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Application of the Analytic Hierarchy Process and Geographic Information System in Selecting Sites for a Seafood Market Study

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Study site selection is essential for the success of many fisheries-related programs. A thorough site selection could provide transparency in the decision-making process and optimize resources. In this research, the analytic hierarchy process (AHP) approach was used to select sites for a market study of reef-associated seafood in Alaminos City, Northwestern Philippines. Out of the 10 coastal barangays, four (Lucap, Sabangan, Telbang, and Victoria) were initially chosen, and the difference between these sites and the priority sites generated from AHP was examined. Five decision criteria and 10 alternatives (coastal barangays) were analyzed to calculate priority weights using pairwise comparisons. The AHP analysis showed that among the set of criteria, the presence of coral reefs, registered number of fishers, proximity to public market, and existence of fish ports were the most relevant. Among the alternatives, Lucap (0.196), Telbang (0.127), and Victoria (0.118) obtained the highest global priority values followed by Pangapisan (0.105), Pandan (0.098), and Bued (0.096); however, Sabangan, which was included in the initially selected study sites, only ranked 7th (0.073). The results confirmed the suitability of the selected sites and helped identify additional potential sites for a market study. The final priority values from the AHP were imported into the Quantum Geographic Information System (QGIS) to generate thematic and suitability maps. The usefulness of AHP was demonstrated in selecting the most suitable sites for a market study. This method uses a systematic and simple procedure that could be utilized by local decision makers for future studies and projects that require prioritization of multiple options.

Keywords: analytic hierarchy process, coastal management, market study, reef fisheries, site selection

INTRODUCTION

In the Philippines, the low income from fishing and post-harvest losses are becoming increasingly critical to the socio-economic conditions of small-scale fishers. Among the direct causes of fishers' low income include the declining volume of catch (Anticamara and Go 2016; Macusi et al. 2020), low prices of catch, limited alternative livelihood opportunities (Muallil et al. 2014), and limited capability to preserve and maintain high quality of catch. In recent years, market studies are becoming more important in addressing substantial post-harvest losses and improving value addition for agricultural products as well as fish and fishery products (Baylon 2007; Pelea 2008; Mopera 2016; Rosales et al. 2017). Peralta-Milan et al. (2020) also conducted a study to understand the market structure and to identify the current problems and opportunities in the marketing of reef-associated seafood in Lingayen Gulf, Philippines. Their work elucidated the marketing of reef-associated seafood "from reefs to plate" and examined potential linkages to tourism that could improve the socioeconomic situation of local fishing communities.

Choosing the most appropriate study sites was part of the methodology for the aforementioned market study. Prior to the implementation of the study, consultation with relevant stakeholders was conducted. Sites for the market study were selected based on available data on the presence of coral reef habitat, number of registered small-scale fishers, proximity to the public market, proximity to tourism sites, and existence of fish ports or landing sites, as well as stakeholders' judgment, knowledge, and past field experiences.

Study site selection is an essential component for the success of many fisheries-related programs mainly in

terms of pilot testing, planning, and implementation. Prioritizing the most appropriate sites is needed to narrow down several potential options (Rife et al. 2018). A thorough site selection could also avoid biases in the decision-making process and conflicts of interest among stakeholders (Syahputra et al. 2019). Moreover, prioritizing sites is useful for maximizing resources such as space, funds, and time.

Choosing priority sites can be a challenging task especially with decision-makers having different opinions and views (Yap et al. 2018). At times, decisions are made by following intuition or relying on past experiences (Jagoda et al. 2020). However, individual knowledge and experiences are insufficient bases when the decision-making is for the welfare and quality of life of a group (Saaty 1994). A systematic but practical tool is needed to help make rational decisions. One of the most effective methods that help address complex decision-making is the analytic hierarchy process (AHP) (Andalecio 2010; Vargas 2010; Jagoda et al. 2020).

AHP is a methodological approach introduced by Thomas L. Saaty in the 1970s. This method is commonly used as a management tool (Ramos et al. 2006) to help solve complex problems by guiding users to make decisions based on their goals and their understanding of the problem (Syahputra et al. 2019).

