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Expert and Local Community Evaluations of Site Suitability to Support Mariculture Planning in Indonesia

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Abstract

Research on the value of local ecological knowledge has flourished in recent years, but is still relatively under-used in mariculture development planning. This research assesses a site suitability approach for net-cage grouper mariculture off Kaledupa Island in Indonesia. Biophysical capability analysis identified a 4,511 hectare marine area capable of sustaining grouper farming within a 8,582 hectares coastal study area. Suitability analysis on marine areas defined as capable which utilized the local ecological knowledge of villagers identified 2,667 hectares as potentially appropriate for development. Suitability analysis that relied upon expert knowledge was much less detailed and defined 4,083 suitable hectares as potentially appropriate for mariculture development. These results confirm that local ecological knowledge can be a powerful supplement to marine spatial planning conducted as part of a broader mariculture development process and must not be overlooked.

Keywords: suitability analysis; marine spatial planning; mariculture; grouper; Indonesia

1. Introduction

Although research on the value of local ecological knowledge in marine resource management has flourished in recent years (Williams and Baines 1993; Aswani and Hamilton 2004) but this type of information continues to be under-valued or overlooked (Kile *et al*., 2000). A variety of explanations have been proposed to explain this situation. A majority of marine scientists and resource managers are trained in the biophysical sciences and often do not possess experience with social science techniques such as interviewing or surveying that are required to interpret local ecological knowledge (Hamilton and Walter 1999). Elitism or ethnocentrism have also been cited as reasons for overlooking the value of this type of information (Johannes, 1982). The insufficient integration of local ecological knowledge has been even more pronounced in mariculture research (Walters, 2007) which is a serious given the explosive growth of sea farming in many coastal regions. Proper siting of facilities has been demonstrated to be one of the most important components of an effective mariculture planning (Ross *et al*., 1993). Mariculture siting typically consists of two primary elements: site capability analysis which evaluates the biophysical capacity of an area to support production, and site suitability which considers additional socio-economic factors (FAO, 1989). It is in this latter phase that local ecological knowledge can play a particularly important role.

This study investigates the influence of both expert and local ecological knowledge on net cage grouper site suitability analysis carried out in marine areas off Kaledupa Island, Indonesia. The study area is located in Wakatobi National Park which is one of Indonesia's largest marine conservation areas and includes four main islands: Wanci, Kaledupa, Tomia and Binongko (Fig. 1). Kaledupa Island was chosen among four main islands in Wakatobi National Park because it is relatively protected by long fringing reefs and also contains at least 10 coastal villages where a majority of residents are fishermen who are in need of economic development opportunities. The waters surrounding Kaledupa Island are also considered a local use zone in the Wakatobi National Park zoning system which can only be used by local people. Grouper is regarded as one of the most valuable market fishes throughout Indonesia where it is favored because of its rapid growth and ability to live in dense populations (Pierre *et al*., 2007) and a large marine area in Indonesia could potentially support additional production of this species (Nurdjana, 2006). Given the need for sustainable development opportunities in many of Indonesia's coastal communities, marine spatial planning tools such as site suitability analysis which integrate both scientific and local ecological knowledge are urgently needed to support income generation and the protection of marine resources (Pet-Suede, 2003).

