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Assessment of Shrimp Farming Impact on Groundwater Quality using Analytical Hierarchy Process

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Abstract. Improved shrimp farming affects the groundwater quality conditions. Assessment of shrimp farming impact on groundwater quality conventionally has less accuracy. This paper presents the implementation of Analytical Hierarchy Process (AHP) method for assessing shrimp farming impact on groundwater quality. The data used is the impact data of shrimp farming in one of the regions in Indonesia from 2006-2016. Criteria used in this study were 8 criteria and divided into 49 sub-criteria. The weighting by AHP performed to determine the importance level of criteria and sub-criteria. Final priority class of shrimp farming impact were obtained from the calculation of criteria's and sub-criteria's weights. The validation was done by comparing priority class of shrimp farming impact and water quality conditions. The result show that 50% of the total area was moderate priority class, 37% was low priority class and 13% was high priority class. From the validation result impact assessment for shrimp farming has been high accuracy to the groundwater quality conditions. This study shows that assessment based on AHP has a higher accuracy to shrimp farming impact and can be used as the basic fisheries planning to deal with impacts that have been generated.

INTRODUCTION

Aquaculture is one of the fastest growth food production sectors and contributes to 47% of world fish supplies of human consumption[1]. The growth of human consumption increased international fish trade. Shrimp commodity became the biggest commodity with international fisheries traded to value 15%[2]. Shrimp commodities growth due to the increasing value of international fisheries traded in some developing countries[3]. Rapid growth of shrimp farming is an attempt to increase the economic value of that commodities.

Coastal areas are suitable for shrimp farming[4]. Appropriate conditions of water, soil, and temperature makes shrimp farming growth in coastal region[5]. Shrimp farming on costal area has positive impact such as water for economics benefit and marginal land use[6, 7]. Large coastal areas can be utilized to be shrimp ponds, and brackish water in coastal areas are suitable for shrimp farming. In addition, shrimp farming has negative impact such as loss of reasonable lagoons, mangrove forest destruction, wetland degradation, and degradation of groundwater quality[8, 9].

Groundwater is an important part of human consumption[10]. The importance of groundwater for fundamental human consumption is inconsistent with improved groundwater quality[11]. Degradation of groundwater quality due to human activities needs to be proven. Groundwater quality assessment is an attempt to prove the degradation of groundwater quality due to shrimp farming[12]. Assessment of groundwater quality needs a representative sample and indicators of groundwater conditions[13].

Selection of a representative sample unit is the first and main task for the environmental impact assessment[14]. Sampling location requires a comprehensive set of factors and balancing with multiple objectives in study area[15]. Factors needed to select a representative sample unit such as., temperature, soil texture, irrigation, forest condition, and agricultural[15]. Shrimp farming technology such as, traditional, extensive, semi-intensive, and intensive can be used to determine a representative sampling unit[16]. A status report on criteria that used to select a representative sampling unit such as lithology, land use, drainage, soil hydrology, lineament, landscape, weather thickness and fracture zones[17]. Criteria are used to determine a representative sampling unit such as, distance, drainage, lineament,

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soil texture, land use, slope, geomorphology, and lithology[12]. Many studied cited above have demonstrated the criteria can be used to select a representative sampling unit to assess the impact on shrimp farming.

Various methods are used in the selection of representative samples unit. Among the sampling method studies reported such as, develop a sampling method using Synthetic Minority Over[18], purposive sampling as a tool for informant selection[19], prepared a status report on selection of a representative sampling unit using Analytical Hierarchy Process (AHP)[12]. Selection of representative samples is important in environmental impact assessment because random sample selection will obscure the field conditions.

Sample selection on environmental impact assessment is an intrinsically complex multi-dimensional process involving multiple criteria and multiple actors[12]. Analytical Hierarchy Process (AHP) is a method with a multi-objective approach that can effectively analyze the order of importance relationship through hierarchical analysis process[20]. AHP relies heavily on problem solving on complex decision making in various fields, such as choosing the best policy after finding a set of alternatives, and priority setting[21]. The AHP gained high popularity due to the ease in obtaining the weights, its capacity to integrate heterogeneous data consequent to which is applied in a wide variety of decision making problems[12]. AHP has been applied in many fields of research, AHP for environmental impact assessment[22], AHP for making decision support model to help managers understand the trade-off between environmental dimensions[23].