This approach has also been used recently in a wide range of applications in many different fields. Several environmental management studies have used AHP as a decision-making tool. For instance, in Portugal, AHP was used for understanding choices and preferences on reef diving (Ramos et al. 2006). In the Philippines, Andalecio (2010) used AHP as a method for impact evaluation of fisheries management. Orencio and Fujii (2013) discussed the application of AHP to identify criteria and elements that can be used to evaluate the resilience of coastal communities to disasters. Promentilla et al. (2013) evaluated sustainable energy systems to mitigate climate change using AHP. Galang and Dolores (2020) used AHP to help assess the species-site suitability of native tree species in a watershed. AHP was also used for choosing fish collection centers in Indonesia to optimize the fish supply chain system (Verani and Fharidaty 2019), to select sites for the establishment of marine protected areas (MPAs) (Syahputra et al. 2019), and to evaluate the sustainable performance of the fish supply chain (Muslimin et al. 2021). In Ghana, Baffoe (2019) applied AHP to identify the best livelihood options for possible interventions to support an effective and sustainable poverty reduction program.

In this study, a case experiment was conducted to utilize the AHP approach for the site selection of a market study. The decision to select the most suitable sites is a crucial step for market studies because of its significant impact on key market players, society, and the environment. Baseline data obtained from appropriately selected sites could facilitate relevant management interventions to help improve the socioeconomic condition of local fishing communities.

The possibility of selecting the most suitable sites among the 10 coastal barangays in Alaminos City, northwestern Philippines, for the market study of reef-associated seafood was explored using AHP. This method was applied because of its simple mathematical features and systematic approach to decision-making, and the aim was to examine the difference between the initially chosen study sites and the priority study sites generated from AHP.

MATERIALS AND METHODS

Study Site

The city of Alaminos is situated in the northwestern part of Luzon, Philippines. It is one of the coastal towns along the Lingayen Gulf in the province of Pangasinan. In the 2020 Census of Population and Housing, the city has a total population of 99 397, of which 29 152 (29.3%) are from the coastal areas (PSA 2021). The agriculture sector including crops, fisheries, and livestock is one of the major economic contributors of the city.

The city has 39 barangays, of which 29 are landlocked and 10 are coastal (Fig. 1). Four coastal barangays, namely Lucap, Sabangan, Telbang, and Victoria were initially chosen for a market study of reef-associated seafood.

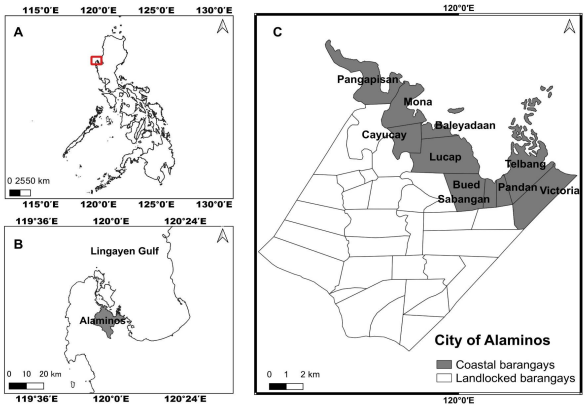

Fig. 1. Location of the study site. Lingayen Gulf in the Philippines (A), the city of Alaminos in Lingayen Gulf (B) and the barangays (villages) in the city (C).

Steps in Using the Analytic Hierarchy Process (AHP)

The 1st step was to identify the main goal or problem for analysis. The criteria (which refers to the relative factors or conditions to be considered during the selection process) and the alternatives (or different options) were then determined and structured in a hierarchical order. The priority weights of each criterion and the weights of the alternatives with respect to each criterion were determined using pairwise comparison. Then, the overall priority weights were calculated and synthesized to identify the best option.

AHP Structure for the Study

Goal, Criteria, and Alternative

The goal of this AHP analysis was to identify the most suitable sites for a market study of reef-associated seafood. The AHP hierarchy has two levels namely, the upper level, which aims to establish a set of evaluation criteria to reach the goal, and the lower level, which identifies the alternative options. For the upper level, five decision criteria were chosen: the presence of coral reef habitat (CRH) for the biological aspect; the number of registered small-scale fishers (RF) and the existence of fish ports (FP) for the economic aspect; and the proximity to the public market (PM) and proximity to tourist spots (TS) for the geographic aspect. Basic information on the five criteria were compiled into a site profile (Table 1). Data on CRH, RF, and FP were obtained from the initial consultation meetings with staff members from the Coastal Resource Management Office of the city while the information on PM and TS were generated using Google Maps.