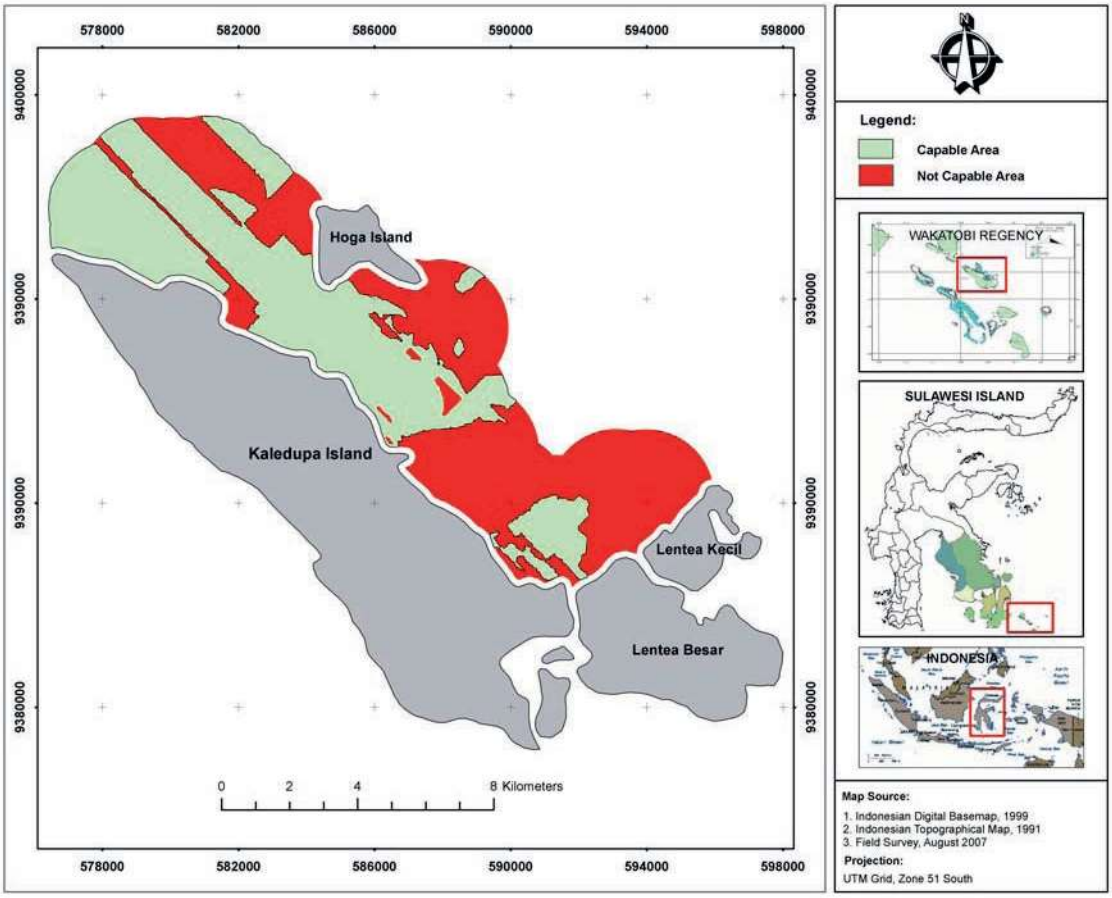

Figure 1. Biophysical capability map for grouper net-cage mariculture

2. Materials and Methods

Grouper possess a range of biophysical preferences (water temperature, dissolved oxygen, salinity, ammonia-nitrogen concentration, nitrate concentration, COD and turbidity) that have been well documented (Table 1). Capability analysis was conducted during August 2007 with sampling of the seven capability parameters conducted at 31 stations in areas where water depth ranged between 5 and 100 m. Each sampling station was centered within individual grid squares approximately 1 km^2 in area and plotted using a field GARMIN GPS MAP Sounder 178. After laboratory analysis all biophysical data was complete, this data was imported into ArcGIS 9.1 and Kriging interpolation (Bolstad, 2005) was used to display the distribution of values for each parameter. The use of GIS in marine environments is particularly valuable because it can show strong interactions among parameters in areas that are relatively homogenous lacking obvious boundaries. Different layers generated from the capability variables were overlaid on the base map using Boolean operators for the spatial selection of features (Nath *et al*., 2000). This approach creates a binary definition of capability and clarity between these categories. A final composite capability map was then produced that included a single thematic layer defining 4,511 hectares of water area possessing the biophysical conditions to support grouper net cage mariculture out of the entire 8,582 hectare study area (Fig. 1).

Successful grouper mariculture not only depends on the biophysical capability of the environment to support cultured fish, but also the consideration of a wide range of socio-economic and resource use factors as outlined in Table 1 (Kapetsky and Manjarrez, 2007; Perez *et al*., 2005). Net cages should be positioned away from local fishing grounds, shipping lanes, harbors and tourist sites (Henderson and Davies, 2000). The existence of conservation zones, spawning grounds and critical habitats such as coral or sea grass must also be considered (Villalba, 2006). A rapid rural appraisal (RRA) approach was used in this study to complete semi-structured interviews with local villagers on Keladupa Island. The interviews consisted of open-ended questions and were carried out in ten villages with a total of 30 individuals drawn a purposive sample of adult villagers selected on the basis of occupation and gender. Most interviewees worked as fishermen and seaweed farmers with only a small number employed as farmers and skilled laborers. Semi-structured interviews were also conducted with an

