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Crab culture potential in southwestern Bangladesh: alternative to shrimp culture for climate change adaption

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Abstract

Outbreaks of disease, price increases, international competition and impact of climate change has setback shrimp culture in the coastal region of Bangladesh. In this changing environment, crab has emerged as a potential exportable commodity in the country. Farmers are transferring to crab farming as it is less susceptible to disease, resistant to adverse environmental conditions and has a good market price. This paper highlights the application of remote sensing and GIS for crab culture potential. The paper discusses the imminent capabilities of satellite imaging technology and Multi criteria evaluation (MCE) module in GIS environment for development of sustainable crab aquaculture consisted physical, environmental and socioeconomic data to evaluate coastal land based criteria for mud carb farming based on water quality, water availability, salinity, risks of flooding, soil types, topography, land use/land cover; infrastructure, inputs, seed sources, market and support services. All the layers with associated attribute data were digitally encoded in a GIS database to create thematic layers. The database was verified to remove the inconsistency if any. The expert opinions were combined into the model by assigning weights of relative importance to evaluate crab farming and land suitability was categorized as very suitable, moderate suitable, marginal suitable and currently not suitable by implementing the logical criteria. MCE identified a range of suitable land parcels with unique characteristics. The resultant map reveals that a considerable amount of land (28.33%) fell under very suitable category which is situated in the northwest and southwestern part of the area. On the other hand, majority of the land parcel (62.22%) fell within the moderately suitable group that is scattered throughout the area and approximately 9.45% of land was only marginally suitable for crab culture. However, there is no land parcel designated as unsuitable in the present study for crab culture. The suitability output is replicable within the study area and transferable to other areas for other cultured species
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Keywords: crab, southwest, shrimp, MCE, climate change adaptation.

1. Introduction

Shrimp culture in the coastal region of Bangladesh expanded at 20 to 30% per year during the 80's and 90's (Primavera, 1995). This growth and importation of postlarvae was largely unregulated and did not follow proper quarantine rules, leading to disease outbreak, loss of biodiversity and environmental degradation in the region. Moreover, price increases, international competition and impact of climate change has reduced production and further setback shrimp farming in the coastal areas (Chowdhury and Muniruzzaman, 2003; Karthik, *et al*., 2005; Nuruzzaman, 1996 and Primavera, 1995).

In this changing environment, crab, which was previously an incidental product of culture operations for shrimp, milk fish and other fin fishes in Southeast Asian Countries (Ali, *et al*., 2004; Chandrasekaran and Perumal, 1993), has emerged as an alternative livelihood and potentially exportable commodity. Shrimp farmers are now changing to crab farming as it is less susceptible to disease, easier to culture, more resistant to adverse environmental conditions and has a high commercial value and market price both locally and internationally and can provide a new source of income for coastal fisher folk (Khan and Alam, 1991). Crab culture is increasing the country's export earnings day by day (Ali, *et al*., 2004). About 7,000 MT of mud crab was landed at 292 crab depots in 15 sub-districts of Southwestern Bangladesh in 1995-96 (Kamal, 2003), whereas more than 10,000 MT were produced in 2000. Total earnings in 2007-08, were US$ 7,068,000 (Ferdoushi *et al*., 2010 and Zafar and Siddique, 2000). Crabs are second most exported crustacean product from Bangladesh and the crab fishery supports the livelihood of more than 50,000 fishers, traders, brokers, transporters, and exporters (Molla et *al*. (2009). Hence, proper land use planning is required to expand the crab culture in the region for environmental and ecological sustainability.

Geographic information systems (GIS) and remote sensing (RS) can play a vital role in crab farming development and crab fishery management in the country. Both these technologies can be used to explain and model geographic context, ecological constraints and categorize the degree of limitations (Salam *et al*., 2003). Several applications of GIS and RS for land use and site selection for aquaculture, fisheries habitat restoration and conservation and other industries have been reported, including hard clam culture in Florida (Arnold *et al*., 2000), shrimp, crab and carp farming in Bangladesh (Salam *et al*., 2003 and 2005), shrimp culture in India **(**Rajitha, 2007**),** scallop culture in Japan (Radiarta, 2008) water quality and fish culture in cage in Canary Islands (Pérez *et al*., 2003 and 2005) and mangrove oyster raft culture in Margarita Island, Venezuela (Buitrago *et al*., 2005). Traditional shrimp culture methods have created various problems in coastal Bangladesh because the spatial nature of the resource use was not properly considered. To make crab farming sustainable and environmentally acceptable, spatial aspects of physical and environmental parameters which affect sustainability need to be incorporated in an analytical hierarchy process (AHP) (Giap *et al*., 2005) which can be achieved within GIS.

