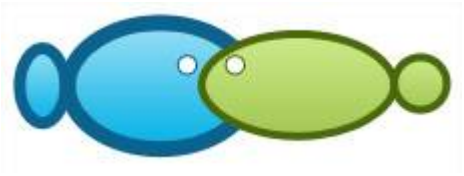

The use of idle shrimp ponds for intensive grouper cultivation in the eastern coast of Aceh

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Abstract. This study aims to analyze the suitability of idle shrimp ponds for grouper aquaculture on the eastern coast of Aceh. The samples were collected from 7 districts, namely Aceh Tamiang, Langsa, Aceh Timur, Aceh Utara, Lhokseumawe, Bireuen, and Pidie Jaya, which consists of 51 sub-districts and 98 villages. The method applied was the mapping of idle shrimp ponds using a GIS system, interviews, and water quality measurements, as well as the matching approach to obtain the ponds' eligibility classes. The results showed that 33.72% of the total pond area in eastern Aceh is categorized as idle. The quality of soil and water in the sampling areas was feasible for grouper aquaculture. Based on the soil types, 62% are sand, 46% clay, 31.44% organic matter, and pH 5.5. Furthermore, the salinity ranges from 27 to 32.1 ppt, dissolved oxygen from 4.5 to 6.2 mg L^{-1}, pH from 5.5 to 8.3, with a brightness level of 1.3 m, and the pond conditions were classified as moderately suitable. Based on these results, the use of idle shrimp ponds is recommended for grouper aquaculture.
Key Words: Aceh, GIS, grouper, idle pond, mapping.

Introduction. Recently, aquaculture is well known as a fast growing food production sector in the world (Samad et al 2022). Apart from freshwater aquaculture, brackish, and seawater area have also gained rapid intensification in the last decades (Samad et al 2014; Ahmed et al 2018; FAO 2021). One of the commodities that are mostly cultivated in brackish water is shrimp but its production has decreased due to water pollution, degradation of mangrove areas, sediment discharge, and other environmental impacts (Joffre et al 2018; Pongtippatee et al 2018). Furthermore, unwell planned-management and diseases problem caused worsening shrimp production (Tawade et al 2019). This condition leads to the reluctance of aquaculturists to continue their shrimp culture, thereby causing unproductive (idle) ponds in Aceh.

Aceh Regency, in particular the eastern sector, has a great potential for fisheries development, but is not yet being used to its full capacity (Putra et al 2021). This province mostly still depends on traditional aquaculture system to cultivate shrimp and fish. Consequently, the fisheries sector appears to be developing slowly. Therefore, determining appropriate management in using the idle ponds is crucial to increase fisheries production (Jayanthi et al 2018; Nagamani & Suresh 2019). Idle pond is defined as an abandoned body of water that is suspected of not being used, not being cultivated, or not being used in line with the conditions, nature, and purpose of giving rights or the basis of control (Aris et al 2022).

There is a need to capitalize on these idle ponds by cultivating other commercial commodities such as grouper to increase fisheries production and improve the income of coastal communities. Grouper is among high economic value fish (Rimmer & Glamuzina 2017) that can be cultivated in ponds and floating net cages (Putra et al 2021) and grow fastly with massive production (Soejarwo et al 2018). Its soft flesh and high protein contents have increased the demand for domestic and export markets (Hermawan et al 2019)). Dennis et al (2020) and Putra et al (2021) mentioned that the application of

intensive technology in grouper culture might increase productivity to meet the demand of consumers.

However, to support these efforts, it is necessary to collect data on pond eligibility analysis, to predict and assess potential idle ponds. Thus, this study aims to analyze the feasibility and eligibility of idle shrimp ponds for reviving grouper aquaculture in the eastern region of Aceh.

Material and Method

Research site. This study was conducted in 7 districts in Aceh as shown in Figure 1, namely Aceh Tamiang, Langsa, Aceh Timur, Aceh Utara, Lhokseumawe, Bireuen, and Pidie Jaya; these districts consist of 51 sub-districts and 98 villages as illustrated in Table 1 and the data used were collected from July to August 2022. Soil and water quality parameters were analyzed in the Laboratory of the Faculty of Agriculture, Universitas Samudra.

