GIS–BASED PLANNING FOR SUSTAINABLE SHRIMP FARMING IN THANH PHU DISTRICT, BEN TRE PROVINCE, VIET NAM

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ABSTRACT

This study was conducted to develop a GIS-based approach to identify and quantify the suitable areas for shrimp farming in Thanhphu district, Bentre province, Vietnam. The data used were Landsat image, thematic maps, related reports and field survey data. Nine raster data layers were prepared and put in two groups namely: natural physical condition (soil types, salinity, water pH, proximity to mangroves, distance to water sources) and socio-economic condition (distance to roads, population density, experience in shrimp farming and land-use). Different criteria usually have different levels of importance. It is necessary to incorporate some criteria giving weight to indicate relative importance. Criteria weighting is done using analytic hierarchy process (AHP), which translates pair wise comparison matrix for different land-use into vectors of relative weights. Ammonia-N was used as criteria for calculating the carrying capacity of water bodies for shrimp farming with the assumption that NH3 in the study area was only produced from shrimp farming activities.

The overall assessment has revealed that 21.17% of the total area is moderately suitable for shrimp culture and can be used for improved-extensive culture, 23.9% is suitable and can be used for semi-intensive culture and 14.3% is highly suitable and can be used for intensive culture. The present study has shown that 21,621.45 ha can be used for shrimp farming development while the current shrimp farms area is 15,871.74 ha. It means that the area for shrimp farming can be expanded to include rangeland and bare land. This study demonstrates the use of GIS in aquaculture planning which can be applied in other places and the results from this study can be very useful for decision makers to make shrimp culture sustainable through proper consideration of natural conditions, socio–economic and environmental issues.

Key words: GIS, land evaluation, shrimp farming.

1. INTRODUCTION

Zoning involves an integration analysis of various spatial factors of features that are complex and relatively relevant each other, and it requires a combination of these factors to identify suitable zones as expected. Spatial factors including physical, biological and others such as land-use have complex relationships and they have certain effects on zoning objectives. Zoning also is considered to be relevant to process of multiple-criteria and multiple-objectives evaluation in which factors or map layers are superimposed together to create a new layer that presents a spatial distribution of zones. Therefore, to deal with this complexity, overlaying-mapping method is used for spatial analysis and simple mathematical models are employed in zoning to facilitate the process. A large number of land evaluations for aquaculture using GIS have been studied at different scales for various cultured species and environments, for example, hard clam aquaculture in Florida, USA: GIS applications to lease site selection (Arnold et al., 2000); zoning and management of razor clam in the muddy coastal zone between the Mae Klong and Tha Chin rivers, Thailand (Benjarat, 2002); analysis of sustainability of the shrimp farming systems in Hai Phong, Vietnam (Dao, 2005).

In Vietnam, aquaculture has become a highly profitable business, and will continue to grow to meet domestic and export demands. Shrimp farming in particular has expanded rapidly in recent years, and contributed about 50% of the total export earning of Vietnamese fisheries products with 324,680 tons of farmed shrimp in the year 2005 (MOFI, 2006). It has been so difficult to control the development of brackish water shrimp culture. Due to the potentially high income from shrimp culture, rice farmers have converted their farms to shrimp farms but most of these rice farms are not suitable for shrimp culture only. In other areas, mangrove forests have been cleared to acquire areas for shrimp culture. A major cause of the farmers' problem is the unsuitable site used for shrimp culture. It is therefore necessary to identify which areas are suitable for shrimp culture and models position of shrimp farming as well.