This study presents a GIS-based identification of the most suitable sites for crab culture in the southwestern coastal region of Bangladesh, based upon remotely sensed imagery, global positioning system (GPS) for field verification and accuracy assessment, GIS tools and multi-criteria evaluation (MCE).

2. Materials and Methods

Study area

The Paikgachha sub-district (upazilla) is a part of Khulna district, located 160 km southwest of Khulna city and situated between longitudes $22^0$28´ and $22^0$43´ North and latitudes $89^0$09´ and $89^0$23´ East (Fig. 1). The area is influenced by three large and several small tidal rivers flowing from north to south towards the Sundarbans, the world's largest continuous mangrove forest (Rashid, 1991). The annual average temperature in the study area ranges between a minimum of 12.5^{o}C in winter to a maximum of 35.5^{o}C in summer and average annual rainfall is 1710 mm which mainly occurs in summer. The main occupation of the inhabitants is agriculture and agricultural labour, however, a considerable number of people are engaged in shrimp culture, fishing and crab harvesting in the natural water bodies and mangrove forest. Although agriculture is the main occupation, involving 35.48% of the population, most of the land in the area is not suitable for agricultural crops due to saline intrusion. The area is characterized by 2 to 4 meter above the mean sea level and the soils in the area are loam, clay loam or clay.

Software and hardware used

All remote sensing image processing and GIS manipulation and modeling was completed using IDRISI Andes (Clark Labs, USA).The software was used to extract vector layers from maps scanned using a HP 4200 precision scanner and on-screen digitizing. Further corrections were made using DIGI-EDIT for Windows- version 1.05 and some tabular data was pre-processed in Microsoft Excel before being incorporated into the GIS database.

Landsat TM image acquisition and classification

A Landsat Thematic Mapper (TM) satellite image for November 2003 was used to identify land use, this being more up to date and detailed than the available survey maps. Land use was reduced into seven clusters by unsupervised classification and the resultant image was reclassified based on local knowledge into five land use categories; water bodies, homestead vegetation, shrimp farms, bare land and agricultural crops. The reclassified image was further classified to establish potential for crab culture with , where shrimp farms and fallow land being assigned as very suitable, agricultural crops being less important, fallow water bodies being marginally suitable and homestead vegetation assigned as the least important for crab culture potential (Table 1).