Table 1

Idle ponds on the eastern coast of Aceh

Districts	*Sub-districts*	*Villages*
Aceh Tamiang	Banda Mulia, Bendahara, Manyak Payed, Seruway	Alue Sentang, Alur Nunang, Bandar Khalifah Kampung Baru, Kuala Pusong Kapal, Senubok Cantek, Sungai Kurok III, Tanjung Keuramat
Langsa	Langsa Barat, Langsa Timur, Langsa Baro	Birem Puntong, Cinta Raja, Kuala Langsa, Simpang Lhee, Sungai Lueng, Sungai Pauh, Alue Dua
East Aceh	Birem Bayeun, Darul Aman, Idi Rayeuk, Idi Timur, Julok, Madat, Nurussalam, Peudawa, Peureulak Barat, Peureulak Timur, Peureulak, Rantau Seulamat, Simpang Ulim, Sungai Raya	Abuek Geulante, Alue Bu, Alue Dua Muka O, Alue Kumba, Babah Krueng, Bagok Panah Sa, Bantayan, Bayeun, Birem Rayeuk, Gampong Kuala, Geulumpang Payong, Kuala Bagok, Kuala Geulempang, Kuala Peudawa Puntong, Kuala Simpang Ulim, Labuhan Kedee, Kuala Legeu, Lhok Sentang, Matang Rayeuk, Meunasan Asan, Meunasah Blang, Meunasah Tingkeum, Naleung, Paya Dua, Paya Gajah, Paya Peulawi, Peulawi, Seunubok Dalam, Seunubok Pidie, Teupin Mamplam
North Aceh	Baktiya Barat, Baktiya, Dewantara, Lapang, Muara Batu, Samtalira Bayu, Samudera, Seuneudon, Tanah Pasir, Tanah Jamboaye	Alue Campli, Baroh Blang Rimung, Cot Kapiraton, Kereuto, Lancang, Lueng Baro, Lhok Iboih, Matang Baroh, Matang Cut, Matang Janeng, Matang Jurong, Matang Raya Barat, Matang Sijuek Barat, Matang Ulim, Meucat, Paloh Gadeng, Punti, Teupin Gajah, Ulee Matang, Ulee Pulo
Lhokseumawe	Banda Sakti, Blang Mangat, Muara Dua, Muara Satu	Cut Mamplam, Alue Awe, Batu Phat Timur, Blang Naleung Mameh, Jambo Timue, Tunong, Ujong Blang
Bireuen	Ganda Pura, Jangka, Jeunieb, Kuala, Pandrah, Peudada, Peulimbang, Samalanga, Simpang Mamplam	Mon Jambe, Blang Rheu, Lancang, Alue Buya, Tanah Anoe, Ujong Blang Mesjid, Kuala Raja, Uteun Krut, Matang Pasi, Gampong Baro, Meunasah Lancok, Pante Rheung, Rheung Baroh, Ulee Kareung
Pidie Jaya	Bandar Baru, Jangka Buya, Meurah Dua, Meureudu, Pante Raja, Trieng Gadeng, Ulim	Buangan, Cot Lheu Reng, Cot Nyong, Gampong Cot, Gampong Mesjid, Grong grong Capa, Kiran Baroh, Mee Pangwa, Meuraksa, Paru Keude, Siblah Cot, Udeung