Table 1. Capability And Suitability Parameters

SITE CAPABILITY			
Parameters	**Optimal Capability**	**Method**	**Source**
Bathymetry	>5 m - <100 m	Field survey	Chou & Lee (1997)
pH	7.0 – 8.5	Field survey	FAO (1989)
Temperature	26 – 31 ^{0}C	Field survey	Chou & Lee (1997)
Dissolved Oxygen	>3 ppm	Field survey	Chou & Lee (1997)
Salinity	15 – 33 ppt	Field survey	Chou & Lee (1997)
Nitrate	< 4 mg/liter	Field survey and lab analysis	Chou & Lee (1997)
Phosphate	< 70 mg/liter	Field survey and lab analysis	Chou & Lee (1997)
Wave Height	< 1 m	Field survey	Chou & Lee (1997)
Water Current	>10 cm s^{-1} - <100 cm s^{-1}	Field survey	Chou & Lee (1997)
Sediment	Rock, sand or gravel	Field survey	Caine (1987)
Water Clarity	Secchi depth > 3 m	Field survey	Buitrago *et. al.* (2005)
Red Tide	No red tide reported	Interviews and literature	Buitrago *et. al.* (2005)
Parasites + Disease	No parasite reported	Interviews and literature	Buitrago *et. al.* (2005)
Pollution	No pollution reported	Interviews and literature	Buitrago *et. al.* (2005)
Tidal (Low tide)	> 2 m	Literature	Tookwinas (1989)
SITE SUITABILITY			
Parameters	**Optimal Suitability**	**Method**	**Source**
Coastal activities	No overlap	Field survey and interviews	Kapetsky & Manjarrez (2007), Perez *et. al.* (2005)
Transportation	No overlap	Field survey and interviews	Kapetsky & Manjarrez (2007), Perez *et. al.* (2005)
Diving sites	Buffer	Field survey and interviews	Perez *et. al.* (2005)
Fishing grounds	No overlap	Interviews	Perez *et. al.* (2005)
Harbors	>500 m , < 8 km	Field survey and interviews	Perez *et. al.* (2005)
Protected areas	>1000 m	Field survey and interviews	Kyrvi (1995)
Benthic species	No overlap	Field survey and interviews	Villalba (2006)
Spawning ground	>1000 m	Interviews	Kyrvi (1995)

"expert" sample that included six resource management professionals from the Wakatobi National Park Authority and a local university researcher. All individuals defined as experts had extensive knowledge of fisheries and environmental conditions in the study area as a result of conducting multiple scientific studies in the region. Both local villagers and experts were asked to pinpoint important physical features or resource use areas on a base map, and were repeatedly asked for clarifications and more detailed information. Features identified by interviewees were cross-checked by field visits to ensure the accuracy of this information. The resulting maps were then scanned and geo-referenced to fit a previously constructed digital base map, and each suitability parameter was digitized to determine spatial coordinates, import attribute information, and produce eight separate suitability layers. A 200 meters buffer area was also created around each island to limit future interpolation analysis because of visible near-shore turbidity. Interpolation using Kriging analysis was then performed on each parameter and results were overlaid to produce two suitability maps based on: 1) local ecological knowledge of villagers, and 2) expert knowledge of the study area.

3. Results and Discussion

The net cage grouper suitability map based on local ecological knowledge of villagers (Fig. 2) identified a total of 2,667 hectares of "suitable" marine area for grouper farming within the 4,511 hectares previously defined as "capable" (approximately 60% of the capable

area). Most of the suitable areas are located in the central and northern portions of the study area, with the presence of seaweed farms and protected areas representing the two most important parameters that limited villager suitability ratings. Other parameters such as sea grass, dive spots, and harbors excluded smaller areas and shipping lanes contributed to a degree of fragmentation. A very different suitability assessment was produced by experts (Fig. 3) who identified 4,083 hectares of marine area as "suitable" for grouper mariculture from the total of 4,511 hectares previously classified as "capable" (over 90% of the capable area). The consideration of seaweed farming areas in the southern part of Kaledupa illustrates the substantial differences between expert and villager knowledge of local site conditions. Villagers identified 2,169 hectares of marine area allocated to seaweed farming which could potentially conflict with net cage grouper production. This was far larger than the 89 hectares identified by experts. This discrepancy was duplicated in the case of sea grass ecosystems where villagers identify 940 hectares that would not be suitable for net cages as compared to 91 hectares identified by the experts. Villagers and experts did agree on the extent of protected areas that totaled 2,434 hectares and both groups identified more than 14 dive spots around Hoga Island that were located inside a protected area buffer zone.