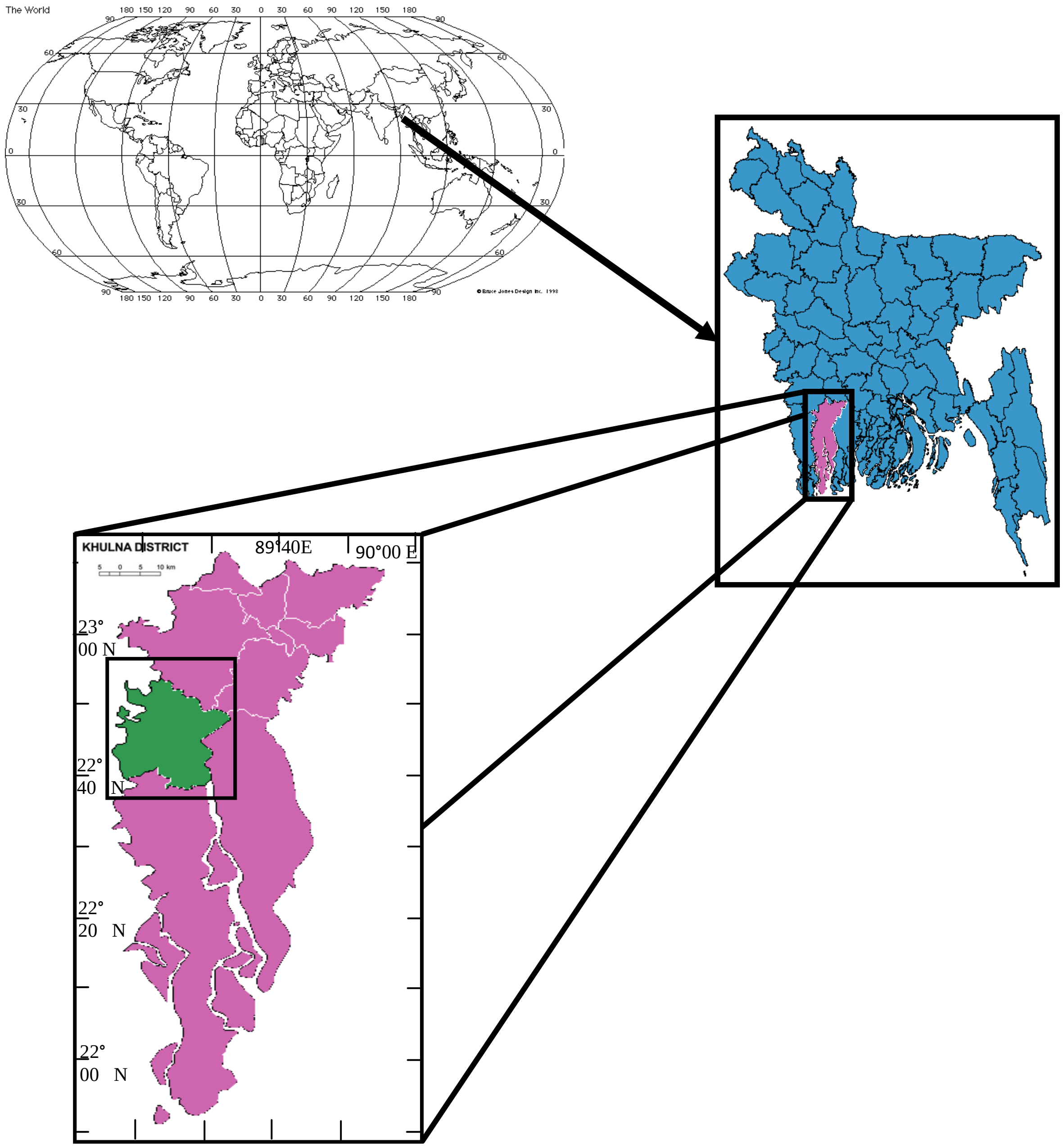

Fig. 1. The map showing the study area; Paikgachha sub-district (upazilla), Bangladesh

Table 1. Land use classification based on Landsat TM image in Paikgachha sub-district, Khulna, Bangladesh.

Suitability range	Land use type	Land mass (%)
Very suitable	Shrimp farm and bare land	44.41
Moderately suitable	Agricultural crop lands	11.43
Marginally suitable	Fallow water bodies	11.10
Currently unsuitable	Homestead vegetation	33.05

Factors influencing crab farming

A primary task is identification of the appropriate data set to evaluate in multi criteria evaluation (MCE) within the GIS environment. The most important production functions (Meaden and Kapetsky, 1991) for crab culture potential within the region are of two types, factors and constraints (Eastman, 1995). Seventeen factors were identified, grouped into seven main categories; (1) Water resources (2) Land use (3) Soil quality (4) Infrastructure (5) Extension support services (6) Market facilities and (7) Seed sources. Five different land use types were incorporated into a constraint map. The soil properties were digitized from the Soil Resource Development Institute (SRDI) soil map (1992-93) that scale is 1: 50,000, prepared based on the FAO/UNESCO soil map. The roads, settlements, local and town markets and extension support services were derived from Local Government Engineering Department (LGED) map. River transport, settlements and ecological sensitive areas were extracted from Landsat 5's thematic mapper (TM) sensor acquired in November 2003. Integrating selected data through MCE requires transformation of parameters into comparable units. Each parameter needs to be reclassified in terms of suitability to the specific biological or physical requirement (Longdill *et al*., 2008). The components of the database for crab farming is shown in Table 2. Interpolation and distance buffers were used to create the proximity to roads, rivers, markets and seed sources and all parameters were reclassified in terms of crab culture as either very suitable (optimum), moderately suitable, marginally suitable and currently not suitable according to Kapetsky and Nath (1997) (Table 3).