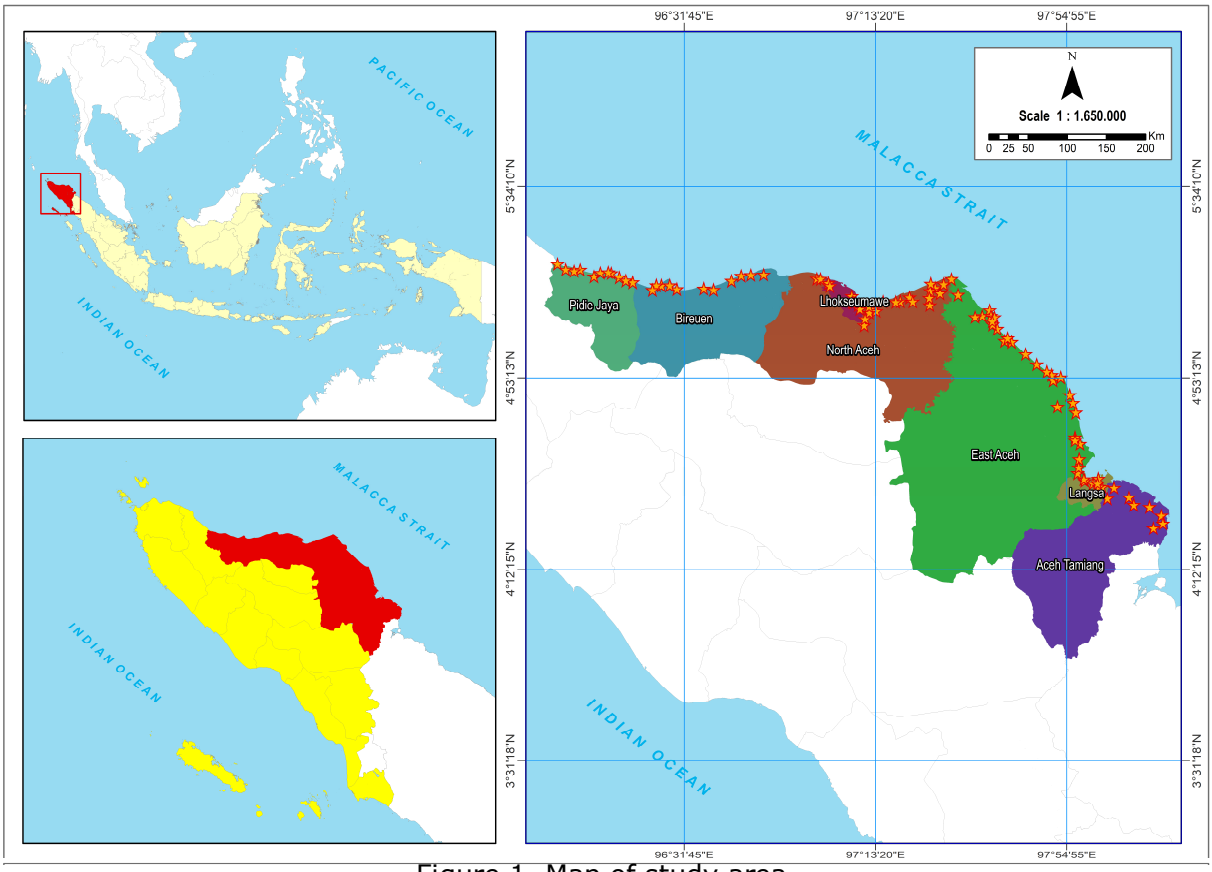

Figure 1. Map of study area.

Research methods. To notify the idle shrimp ponds, the geographic information system (GIS) system was used to obtain data on the villages and pond areas. The geo-tagged locations of shrimp farms were obtained from the Department of Fisheries in each district. Soil and water samples were taken at 3 points in each pond. Interviews and questionnaires were also filled out by respondents, and data or references were collected from agencies related to the research objectives. Subsequently, tabulation of the data was carried out and analyzed based on the objectives to be achieved with the analysis tools that have been determined. The ponds' suitability was determined by compiling the matrix suitable for the growth of the grouper. Ponds eligibility class assessment was also determined according to instructions for Reconnaissance Land Resources Surveys. The class was distinguished in the appropriate order 'S' (suitable) and 'N' (not-suitable), where the order 'S' is divided into 3 classes, namely S1 (highly suitable), S2 (moderately suitable), and S3 (suitable conditional).

Soil and water quality parameters. The inclusion criteria for sample collection were soil characteristics (color, type/visual), water sources, and cultivation activities. The sampling location was determined by considering the ease of reaching the location of the sampling point, as well as time and cost efficiency based on the initial interpretation of the study area. Primary data were taken directly in situ for water quality parameters, namely temperature, salinity, dissolved oxygen (DO), pH, and brightness. Subsequently, both soil and water quality were analyzed in the Laboratory of the Faculty of Agriculture, Universitas Samudra.

Data analysis. To determine the eligibility of ponds for grouper aquaculture, a qualitative method was used by combining the results of soil and water sample analysis with the eligibility criteria. This was carried out to obtain the ponds' characteristics and the parameters were analyzed by matching the method to get the pond's eligibility class.

Results. The results showed that the largest percentage of idle pond area was found in Langsa city which reached 56.69% (1,440.57 ha), followed by Aceh Tamiang district at 53.74% (1,752.47 ha). Based on the data, it was also recorded that although Bireuen is listed as the second largest pond area with 4,406.31 ha, the use of the ponds was very high. Therefore, the city has the lowest idle ponds percentage of 6.97%, as presented in Table 2.