The biological criterion considered the presence of coral reef habitat mainly because coral reefs are the chief source of reef-associated seafood for local consumption. Knowledge and understanding of the characteristics and status of the coral reefs are necessary. The Hundred Islands National Park (HINP) in the city of Alaminos is the first proclaimed marine national park in the Philippines with substantial coral reefs and was important for the tourism industry.

Table 1. Site profile. Information on the presence of coral reef habitat (CRH), number of registered fishers (RF), existence of fish ports (FP), proximity of coastal barangays (in km) to public markets (PM) and to tourist spots (TS).

Candidate Sites	CRH	RF	PM	FP	TS
Baleyadaan	Yes	132	6.60	None	4.10
Bued	Yes	155	4.00	Yes	1.60
Cayucay	None	145	5.00	None	4.90
Lucap	Yes	246	5.20	Yes	0.75
Mona	None	107	8.10	Yes	8.40
Pandan	Yes	72	7.70	Yes	2.50
Pangapisan	None	230	11.00	Yes	11.00
Sabangan	Yes	126	6.40	Yes	5.50
Telbang	Yes	194	12.00	Yes	3.60
Victoria	Yes	177	13.00	Yes	4.40

The economic criterion considered the number of registered fishers who were engaged in reef-associated fisheries. All the necessary information about marketing seafood (e.g., market structure, supply chain, and prices) were generated from the fishers. The Bureau of Fisheries and Aquatic Resources (BFAR) and the Fisheries Information Management Center (FIMC) have set up the National Program for Municipal Fisherfolk Registry (referred to as FishR) to help register municipal fishers. Another economic criterion was the existence of fish ports or landing sites, which are essential to fishing communities because these sites function as the main landing and distribution areas for their daily catch. The market route of fish catch typically starts from the fish ports or landing sites and passes through multiple local market agents. The fish ports in the city are in barangays Lucap, Mona, and Pangapisan and the landing sites were in barangays Telbang and Victoria. In addition to these existing fish ports and landing sites, there are several landing sites without facilities in some coastal barangays.

The geographic criterion considered the distance to public markets and proximity to tourist spots. The proximity to public market outlets is an essential criterion because fishers need to sell their catch while fresh and at its best quality. Access and proximity to public markets play a significant role in ensuring a regular supply of seafood. Local public markets support and shield micro-entrepreneurs and directly or indirectly connect producers, retailers, and consumers. Fish markets in the city of Alaminos are located at Nepo Mart and Suki Wet and Dry Market. In addition, various small fish retail shops (locally known as "*talipapa*") are operational and mainly located in coastal areas. Another geographic criterion was the proximity of tourist destinations that are primarily important for attracting tourists who would also take advantage of the available fresh seafood. The HINP in the city of Alaminos is considered one of the main tourist destinations in the country, attracting foreign and domestic tourists.

The lower level of the hierarchy represents the alternatives, which refer to the 10 coastal barangays in the city that were used as the candidate study sites. The goals, criteria, and alternatives were arranged into a hierarchy with the goal at the top, the criteria that are necessary to achieve the goal below, and the alternatives at the bottom.

Pairwise Comparison

The five criteria were evaluated using pairwise comparisons to determine the relative importance between them and their relative priority weights to the goal. The relative weights of each criterion with respect to each of the others were determined and decided through individual pairwise ratings (using the AHP numerical scale; Table 2). If one criterion is more important than the other, it is given a rating (referring to the 1 – 9 numerical scale) corresponding to its importance. If it is less important, then it is given the corresponding reciprocal value. For example, in the pairwise comparison between the criteria CRH and PM, a rating of 3 was assigned to CRH. In turn, the comparison score of PM has the reciprocal value of 1/3. The comparison of a criterion to itself is given the value of 1.

The assigned weights were normalized using the eigenvalue method. The study conducted by Vargas (2010) explained the operational mechanism of the Eigenvector Method for AHP. The consistency of the assigned weights was checked through the consistency ratio (CR). The CR value obtained was 0.033 (< 0.1) which means that the weights used in the pairwise comparison were consistent. The computation for the eigenvalue and consistency ratio are attached in Appendix A.