Based on the explanation above, the selection of representative samples is very important in assessing the impact of shrimp culture on groundwater quality. Random sample selection will provide a low level of accuracy, and cannot describe the state of the field. Therefore, in this study the AHP method is used to perform the selection of representative groundwater samples to assess the impact of shrimp farming.

MATERIAL STUDY

This research is based on watershed approach. The watershed is a basic geo hydrological unit that handles the environmental impact assessment process as well as gives a realistic and cumulative effect[12] The geology of the area consist of sedimentary formations, which include sandstone, clay, alluvium, and small patches of laterite soils of quaternary age. The study area has tropical climate and average annual rainfall recorded in the area is 2200 mm/year. In case study areas have rich natural resources in the coastal zone. The total area used for shrimp farming is 32.36 km^2 with total production of 7,148,675 tons.

METHODOLOGY

Analytical Hierarchy Process (AHP) was originally designed by Saaty to solve the complex multi-criteria decision making problem[12]. AHP is an analytical tool that enables individuals to explicitly rank tangible and intangible criteria against each other for the purpose of selecting priorities, structuring a problem from a primary objective to secondary levels of criteria and alternatives. AHP has become one of the most widely used methods for the practical solutions of Multi Criteria Decision Making (MCDM)[21]. The AHP method has been refined into seven steps, and their detailed explanation is given below.

Step 1: Identification of criteria influencing groundwater quality

For the selection monitoring wells, all probable criteria which could have an influence the groundwater quality due to aquaculture, have been considered based on previous studies. The main-criteria and its corresponding sub-criteria involved in groundwater monitoring site were selected with the help of 6 experts which included both aquaculture and groundwater experts. With their suggestion and field study, the following eight criteria have been selected viz., technology of shrimp farming, distance from shrimp farms, soil texture, soil color, and soil bearing capacity, land use, slope, and geomorphology.

Step 2: The creation of hierarchical structures

Before determining the weight of each criterion using the Intensity Interest Scale of the AHP method, the first step is to construct a hierarchical system of weighting to be performed[21]. The weighting hierarchy is presented in Fig. 1

Step 3: Assessment by expert with interest intensity scale

The comparisons concern with the relative importance of two criteria involved in determining shrimp farming impact for the stated objective. In order to use this procedure, it is necessary for the weights to sum up to 1. Ratings are systematically scored on a 17-point continuous scale from 1/9 (least important) to 9 (most important)[21]. Based on the study, the relative ranking of the factors was made before completing the pair-wise comparison matrix. Scores were assigned in rank order according to the number of factors involved in the evaluation for shrimp farming without repetition.

Step 4: Calculating the pairwise comparison and geometric mean calculation of experts

Geometric mean averaging methods are used to find the mean and combine different weighting preferences from some experts as to minimize errors in the calculation of pairwise comparison matrices on the AHP method [24, 25, 26]. The geometric mean method was chosen because it has a better consistency rate of average yield than the commonly used averaging method of arithmetic mean[27]. The result of pairwise comparisons from six experts are different. To combine the opinions of expert used geometric mean method shown in Table 1.
The average calculation using geometric mean method can be seen in the following Eq. 1:

$$G = \sqrt[n]{\prod_{i=1}^{n} x_i} \quad (1)$$

Where: G = geometric mean n = number of sample x_i = the i-th sample value
Π = Its usefulness is almost equal to Σ, but Σ is used for addition, whereas Π is used for multiplication.