The substantial discrepancy in suitability evaluations of experts and villagers in this study illustrates that local ecological knowledge can be a powerful supplement to site suitability analysis which must not be overlooked. Local residents who are actively involved in coastal livelihoods such as fishing are often very knowledgeable about specific activities and local site conditions which can influence site suitability evaluations. Of course local ecological knowledge cannot be successfully applied without maintaining rigorous standards of data collection and analysis, and researchers should avoid a sentimental belief local people "know best" without attempting to understand why and under what circumstances (Richards 1980, 185). Many people on Kaledupa Island support the idea of introducing grouper net cage mariculture along the eastern coastline of their island, and results of this study suggests that conservation areas such as WNP can be used for both conservation and sustainable livelihood activities important if proper consideration is allocated to both biophysical and socio-economic factors. Economic activities such as grouper farming can be developed with minimal impacts on the surrounding environment,

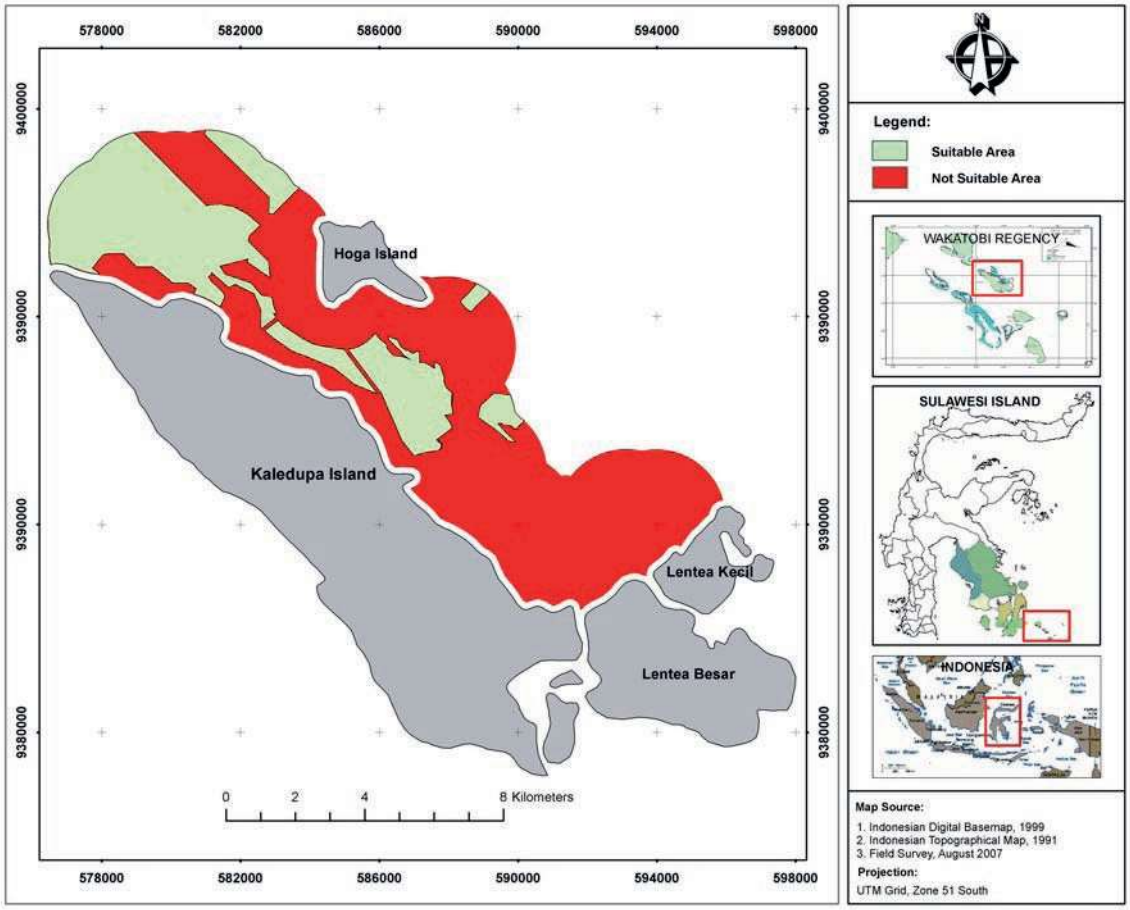

Figure 2. Suitability map for grouper net-cage mariculture (villagers)