The fitness of each alternative (candidate sites) was determined after establishing the relative priority weights for the criteria. The alternatives were subjected to pairwise comparisons considering every criterion. For each comparison, the stronger coastal barangay was first determined and scored with respect to the criterion under consideration. Each alternative was assigned a weight relative to the other candidates based on the AHP numerical scale.

Ratings or scores for the pairwise comparison of all the alternatives were developed for each criterion. For the CRH criterion, the scores used were as follows: 1 if both barangays have existing CRH, or both do not have existing CRH; 2 if both barangays have CRH but one barangay is closer to an MPA; 3 if one barangay has an MPA and the other barangay has CRH; 4 if one barangay has CRH and the other has no CRH; 5 if one barangay has an MPA and the other barangay has no CRH.

The scores used for the pairwise comparison with respect to the RF criterion were based on the difference in the number of registered fishers between two barangays: 1 if the difference ranges from 1 to 25; 2 from 26 to 50; 3 from 51 to 100; 4 from 101 to 150; 5 from 151 to 181. For the PM criterion, the scores used were based on the difference in distance (km) between two barangays: 1 if the difference ranges from 0.1 to 0.5; 2 from 0.6 to 1.4; 3 from 1.5 to 2.9 and if the other barangay has no CRH; 4 from 3.0 to 4.5; 5 from 4.6 to 9.0. For the FP criterion, the scores used were as follows: 1 if both barangays have existing fish ports or both do not have existing fish ports; 2 if one barangay has a fish port and the other has a landing site with facilities or if one barangay has a landing site with facilities and the other barangay has landing sites without facilities; 3 if one barangay has a landing site without facilities and the other barangay has none or if one barangay has a fish port and the other has a landing site without facilities; 4 if one barangay has landing sites with facilities and the other has none; 5 if one barangay has fish port and the other has none. The scores used for the pairwise comparison with respect to the TS criterion were based on the difference in distance (km) between two barangays: 1 if the difference ranges from 0.1 to 0.3; 2 from 0.4 to 0.9; 3 from 1.0 to 3.9; 5 from 4.0 to 10.0.

The data from all the pairwise comparisons were calculated using an online AHP calculator developed by Goepel (2018). The priority weights of each criterion and

Table 2. Fundamental numerical scale used for the pairwise comparison.

AHP Fundamental Scale (adapted from Saaty *1990)*		
Intensity of Importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is favored very strongly over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgement
Reciprocals of above	If activity *i* has one of the above numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared to *i*.	The lesser element is always used as the unit and the greater one is estimated as a multiple of that unit.

alternatives were then calculated to determine final priority and consequent rankings.

AHP and Geographic Information System (GIS) Integration

The final priority values were imported into Quantum GIS (QGIS) version 3.30.0 to generate maps for easy visualization of the suitable sites for a market study. Five thematic maps and an overall suitability map, each with different classifications, were created. The presence of coral reef habitat was divided into two classes (no coral reefs and with coral reefs) and the existence of fish port into four classes (no fish port, landing sites without facilities, landing sites with facilities and with fish port). The proximity to the public market was categorized into three classes based on the ranges in distance: very far (9 – 13 km); far (6 – 8 km); and near (4 – 5 km). The proximity to tourist spots were also divided into three classes: far (8 – 11 km); near (4 – 7 km); and very near (0.5 – 3.9 km). The registered number of fishers was classified into three: low (less than 100 fishers); moderate (100 – 150 fishers); and high (151 – 250 fishers). The overall suitability map was categorized into three classes ranging from least suitable, suitable, and most suitable sites.

RESULTS AND DISCUSSION

Upper-level Hierarchy Analysis

Results of the pairwise comparison indicated that the criterion with the highest level of importance in relation to the defined goal was the CRH (0.35), followed by the RF (0.32). The PM and FP criteria obtained the same level of importance (0.13), and the lowest was the TS criteria (0.07) (Fig. 2).

Though the TS ranked the lowest, priorities towards this criterion may shift in the future with the city's rapidly emerging tourism industry. The TS and the presence of tourists could create opportunities for local fishing communities and can help fishers diversify their income. High-value fish and invertebrates command higher prices when marketed to tourists (Peralta-Milan et al. 2020). Hence, tourism opportunities might become a priority consideration for future studies and programs, considering the potential in marketing and impacts on the environment.

The applicability of AHP to evaluate a set of criteria for the selection of market study sites is shown through the results of the study. Some relevant works include the application of AHP to identify reef diving sites (Ramos et al. 2006) and to determine the most relevant criteria for sustainable supply chain for seafood management (Muslimin et al. 2021).