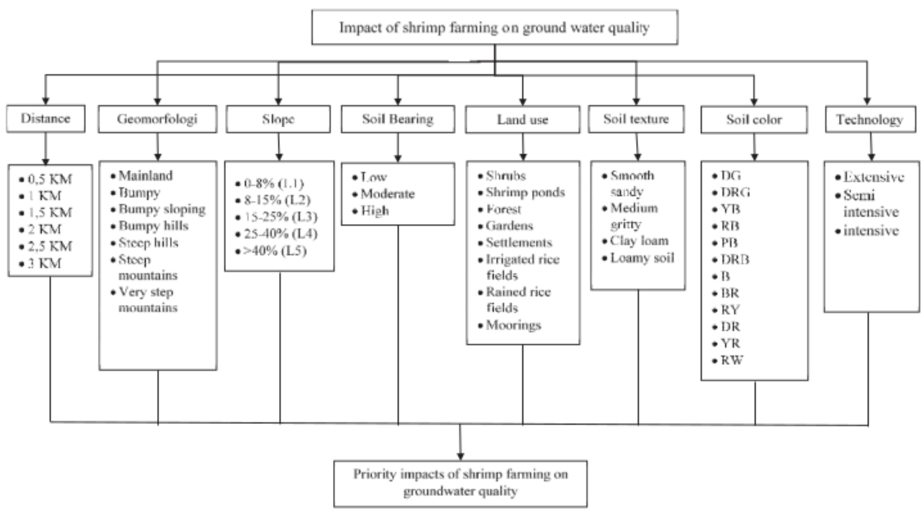

FIGURE 1. Hierarchy Structure of criteria and sub criteria

Where:
Dark grey (DG), dark reddish grey (DRG), yellowish brown (YB), reddish brown (RB), pale brown (PB), dark reddish brown (DRB), black (B), reddish black (BR), reddish yellow (RY), dark red (DR), yellowish red (YR), reddish white (RW).

Step 5: Calculation of weights

The calculation of priority weight obtained in exact form by raising the matrix to large powers and summing each row and dividing each by the total sum of all rows, or approximately by adding each row of the matrix and dividing by their total. The result from the average or weight of priority can be shown in Table 1.

Step 6: Calculating Consistency Ratio

The AHP provides a measure of the consistency of pairwise comparison judgments by computing a consistency ratio. The ratio is designed in such a way that values of the ratio exceeding 0.10 are indicative of inconsistent judgments. Although the exact mathematical computation of the consistency ratio is beyond the scope of this, an approximation of the ratio can be obtained. To calculate the consistency index (CI) can be shown in Eq. 2.

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{2}$$

Where λ max is the maximum eigen value of the judgment matrix. This CI can be compared with that of random matrix, RI. The ratio derived, CI/RI, is termed the consistency ratio, CR. Saaty suggest the value of CR should be less than 0.1.

Step 7: Rating of each criteria

The rating of each criteria is multiplied by the weights of the sub-criteria and aggregated to get local ratings with respect to each criterion. The local rating are then multiplied by the weights of the criteria and aggregated to get global rating.

RESULT AND DISCUSSION

Selection of groundwater samples on impact assessment of shrimp farming is quite important. In this research, the selection of representative samples on ground water is using AHP method. The result of calculation on ground water sample is weighted value from each criterion. The weight values of each sample are classified into 3 classes, such as low, medium, and high. Classification is used to know the priority of handling the impact of shrimp farming. If the sample point is at a high priority level, immediate impact handling is required. However, if the sample point is at the low to moderate priority level, the impact of shrimp farming can be done periodically. Results of classification of each sample can be seen in Fig. 2.

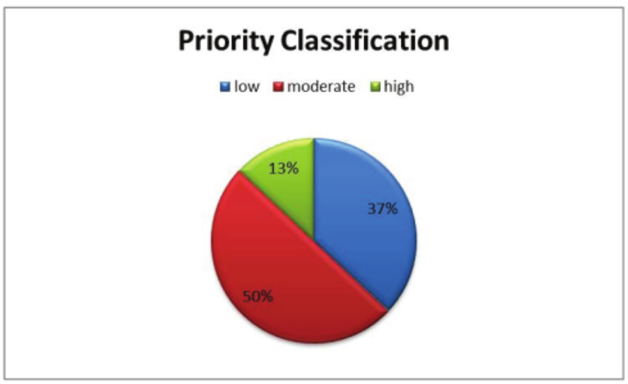

FIGURE 2. Priority Classification

Low priority of 37% indicates that on the priority some samples have a state with low sub criteria. Cultivation technology is the criterion with the highest weight. In some samples with low priority, the cultivation technology used is extensive, with geomorphological conditions in the form of oblique waves and with low soil bearing capacity, and soil texture of clay.