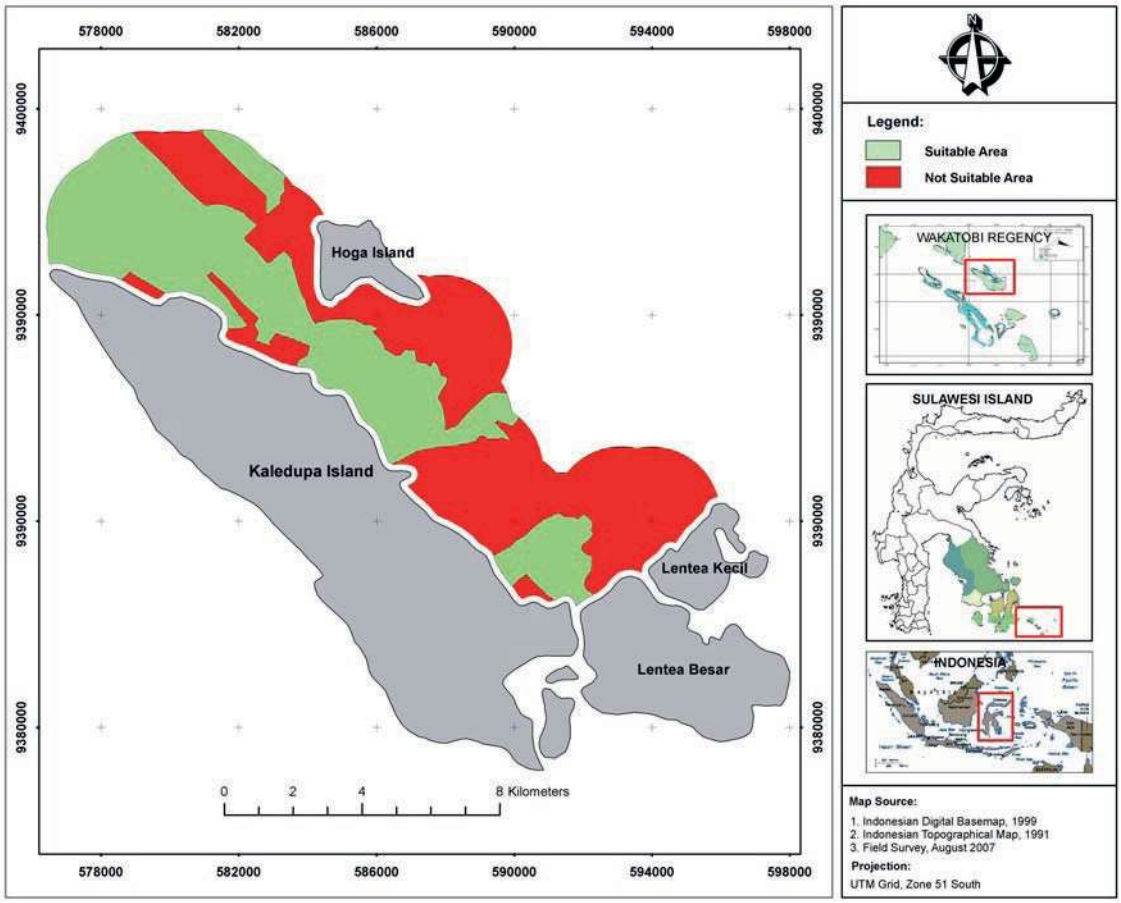

Figure 3. Suitability map for grouper net-cage mariculture (experts)

but this is heavily reliant upon the local government to support proper planning and management activities such as site suitability analysis that meet local needs, attempt to avoid potential conflicts, and promote clear conservation goals.

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