Lower Level Hierarchy Analysis

The result of the pairwise comparison on the lower level showed that for the CRH, the top five sites with high priority weights were Lucap, Pandan, Telbang, Victoria, and Sabangan. Lucap obtained the top rank in terms of the RF followed by Pangapisan and Telbang. For the PM, Bued obtained the top rank, being the nearest to the main public market in the city, followed by Cayucay, Lucap, and Sabangan. Barangays with existing fish ports were all in the top rank for FP, including Lucap, Mona, and Pangapisan followed by Telbang and Victoria, as these barangays have fish landing sites with facilities. Bued, Pandan, and Sabangan were next in rank, all of which have functioning landing sites without facilities. For the TS, Lucap obtained the top rank, given that it serves as the access point for tourists to the HINP. The 2nd in rank was Bued which is known for the Mangrove Forest Ecopark and is now considered a new tourist spot. It was followed by Pandan, which is known for the Bolo white sand beach. Telbang, which is adjacent to Pandan, ranked 4th.

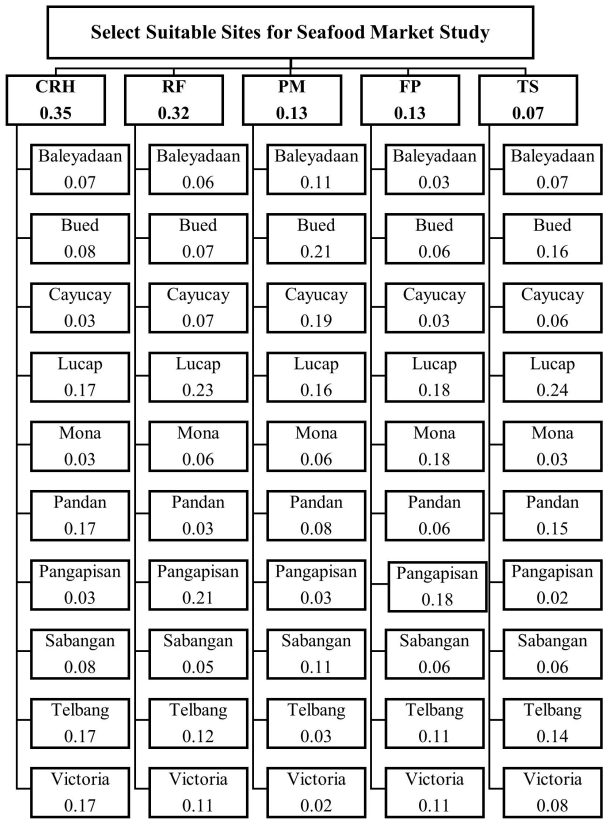

Fig. 2. Results of the AHP Analysis. The priority weights of each criterion (upper level) to the defined goal and the weights of each alternative with respect to each criterion (lower level).

Table 3. Summary of priorities (criteria and alternative levels), the associated CR values, final priority, and overall rankings.

Candidate Sites	CRH 0.35	RF 0.32	PM 0.13	FP 0.13	TS 0.07	Final Priority	Overall Ranking
Baleyadaan	0.025	0.019	0.014	0.004	0.005	0.066	8
Bued	0.027	0.022	0.027	0.008	0.011	0.096	6
Cayucay	0.009	0.021	0.025	0.004	0.004	0.063	9
Lucap	0.061	0.074	0.021	0.023	0.017	0.196	1
Mona	0.009	0.018	0.008	0.023	0.002	0.061	10
Pandan	0.061	0.009	0.010	0.008	0.010	0.098	5
Pangapisan	0.009	0.067	0.004	0.023	0.001	0.105	4
Sabangan	0.029	0.016	0.014	0.008	0.004	0.073	7
Telbang	0.061	0.040	0.003	0.014	0.010	0.127	2
Victoria	0.061	0.035	0.003	0.014	0.006	0.118	3
CR	0.024	0.029	0.044	0.009	0.091		