This paper presents results of the application of GIS techniques to develop a land evaluation method for identifying and quantifying appropriate sites and culture models of shrimp farming development in Thanh Phu district, Ben Tre province, Vietnam.
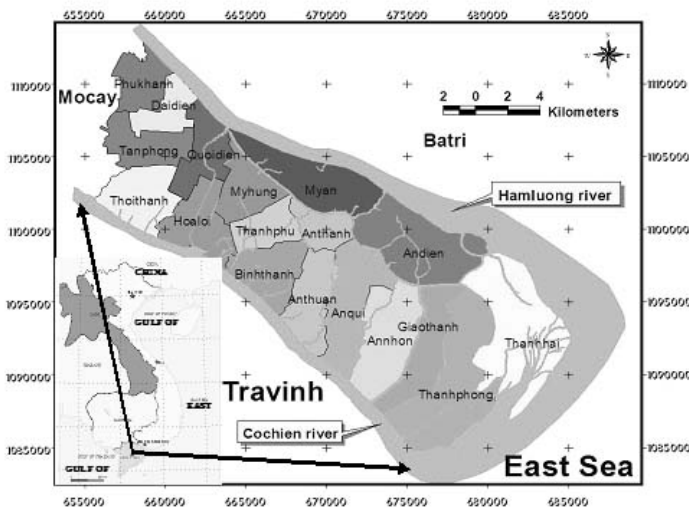

Figure 1. Study area – Thanh Phu district, Ben Tre province

2. METHODOLOGY

2.1 Study area

Thanh Phu is one of the coastal districts of Ben Tre province. It is located in the end of Minh island, between two rivers: Ham Luong and Co Chien and contiguous with the East Sea. It covers from $9^007'95''$N to $10^003'52''$N and $106^024'41''$E to $106^041'47''$E (Figure 1).

Except for some high sand dunes (height about 2 – 5 m), the topography is quite flat, the differential between highest and lowest areas just about 50 – 60 cm. Thanh Phu's climate has been affected by tropical climate. Average rainfall is 1,279 mm yearly. Amount of rainfall 1,218 mm and 61 mm in rainy season and dry season occupies 95% and 5% total rainfall of the whole year respectively.

2.2 Data used

The used data were Landsat images, thematic maps, related reports and field survey's information. Nine raster layer were prepared and put in two groups namely: natural physical

condition (soil types, salinity, water pH, Proximity to mangroves, distance to water sources) and socio-economic condition (distance to roads, population density, experience in shrimp farming and land-use).

Table 1. Landuse types of the study area

Landuse	Area (ha)	Percentage
Abandon pond	89.69	0.25
Agriculture	3177.47	8.72
Mangrove	1980.79	5.44
Paddy field	6026.94	16.54
Pond	7843.74	21.53
Rangeland	2949.41	8.09
Rice - Shrimp	7572.11	20.78
Sand dune, Bare land	5578.51	15.31
Water body	1219.74	3.35
Column total	**36438.41**	**100.00**

Salinity, water pH, population density, experience in shrimp farming were derived from related reports which getting from Research Institute for Aquaculture No.2, Ben Tre Statistical Office and Thanh Phu Statistical Office. Soil types, distance to water sources, distance to roads were derived from related thematic maps, proximity to mangroves and land-use map were extracted from Landsat image of the year 2006 (p125r053_20060304 FCC 542).

2.3 Analysis procedure

Suitability ratings were established according to FAO classification (Dao, 2005) on the appropriateness of land for defined uses. Weighing and suitability rating were based on the level of importance of a particular factor that influences aquaculture. Each factor was ranked and classified according to the following hierarchy

+ Highly suitable (3): provides a situation in which a minimum time and investment are required to develop shrimp farming

+ Suitable (2): requires modest investment and time period

+ Moderately suitable (1): requires significant intervention before shrimp farming can be operated.

+ Unsuitable (0): requires considerable time and cost or both. These are not appropriate for shrimp farming.