Table 2

Idle ponds in the eastern Aceh

Districts	*Pond areas (ha)*	*Idle ponds (ha)*	*Percentages (%)*
Langsa	2,540.97	1,440.57	56.69
Aceh Tamiang	3,260.75	1,752.47	53.74
Lhokseumawe	365.27	134.89	36.93
East Aceh	12,363.24	3,700.74	29.90
North Aceh	2,470.24	641.78	25.98
Pidie Jaya	748.38	194.25	25.87
Bireuen	4,406.31	307.14	6.97
Total	26,115.16	8,171,84	33.72

East Aceh district had the highest sampling site, with 15 coastal sub-districts and 30 villages covering 12,363.24 ha of ponds. Langsa, which has three sub-districts and seven villages, and a total pond area of 2,540.97 ha, had the lowest sampling site. However, Lhokseumawe had the smallest pond area, measuring 365.27 ha.

Characteristics of soil and water. In this study, the soil quality parameters were sand, clay, organic matter, pH, and iron (Fe) content. Meanwhile, the water quality parameters were temperature, DO, salinity, brightness, and pH (Table 3).

Table 3

Soil and water quality parameters

Variables	*Value*
Soil quality parameters	
Sand	40-62%
Clay	5.0-46%
Organic matter	3.25-31.44%
pH	5.0-5.5
Iron (Fe)	200-700 ppm
Water quality parameters	
Temperature	29.5-32.6°C
DO	4.5-6.2 mg L^{-1}
Salinity	27.0-32.1 ppt
Brightness	0.8-1.5 m
pH	5.5-8.3

Based on observations of water quality parameters, it was discovered that generally, the water quality was feasible to support the development of the aquaculture business. Temperature values of 29.5-32.6°C, pH 5.5-8.3, salinity 27.0-32.1 ppt, and DO 4.5-6.2 mg L^{-1} were considered suitable for grouper farming. This water quality condition is in line with the values obtained by Putra et al (2021) and Samad et al (2022), while the pH in Langsa water was 7.2 to 7.3, and DO 3.8 to 4.7 mg L^{-1}. However, water quality is sometimes influenced by weather and tidal conditions. Additionally, the DO values obtained din our study are suitable for grouper, as mentioned in the previous study that the optimum limit is 4-7 mg L^{-1} (Samad et al 2014).

Pond eligibility. The results showed that the eligibility class of the pond was in S2 (moderately suitable) in all sampling sites, while the soil texture was sandy and clayey. The ponds eligibility class in East Aceh and Lhokseumawe can be seen in Table 4.

Soil texture and water sources also play an important role in determining whether a pond is suitable for aquaculture activity. According to Salvo et al (2017) and Sanz-Lazaro et al (2021), good soil does not only hold water, but the texture must be able to provide various nutrients for the live feed. Keeley et al (2018) and Woodcock et al (2018) also stated that the optimal type of sedimentary substrate for aquaculture activities is sandy loam type.

Table 4

Pond eligibility class

Location	*Sand quality score*	*Water quality score*	*Sand + water quality score*	*Pond eligibility class*
ATAG	65	65	130	S2
ATAB	65	62	127	S2
ATAD	73	70	143	S2
ATAK	75	73	148	S2
ATBK	70	69	139	S2
ATBP	71	65	136	S2
ATBT	71	70	141	S2
ATBY	69	65	134	S2
ATBR	72	69	131	S2
ATGK	68	65	133	S2
LKCM	70	70	140	S2
LKAA	71	72	143	S2
LKBP	71	69	140	S2
LKBN	73	71	144	S2
LKJT	72	69	141	S2
LKT	70	70	140	S2
LKUB	71	70	141	S2

ATAG = Abuek Geulante, ATAB = Alue Bu, ATAD = Alue Dua Muka O, ATAK = Alue Kumba, ATBK = Babah Krueng, ATBP = Bagok Panah Sa, ATBT = Bantayan, ATBY = Bayeun, ATBR = Birem Rayeuk, ATGK = Gampong Kuala, LKCM = Cut Mamplam, LKAA = Alue Awe, LKBP = Batu Phat Timur, LKBN = Blang Naleung Mameh, LKJT = Jambo Timue, LKT = Tunong, LKUB = Ujong Blang.

Mangrove ecosystem structure and composition. Based on observations, the type of mangrove ecosystem surrounding the idle pond area was mainly formed by the genera *Rhizophora*, *Avicennia*, *Bruguiera*, *Sonneratia*, and *Xylocarpus* (Table 5).