A moderate priority of 50% indicates that on the priority some samples have a state with moderate sub criteria. The cultivation technology used is semi-intensive with the medium carrying capacity of the soil. In addition, the slope of the slope is at an interval of 8% -15%.

A high priority of 13% indicates that on the priority some samples have a state of intensive cultivation technology. Land suitable for shrimp culture and high cultivation technology make some samples have high priority. In case study areas, intensive technology is the highest-tech weights.

The result of classification of sample into priority class then correlated with groundwater quality indicator in the form of pH and electric conductivity. Correlation results can be seen in Figs. 3 and 4.

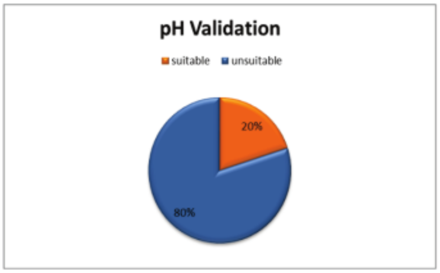

FIGURE 3. pH Validation

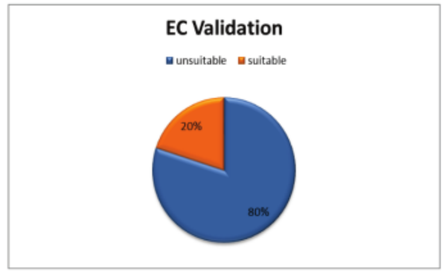

FIGURE 4. EC Validation

Priority class correlation results with pH in Fig. 3 shows an error rate of 20%. This is due to some samples being on suitable land for shrimp culture with high cultivation technology. But the state of the field shows cultivation technology used relatively low.

Based on Figure 4, the result of priority class correlation with electrical conductivity shows an error value of 20%. This is due to the fact that some samples are in areas not suitable for shrimp culture with high technology. But the state of the field shows cultivation technology used relatively high.

Shrimp farming technology is a criterion with a high weight when compared with the criteria on land suitability conditions. The assessment of the impact of shrimp culture on groundwater quality that has been done with the selection of the sample depends on the criteria and sub criteria. Judging from the weight of each criterion, cultivation technology has a high influence on the selection of representative samples. Based on reports of shrimp culture conditions in the case study area shows that there is a fluctuated change in cultivation technology. This change also applies to groundwater conditions in case study areas based on reports of groundwater quality. Based on the movement of cultivation technology change, land suitability level, and ground water quality, shrimp farming gives influence to groundwater quality.

CONCLUSION

This paper presents a selection of groundwater sampling unit methods in an effort to assess the impact of shrimp farming using the Analytical Hierarchy Process. Selection of representative sampling sites is a key task and involves the integration of information from multiple sources. The criteria and sub criteria used in this study were calculated and combined to develop a priority classification. The technological criteria provide the greatest influence in the selection of groundwater sampling units because the technology may provide many changes to ground water quality in the area around shrimp farming. The priority classification results are correlated with pH and electrical conductivity. Of all sample points, 80% priority classification corresponds to groundwater conditions in the case study area. Continuous monitoring of groundwater quality identified significantly varies according to priority classification indicating that groundwater quality depends on the impact of shrimp farming. It can be concluded that shrimp farming affects groundwater quality in the research area.

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REFERENCE

1. FAO, "Climate Change Implications for Fisheries and Aquaculture," in *FAO Fisheries and Aquaculture Technical Paper,* (2009)..
2. FAO, The State of World Fisheries and Aquaculture," (Food and Agriculture Organization of United Nations, 2014).

