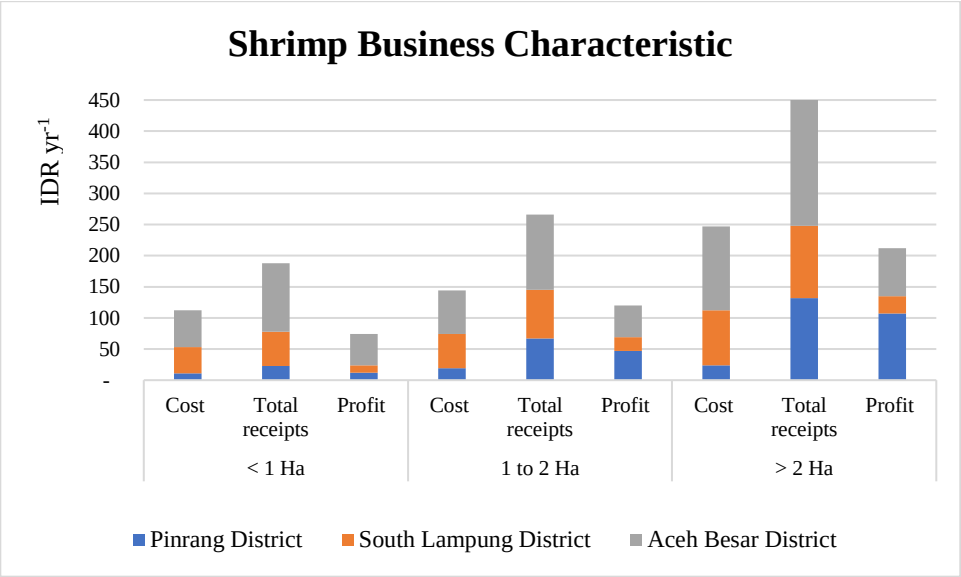


Fig. 3. Characteristics of business shrimp farmers on EAA.

3.3 Perception of shrimp farmers

Shrimp cultivators perceptions of management issues in aquaculture have been analyzed. Figure 3 shows farmers in the three locations demonstrated a good understanding that aquaculture requires a good management system. The goal is to be able to provide maximum results both economically and environmentally. There is an important finding which shows that farmers also believed that conservation and zoning compromy in aquaculture is possible. However, on the other hand, farmers also reject the view that cultivation is included in the category of damaging the environment. The technical aspects of management (in the form of document management and certifications) are relatively neutral to less approved. For farmers, these factors have the potential to increase the operational costs of aquaculture business.

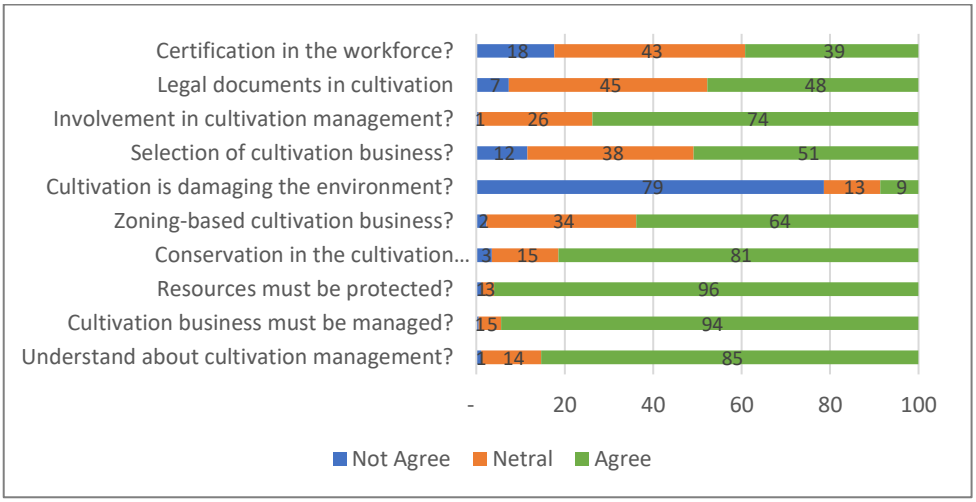


Fig. 4. Perceptions of shrimp farmers on EAA.

3.4 EAA success factor

Based on the results of the PCA, the following conclusions can be drawn: i) Parameter and indicator weights in technical instructions are static; ii) Characteristics of cultivation business, environment, socio-economy are different; iii) Differences in weight the effect of EAA factors/parameters at each location is different; and iv) The key factors in each location are different, according to the magnitude of the eigenfactor value. The PCA results in the research site are shown in Table 2.

Table 2. PCA of the ecosystem approach for aquaculture management at the research site.

Domain/indicator	Principal component analysis			Weight according to technical guidelines
	Pinrang district	South Lampung district	Aceh Besar district	
Suitability with carrying capacity				40
Suitability with layout	0.6139	0.5775	0.6432	10
Cultivation area does not pollute	0.7806	0.5326	0.7235	10
Fulfillment of water quantity	0.6014	0.7390	0.5113	5
Fulfillment of water quality	0.7993	0.2409	0.6504	5
Proximity to pollution sources	0.5013	0.5468	0.5497	10
Sustainability of aquaculture area management				25
Use of environmentally friendly seeds	0.2133	0.4286	0.4959	4
Fulfillment of fish seed needs according to price, quantity and quality	0.7490	0.4002	0.4790	4
Suitability of using fish food from the aspect of legality and method of use	0.6879	0.3328	0.5354	4
Suitability of using fish medicine from the aspect of legality and method of use	0.8163	0.6690	0.4508	4
Outbreak management	0.5219	0.4416	0.7776	4
Land conversion for aquaculture	0.9266	0.6245	0.2411	4
Cultivators have CBIB certificate	0.4707	0.5051	0.7648	4

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Table 2. Continue.