Table 5

Mangrove in the eastern coast of Aceh

No	*Species*	*Location*
1	*Rhizophora apiculata*	AT, LS, EA, NA, LK, BR, PJ
2	*Rhizophora mucronata*	AT, LS, EA, NA, LK, BR, PJ
3	*Avicennia lanata*	AT, LS, EA, NA, LK, BR, PJ
4	*Avicennia marina*	AT, LS, EA, NA, LK, BR, PJ
5	*Bruguiera gymnorrhiza*	AT, LS, EA,
6	*Bruguiera parviflora*	AT, LS, EA,
7	*Sonneratia caseolaris*	AT, LS, EA, NA, BR
8	*Xylocarpus granatum*	AT, LS, EA

AT = Aceh Tamiang, LS= Langsa, EA = East Aceh, NA = North Aceh, LK = Lhokseumawe, BR = Bireun, PJ = Pidie Jaya.

A total of 8 species of mangrove plants were found during sampling periods. In Aceh Tamiang (AT), Langsa (LS), East Aceh (EA), North Aceh (NA), Lhokseumawe (LK),

Bireuen (BR), and Pidie Jaya (PJ), the plants were dominated by *Rhizophora* sp. and *Avicenna* sp. Similarly, Irwan et al (2019) discovered 8 species of mangrove vegetation in Bone Sulawesi, which include *Rhizophora mucronata*, *Rhizophora lamarckii*, *Rhizophora apiculata*, *Nypa fruticans*, *Sonneratia alba*, *Avicennia marina*, *Avicennia officinalis*, and *Xylocarpus granatum*.

Discussion. BPS (2016) estimated that 45% of the 50630 ha of pond area in Aceh is idle. This occurs because of environmental damage due to over-exploitation in intensive shrimp farming. From Table 2, it can be discovered that 33.72% of the 7 districts observed in the eastern part of Aceh have idle ponds. This indicated that the use of idle shrimp ponds for fish cultivation in Aceh is still rare. Therefore, a suitability assessment was carried out using GIS. The advantages of GIS are for selecting locations and managing cultivation which is important to avoid business failure (Jayanthi et al 2018; Nagamani & Suresh 2019).

The understanding of the soil texture and water quality parameters in ponds is significantly important to determine the productivity of ponds. However, due to limited information on these parameters (Samad et al 2022), this study aimed to collect the desired data in 98 villages of 7 districts in Aceh. All data have been carried out at several points of idle shrimp ponds which are suitable to be developed for grouper aquaculture. According to Rizal et al (2020), the suitable pond's location and the maximum use of natural resources are important to determine the success of the aquaculture process. Moreover, another factor that is necessary to be considered is the proximity of the position of the pond to water sources (Mustafa et al 2021). In this study, data showed that idle ponds located on the banks of rivers have better water quality than those in small grooves.

As previously stated, soil texture and water sources play an important role in determining whether a pond is suitable for aquaculture activity; good soil is not only able to hold water, but the texture must be able to provide various nutrients for live feed (Salvo et al 2017; Sanz-Lazaro et al 2021). Results showed that the soil texture was sandy and clayey. According to Keeley et al (2018) and Woodcock et al (2018), the optimal type of sedimentary substrate for aquaculture activities is sandy loam type.

The mangrove ecosystem has a unique function in the environment due to the influence of the sea and land. Mangroves can act as a wave barrier, seawater intrusion, and abrasion barrier (Dat & Yoshino 2013). Another uniqueness is the multipurpose function of its forests as a source of income for rural communities in coastal areas, where certain marine biota, flora, and fauna can be developed as ecotourism. This shows that a conservation strategy involving local communities is more effective compared to one-way preservation involving only the government. Increasing public awareness of the preservation function will also maintain the ecosystem balance and economic function. Therefore, the environmental ecosystem is expected to achieve optimization and sustainability management of the area.

Conclusions. The results showed that the idle ponds in 51 sub-districts and 98 villages in the Eastern Aceh Coast from the total ponds are approximately 33.72%. It was also discovered that the water quality and soil texture were still feasible to support the development of aquaculture. Based on the analysis of the suitability of the idle ponds, the land conditions were classified into S2, namely moderately suitable. The mangrove area and availability of life feed can support aquaculture activities, therefore, the use of idle ponds for grouper aquaculture is recommended

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Conflict of interest. The authors declare that there is no conflict of interest.

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