3. A. Lem and Z. H. Shehadeh, "International trade in aquaculture products," in *FAO Aquaculture Newsletter,* (1997).
4. Giap, D. Huy, Y. Yi and A. Yakupitiyage, *Ocean Coast. Manag.* **48**, 51-63(2005).
5. B. Tapia, A. Luis, S. D. Mondragon and E. Ezcurra, *Int. J. Geogr. Inf. Sci.* **15**, 129-151(2010).
6. O. M. Perez, T. C. Telfer and L. G. Ross, *Aquacult. Eng.* **29**, 1-21(2003).
7. D. O. Rosenberry, "Watershed-scale Research from Many Perspectives—the Interdisciplinary Research Initiate at the Shingobee River Headwaters Area. U.S. Geological Survey" in Minnesota (Fact Sheet 044–98, 1998).
8. B. Dewalt, P. Vergne and M. Hardin, *World Dev.*, **24**(7), 1193-1208(1996).
9. Beveridge, M.C.M; M.J Philips; and D.J Machintosh. 1997. Aquaculture and the environment: the supply of and demand for environmental goods and services by Asian aquaculture and the implications for sustainability. Aquaculture Research 28, pp 797-807.
10. C. R. Ramakrishnaiah, C. Sadashivaiah and G. Ranganna, *J. Chem.* **6**, 523-530(2009).
11. B. L. Morris, A. R. L. Lawrence, P. J. C. Chilton, B. Adams, R. C. Calow and B. A. Klinck, "Groundwater and Its Susceptibility to Degradation: A Global Assessement of the Problem and Options for Management" in *United Nations Environment Programme,* (British Geological Survey, 2003), pp. 126.
12. N. Rekha, R. Gangadharan, P. Ravichandran, P. Mahalaksmi. A. Panigrahi and S. M. Pillai, *Aquacult.* **448**, 491-506(2015).
13. P. N. Rekha, R. S. Kanwarrr, A. K. Nayak, C. K. Hoang and C. H. Pederson, *J. Environ. Monit.* **13**, 2550-2558(2011).
14. P. N. Rekha, N. K. Ambujam, K. K. Khrisnani, V. Parimala and D. D. Vimala , *Bull. Environ. Contam. Texicol.* **72**(2), 312-318(2004).
15. J. A. Manjarez and L. Ross, *Aquacult. Int.* **3**, 103-115(1995).
16. P. Paquittea, L. Chima, J.-L. M. Martinb, E. Lemoscm M. Sternd and G. Tostad, Aquacult. **164**, 151-166(1998).
17. Krishnamurthy, Jagannathan, A. Mani, V. Jayaraman, and M. Manivel, *Int J Appl Earth Obs Geoinf.* **2**(3-4), 204-215(2000).
18. N. V. Chawla, K. W. Bowyer, L. O. Hall and W. P. Kegelmeyer. *J. Artif. Intell. Res* **16**, 321-357(2002).
19. C. Tongco and M. A. Dolores, *Ethnobotany Res. App.* **5**, 147-158(2007).
20. H. Aras, S. Erdogmus and E. Koc, *Renew. Enrgy.* **29**, 1383-1392(2003).
21. T. L. Saaty and L. G. Vargas, "Models, Methods, Concepts and Applications of the Analytic Hierarchy Process," (Kluwer Academic Publishers, Boston, 2000).
22. R. Ramanathan, *J. Environ. Manag.* 63, 27-35(2001).
23. R. Handfield, S. V. Walton, R. Sroufe and S. A. Melynk, *European J. Operat. Res.* **141**, 70-87(2002).
24. R. Mosadeghi, J. Warnken, R. Tomlinson and H. Mirfenderesk, *Comp. Envir. Urban Sys.* **49**, 54–65(2015).
25. J. Suh and J. R. S. Brownson, *Energies,* **9**, p. 648(2016).
26. E. Wali, A. Datta, R. P. Shrestha and S. Shrestha, *Arch. of Agro. Soil Sci.* **62**(7), 921–934(2016).
27. D. Yucheng, X. Yinfeng and D. Lili, *J. Sys. Eng. Elec.* **18**(3), 515–519(2007).

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