The Selected Study Sites vs. AHP Results

Among the initially selected sites, Lucap ranked the highest final priority weight (0.196), followed by Telbang (0.127) and Victoria (0.118) (Table 3). This result confirmed that these barangays are the most suitable sites for a market study. The barangays of Pangapisan (0.105) ranked 4th, Pandan (0.098) ranked 5th, and Bued (0.096) ranked 6th. These three coastal barangays could be identified as additional potential options as sites for the market study. Sabangan, which was included in the initially selected study sites, only ranked 7th (0.073). It was considered and selected as one of the initial study sites for the market study because it has a "traditional fish landing area" that is fully operational (being utilized as a docking area for fishing boats for the landing of daily fish catch), as well as village retail shops. Additionally, the area serves as an alternative pick-up and drop-off point for tourists going to the HINP. However, this barangay ranked relatively low based on the pairwise comparisons. The consistency ratio for the overall pairwise comparison was less than 10%, which indicates that the weights assigned were all consistent.

Results of the AHP analysis indicate that the weights of criteria on the upper level of the hierarchy could influence the overall priority rankings of the alternatives. Song and Kang (2016) noted that, in AHP, the weight of the upper level affects its sublevels. Careful evaluation of criteria is therefore crucial when using the AHP method. Moreover, identifying the key criteria to evaluate the alternative options is another important part of the process to find the best decision.

Ideally, decision-makers represented by various stakeholders and resource users work together to evaluate the criteria and perform pairwise comparisons. The involvement of various stakeholders and resource users is important in the decision-making and evaluation process of multi-criteria evaluation tools (Andalecio 2010). In this experimental study, however, the analysis was mainly carried out by the authors guided by the knowledge and judgment on the set of available data to demonstrate an example of AHP application for study site selection. Although AHP is typically targeted at group decision-making, the study of Kumar (2004) used the method to show a hypothetical example of project evaluation by a single evaluator. Vargas (2010) also used assumptions to show an example of AHP calculations for project prioritization.

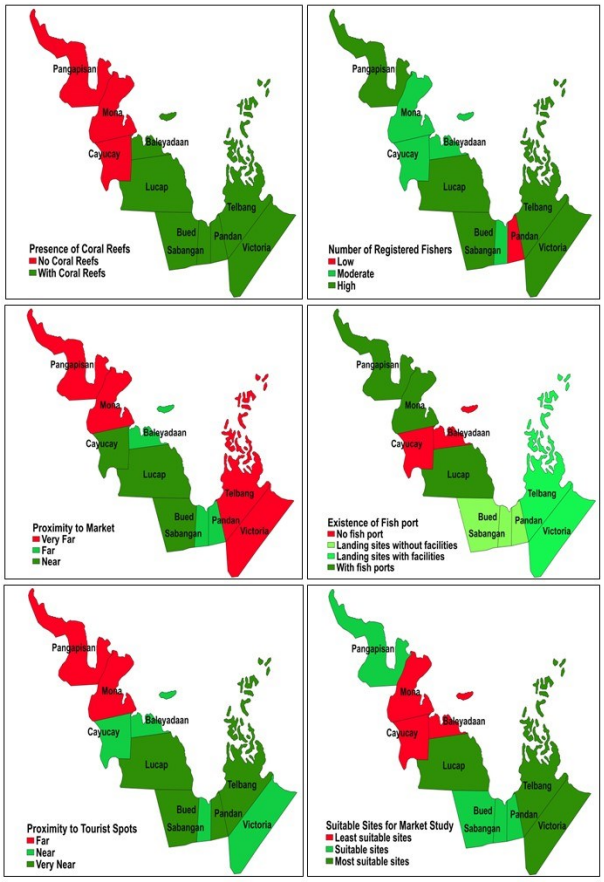

Fig. 3. Thematic and overall suitability maps derived from the final priority values.

Though some stakeholders such as government staff, fishers, and barangay officials were frequently consulted to confirm the correctness of relevant data, no standard questionnaires were developed, and they were not involved in the pairwise comparisons. This limitation of the study is duly acknowledged. Therefore, a team of decision-makers representing relevant stakeholders and resource users could be included to further validate the results of the study.

The five thematic and overall suitability maps show the most suitable as well as the least suitable sites for conducting the market study (Fig. 3). Overall, the most suitable sites are the coastal barangays of Lucap, Telbang, and Victoria. This is mainly due to the presence of coral reef habitats in these barangays which had the highest level of importance in relation to the defined goal. The coastal barangays of Pangapisan, Pandan, Bued, and Sabangan were also considered suitable sites. The first three barangays were not initially selected as priority sites; hence, they can be considered as additional potential study sites. On the other hand, Baleyadaan, Cayucay, and Mona were the least suitable sites for a market study.