Different criteria usually have different levels of importance. It is necessary to incorporate of some form of criteria weighting to take care of their relative importance. Criteria weighting is done by the author using analytic hierarchy process (AHP), which translates pair wise comparison matrices for different land uses into vectors of relative weights. This is done to estimate a ranking or weighting of each of the criteria that describes the importance of each of these criteria in contributing to the overall objectives. The suitability scores then were calculated by the following equation:

$$S = \sum_{i=1}^{n} X_i * W_i$$

where
    S = Suitability score
    X_i = Standardized score for value of criteria i
    W_i = Weight of criteria i

The buffer map of rivers and coast lines was prepared and converted to raster map. This map was multiplied with the shrimp farming final suitability map (raster map) to reach the results on land suitability for shrimp farming models.

3. RESULTS

The classification of land-use types were showed in Table 1. It expressed that the dominant land-use types were shrimp ponds (21.53%), rice-shrimp farms (20.78%), and paddy field (16.54%) of total area.

Most of the soil types of study area can be used for shrimp farming, 40.87% and 24.06% of total area were found as suitable and highly suitable, respectively. The soil types, which considered as highly suitable and suitable, were severely saline soil, moderately and slightly saline soil.

The study area owned the profound water resources, many rivers, streams and man-made canals were connected to make a watercourses network. Cause of that, 87.5% of total area were found as highly suitable for shrimp culture on the aspect of distance to watercourses. 88% of study area were also found as highly suitable related with water pH. In the context of water salinity, 42.1% and 31.2% of total area were recognized as highly suitable and suitable for shrimp farming.

The socio-economic conditions have taken an important role in shrimp farming development. The suitability process revealed as a fact that 16.46% and 43.86% of total area as highly suitable and suitable, respectively, for shrimp culture in terms of socio-economic conditions.

The overall assessment has shown that 21.17%, 23.9% and 14.3% of total area can be applied for improved-extensive as moderately suitable, semi-intensive as suitable and intensive as highly suitable, respectively.

Table 2: The Suitability Areas for Shrimp Farming Models of Each Commune

	Improved – Extensive, Moderately Suitable (ha)	Semi – Intensive, Suitable (ha)	Intensive, Highly Suitable (ha)
Andien	370.70	1323.43	1391.42
Myan	330.95	1163.58	319.68
Thanhhai	235.15	1887.24	1016.30
Thanhphong	973.07	1152.61	982.70
Giaothanh	871.55	288.43	193.26
Annhon	917.87	697.26	227.65
Binhthanh	441.65	941.09	149.30
Anthuan	495.48	513.47	551.60
Thanhphu	1056.56	35.62	-
Hoaloi	11.14	43.34	-

Anqui	916.76	520.46	369.63
Anthanh	623.61	140.68	-
Myhung	468.20	-	-
Column total	7712.67	8707.23	5201.55

4. DISCUSSION

The integration of GIS with MCE (Multi-Criteria Evaluation include Analytic Hierarchy Process (AHP) and Weighted Linear Combination (WLC) is so useful for land evaluation for shrimp farming and shrimp farming models position as well.

The present study has shown that 21621.45 ha can be used for shrimp farming development while the current shrimp farms area were 15871.74 ha. It means the study area can expand shrimp farms to other areas based on the land suitability.

In the context of environment pollution and sustainable farming, the intensive model should take the places nearest to the big rivers or sea and then continuing by semi-intensive, improved-extensive models. On the other hand, the moderately suitable area, suitable area and highly suitable area should be employed for improved-extensive, semi-intensive and intensive respectively because of the reasons about investment risks.

In the context of GIS – based planning for sustainable shrimp farming, three main aspects should be considered: suitable size, suitable locations for shrimp farming and environmental carrying capacity. If these conditions are associated with the government policies, farmers awareness, stable market, the sustainable development can be reached.

5. CONCLUSION

The integration of remote sensing data, GIS data and other socio-economic data, experts' supports and the GIS-based evaluation methods AHP and WLC has been very effective in suitability study for planning a sustainable brackish shrimp farming in our study. Higher resolution satellite imageries such as SPOT, ALOS or QUICKBIRD could have been used to produce maps at a higher scale to help decision makers in more detailed and better planning.

6. REFERENCES

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