Domain/indicator	Principal component analysis			Weight according to technical guidelines
	Pinrang district	South Lampung district	Aceh Besar district	
Environmental management in aquaculture areas				35
Meet the AMDAL* requirements	0.7525	0.6005	0.9603	12
Environmental monitoring	0.5671	0.7081	0.7037	12
Habitat and wildlife protection	0.6114	0.5655	0.6768	12
Social Aspect				60
Absorption of local labor	0.3838	0.4523	0.7700	7
Labor competence	0.7129	0.5816	0.5528	7
Capacity building of local communities	0.5183	0.5997	0.6233	7
Cultivator's social security	0.5870	0.6013	0.5731	5
Social conflict	0.9158	0.5807	0.5182	35
Economy Aspect				40
Land status	0.6400	0.3949	0.6256	5
Asset accumulation	0.4726	0.3757	0.1159	5
Capital accessibility	0.4249	0.4928	0.5281	5
Market accsessibility	0.5763	0.3150	0.4850	5
Creation of fair trade	0.4788	0.3882	0.4325	5
Cultivator household income	0.4194	0.5688	0.3442	5
Saving	0.3647	0.2579	0.5342	5
Profit	0.4721	0.4647	0.3511	5
Governance integration				
Institutional	0.7351	0.5320	0.6376	15
Spatial regulations	0.4244	0.4409	0.4160	8
Licensing regulations	0.4444	0.3883	0.3321	8
Compliance and law enforcement	0.3829	0.4011	0.6258	25
Society participation	0.3977	0.4152	0.4959	15
SKPD Synergy	0.4184	0.2951	0.5232	15
Monitoring and evaluation	0.6621	0.6481	0.4347	15

Source: primary data processed, 2019.

Note: * *Analisa Mengenai Dampak Lingkungan* (AMDAL), is environmental assessment document which describes coverage of facilities and activities under the Government's environmental impact assessment system and the procedural steps and compliance requirements.

The parameter that have the highest eigenvalue indicates the key success factor for EAA implementation in research site. Data obtained in the three location research shows that there were differences in key factors determining the success of EAA resource management for each location. Fact the occurrence of these differences, explains many things, like environmental carrying capacity, shrimp cultivator experience, and shrimp cultivators still need government assistance to implement EAA. Thus, the six parameters with the largest eigenvalue is shown in Table 3.

Table 3. Key success factor for EAA implementation at the research site.

Pinrang district	South Lampung district	Aceh Besar district
Fulfillment of water quality.	Fulfillment of water quantity.	Cultivation area does not pollute.
Land conversion for aquaculture.	Fulfillment of medicine needs.	Outbreak management.

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Table 3. Continue.

Pinrang district	South Lampung district	Aceh Besar district
Meet the AMDAL requirements.	Environmental monitoring.	Meet the AMDAL requirements.
Social conflict.	Cultivator's social security.	Absorption of local labor.
Land status.	Cultivator household income.	Land status.
Institutional.	Monitoring and evaluation.	Institutional.

Source: primary data processed, 2019.

3.5 Synthesis

In general, the results of observing the characteristics of farmers, which are represented by the profiles of the respondents, show that the leading percentages of shrimp cultivators fall into productive age, although young people's have no interest in shrimp farming. Most of the cultivators have fulfilled the 9 yr primary school requirement. The experience of cultivation business was found relatively longer at the Pinrang Regency location compared to other locations. Business experience was also found as a determining factor in the level of aquaculture adoption and the implementation of aquaculture management policy programs. Cultivation business in one cycle for 3 mo to 4 mo.

Linking this with the business performance of the farmers, it appears that there is a link between aspects of the characteristics of the farmers and profitability, especially on the characteristics of costs, revenues and profits. It is also shown that there are differences in the income of farmers in each location, which is caused by differences in shrimp prices and operational costs.

Then, the influence of the characteristics of the farmers and their business performance can be traced on their perception that parameter and indicator weights in technical instructions are static. The characteristics of cultivation business, environment, socio-economy are different. There were differences in weight, the effect of EAA factors/parameters at each location is different and also the key factors in each location were different.

The key factor analysis yielded important clues about the crucial aspects at each site. However, these results do not confirm there is a similarity of factors or aspects for all locations. Nevertheless, a common thread can still be drawn from the results of this analysis, namely that environmental aspects and their management, including disease management, are crucial for all locations.

When compared to the existing literature, these results shows differences environmental carrying capacity between research location, shrimp cultivator experience, and shrimp cultivators still need government assistance to implement EAA.

4 Conclusion

The implementation of the EAA concept in the three locations referred to in this study provides lessons that can be used as a basis for introducing EAA in other locations in the country. Following this, the first lesson to be learned is that no single success factor applies in every location. However, natural conditions and their management, including disease management, seems to be the first concern in the selection of EAA sites. The next important lesson is that in practice various local circumstances forced EAA adopters to modify some of the directions provided by the technical guidelines. Finally, the results of this study also provide a lesson that the implementation of the EAA concept for shrimp farming should be

applied simultaneously at all levels of related business segments. Therefore, the policy implications are the need to design more operational technical guidelines and the need for a massive campaign to local governments.

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