CONCLUSION AND RECOMMENDATION

The application of the analytic hierarchy process (AHP) method in selecting the most suitable sites for the implementation of a market study for reef-associated seafood was demonstrated in this study. Among the set of criteria, the biological and economic criteria were the most relevant in achieving the defined goal of the AHP study. The results confirmed that the initially selected sites were the most fitting for the conduct of a market study and helped identify additional potential study sites. The integration of AHP with a geographical information system (GIS) could facilitate easy visualization and understanding of the selected study sites.

Participation of relevant stakeholders and resource users in the evaluation process could further validate the results of the AHP analysis. Questionnaires may be developed to obtain individual responses from decision makers. Nevertheless, this AHP analysis demonstrated a procedure that could be utilized by local decision makers for future case studies and projects that require the prioritization of multiple options. In addition, the AHP can be used as additional support to justify the decision-making process when choosing sites for management interventions.

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REFERENCES CITED

ANDALECIO MN. 2010. Multi-criteria decision models for management of tropical coastal fisheries. A review. Agron Sustain Dev. 30:557–580. doi:10.1051/agro/2009051.

ANTICAMARA JA, GO KTB. 2016. Spatio-temporal declines in Philippine fisheries and its implications to coastal municipal fishers' catch and income. Front Mar Sci. 3:21. doi:10.3389/fmars.2016.00021.

BAFFOE G. 2019. Exploring the utility of Analytic Hierarchy Process (AHP) in ranking livelihood activities for effective and sustainable rural development interventions in developing countries. Eval Program Plann. 72:197–204. doi:10.1016/j.evalprogplan.2018.10.017.

BAYLON CC. 2007. Micro-enterprise development in selected fishing communities in the province of Iloilo, Philippines. In: Dickson M, Brooks A, editors. Proceedings of the CBFM-2 International Conference on Community Based Approaches to Fisheries Management: Dhaka, Bangladesh. Dhaka, Bangladesh: The Worldfish Center-Bangladesh Office. https://digitalarchive.worldfishcenter.org/bitstream/handle/20.500.12348/1632/WF_37460.pdf?sequence1=.

GALANG MA, DOLORES JC. 2020. Species-site suitability assessment of native species in Pantabangan-Carranglan Watershed using Geographic Information System (GIS) and Analytic Hierarchy Process (AHP). Philipp J Sci. 149(3):529–537. doi:10.56899/149.03.07.

GOEPEL KD. 2018. Implementation of an online software tool for the Analytic Hierarchy Process (AHP-OS). Int J Analytic Hierarchy Process. 10(3):469–487. doi:10.13033/ijahp.v10i3.590.

JAGODA JA, SCHULDT SJ, HOISINGTON AJ. 2020. What to do? Let's think it through! Using the Analytic Hierarchy Process to make decisions. Front Young Minds. 8:78. doi:10.3389/frym.2020.00078.

KUMAR SS. 2004. AHP-based formal system for R&D project evaluation. J Sci Ind Res India. 63:888–896.

https://nopr.niscpr.res.in/bitstream/123456789/5391/1/JSIR%2063(11)%20888-896.pdf.

MACUSI ED, MACUSI ES, JIMENEZ LA, CATAM-ISAN JP. 2020. Climate change vulnerability and perceived impacts on small-scale fisheries in eastern Mindanao. Ocean Coast Manage. 189:105143. doi:10.1016/j.ocecoaman.2020.105143.

MOPERA LE. 2016. Food loss in the food value chain: the Philippine agriculture scenario. J Dev Sustain Agr. 11 (1):8–16. doi:10.11178/jdsa.11.8.

MUALLIL RN, MAMAUAG SS, CABABARO JT, ARCEO HO, ALIÑO PM. 2014. Catch trends in Philippine small-scale fisheries over the last five decades: The fishers' perspectives. Mar Policy. 47:110–117. doi:10.1016/j.marpol.2014.02.008.

MUSLIMIN, MANGUN N, ROMBE E, TAQWA E, SUTOMO M, HADI S.2021. AHP structure for determining sustainable performance of Indonesian seafood supply chain from stakeholders' perspective. J Manage Inform Decis Sci. 24(7):1–10. https://www.researchgate.net/publication/353786287_AHP_STRUCTURE_FOR_DETERMINING_SUSTAINABLE_PERFORMANCE_OF_INDONESIAN_SEAFOOD_SUPPLY_CHAIN_FROM_STAKEHOLDERS_PERSPECTIVE.

ORENCIO PM, FUJII M. 2013. A localized disaster-resilience index to assess coastal communities based on an Analytic Hierarchy Process (AHP). Int J Disast Risk Re. 3:62–75. doi:10.1016/j.ijdrr.2012.11.006.

PELEA NR. 2008. Post-harvest processing, poverty among fishers and fishery resource management in Lagonoy Gulf (Philippines). Mem Fac Fish Kagoshima University. 0453-087X 60–65p. https://cir.nii.ac.jp/crid/1050001338883364608.

PERALTA-MILAN S, BABA O, SALMO SG III. 2020. Linking marketing of reef-sourced seafood with tourism: potential for improving fisheries management. Philipp Sci Lett. 13(2):113–123. https://scienggj.org/2020/PSL%202020-vol13-no02-p113-123-Milan%20et%20al.pdf.

PROMENTILLA MAB, DE LA CRUZ CAM, ANGELES KC, TAN KG. 2013. Evaluating climate change mitigation options in the Philippines with Analytic Hierarchy Process (AHP). ASEAN J Chem Eng. 13 (1):61–66. doi:10.22146/ajche.49725.

[PSA] Philippine Statistics Authority. 2021. 2020 Census of Population and Housing (2020 CPH) counts declared official by the President. https://psa.gov.ph/content/2020-census-population-and-housing-2020-cph-population-counts-declared-official-president.

RAMOS J, SANTOS MN, WHITMARSH D, MONTEIRO CC. 2006. The usefulness of the Analytic Hierarchy Process for understanding reef diving choices: a case study. B Mar Sci. 78(1):213–219. https://www.ingentaconnect.com/content/umrsmas/bullmar/2006/00000078/00000001/art00020?crawler=true.

RIFE AN, FINE L, BATTISTA W, SARTO N. 2018. Project site comparison tool. Environmental Defense Fund. https://fisherysolutionscenter.edf.org/tools/project-site-comparison-tool.

ROSALES RM, POMEROY R, CALABIO IJ, BATONG M, CEDO K, ESCARA N, FACUNLA V, GULAYAN A, NARVADEZ M, SARAHADIL M, SOBREVEGA MA. 2017. Value chain analysis and small-scale fisheries management. Mar Policy. 83:11–21. doi:10.1016/j.marpol.2017.05.023.

SAATY TL. 1990. How to make a decision: the analytic hierarchy process. Eur J Oper Res. 48(1):9–26. doi:10.1016/0377-2217(90)90057-I.

SAATY TL. 1994. Fundamentals of decision making and priority theory with the Analytic Hierarchy Process. Pittsburgh (PA): RWS Publications. https://books.google.co.jp/books?id=wct10TlbbIUC&printsec=frontcover&hl=ja&source=gbs_atb#v=onepage&q&f=false

SONG B, KANG S. 2016. A method of assigning weights using a ranking and non- hierarchy comparison. Adv Decis Sci. 2016:8963214. doi:10.1155/2016/8963214.

SYAHPUTRA F, MUSLIM AM, TALAAT WIAW, IRSALINDA N. 2019. Analytical Hierarchy Process (AHP) in selecting suitable Marine Protected Area (MPA) site in Pulo Breuh (Breuh Island), Indonesia. J Phys: Conf Ser. 1373:012005. doi:10.1088/1742-6596/1373/1/012005.

VARGAS RV. 2010. Using the analytical hierarchy process (AHP) to select and prioritize projects in a portfolio. Proceedings of the PMI® Global Congress 2010; 2010 Oct 9–12; North America, Washington, DC. Newtown Square, PA: Project Management Institute.

VERANI H, FHARIDATY AI. 2019. Analysis of location selection of fish collection center using AHP method in National Fish Logistic System. Civil Eng Archit. 7 (3A):41–49. doi:10.13189/cea.2019.071307.

YAP JYL, HO CC, TING CY. 2018. Analytic hierarchy process (AHP) for business site selection. AIP Conf Proc. 2016:020151. doi:10.1063/1.5055553.