Analytical framework and model construction

The reclassified data was arranged into sub-models based on natural groupings of variables with respect to the function they perform or properties they share (Saaty, 1988)., A hierarchical structure was then developed leading through a series of MCE operations to the final outcome showing the suitability analysis for crab culture site selection in Paikgachha sub-district (Fig. 2). The lowermost level in the hierarchy contains the evaluation objects. These are all the criteria identified as influencing the goal of the study and may represent primary data or be the result of some preliminary data manipulation or model output. The second level represents the outcomes of the sub-models achieved through weighted linear combination. The final level in the hierarchy leads to the ultimate goal of the overall multi-criteria decision-making analysis process.

Table 2. Factors affecting crab culture in Paikgachha sub-district, Khulna, Bangladesh

Principal Categories	***Component criteria***
Land use	Satellite image
Infrastructure	Paved and Unpaved roads and Rivers
Seed sources	Rivers, Local market and crab depots
Soil quality	Soil salinity, soil p^H, soil texture and flood depth
Water sources	Rivers and canals
Market facilities	Local and town market
Extension support services	Sub-district, sub-district fisheries office,

	NGOs, Bank and Research station
Constraints	Roads, rivers, canals, settlements, forests and ecologically sensitive areas

Weighting procedure and Multi-Criteria Evaluation (MCE)

After standardizing and registering all the data set to a common scoring system in a GIS database, their relative weights were determined by the pairwise comparison method according to the Analytical Hierarchy Process of Saaty (1988). Initial scoring of the relative importance of the factors involved in the modeling was based upon the author's experience of species requirements, farming system adopted and knowledge of the natural environment in the region (Salam and Karmokar, 2005) and was evaluated on a seventeen-point, continuous-rating scale from 1/9, 1/8….1/2 (least important) to 1, 2….9 (most important) (Table 4). The eigenvectors of the pairwise comparison matrix should sum to 1, and the the calculated consistency ratio of the matrix, being less than 0.1, was highly acceptable at 0.03.

Table 3. Classification scheme adopted for parameters used in this study.

Factors	***4 Very suitable***	***3 Moderately suitable***	***2 Marginally Suitable***	***1 Presently Unsuitable***
Land use	Shrimp farm and fallow land	One crop agricultural land	Water body	Homestead vegetation
Infrastructure				
River transport	<5,000	5,000-7,000	7,000-10,000	>10,000
Paved roads	<5,000	5,000-10,000	10,000-15,000	>15,000
Unpaved roads	<2,000	2,000-5,000	5,000-8,000	>8,000
Seed sources				
Rivers	<500	500-1,000	1,000-1,500	>1,500
Town market	<5,000	5,000-12,000	12,000-16,000	>16,000
Local market	<3,000	3,000-6,000	6,000-10,000	>10,000
Soil quality				
Soil texture	>75% fine	>75% medium	50-75% coarse	>75% coarse
Soil pH	6.5-9	5.5-6.5	4.5-5.5	<4.5 >9
Soil salinity	8-26ppt	5-8, 26-32ppt	4-5, 32-37ppt	<4 >37ppt
Flood depth	No risk	Marginally risk	Moderately risk	Severe
Water sources	<500	500-1,000	1,000-1,500	>1,500
Market facilities				
Town market	<5,000	5,000-10,000	20,000-16,000	>16,000
Local market	<3,000	3,000-6,000	6,000-10,000	>10,000
Support services				
UFO	<10,000	10,000-15,000	15,000-20,000	>20,000
Research station	<10,000	10,000-15,000	15,000-20,000	>20,000
Bank	<6,000	6,000-12,000	12,000-18,000	>18,000
NGOs	<5,000	5,000-10,000	10,000-15,000	>15,000

The weights were then used in a crab culture model based on the MCE with linear combination in which data are combined according to their relative importance to either a single or a multiple set of objectives (Heywood *et al.*, 1995; Eastman *et al.*, 1993). Although these weightings were assigned according to the current situation, it is possible to change the weights allowing investigation of the effects of change (Siddiqui *et al*., 1996 and Malczewski, 1999). In the final MCE, a Boolean constraint layer was used (Fig. 3) to exclude areas which are already occupied from the modeled outcomes. The suitability S is calculated as a geometric mean of all the factors and sub-models using the equation:

$$S = \sum (WiXi) . Cj$$

Here, S = suitability, W_i = weight of factor i, Xi = criterion score of factor i and Cj = constraint j.

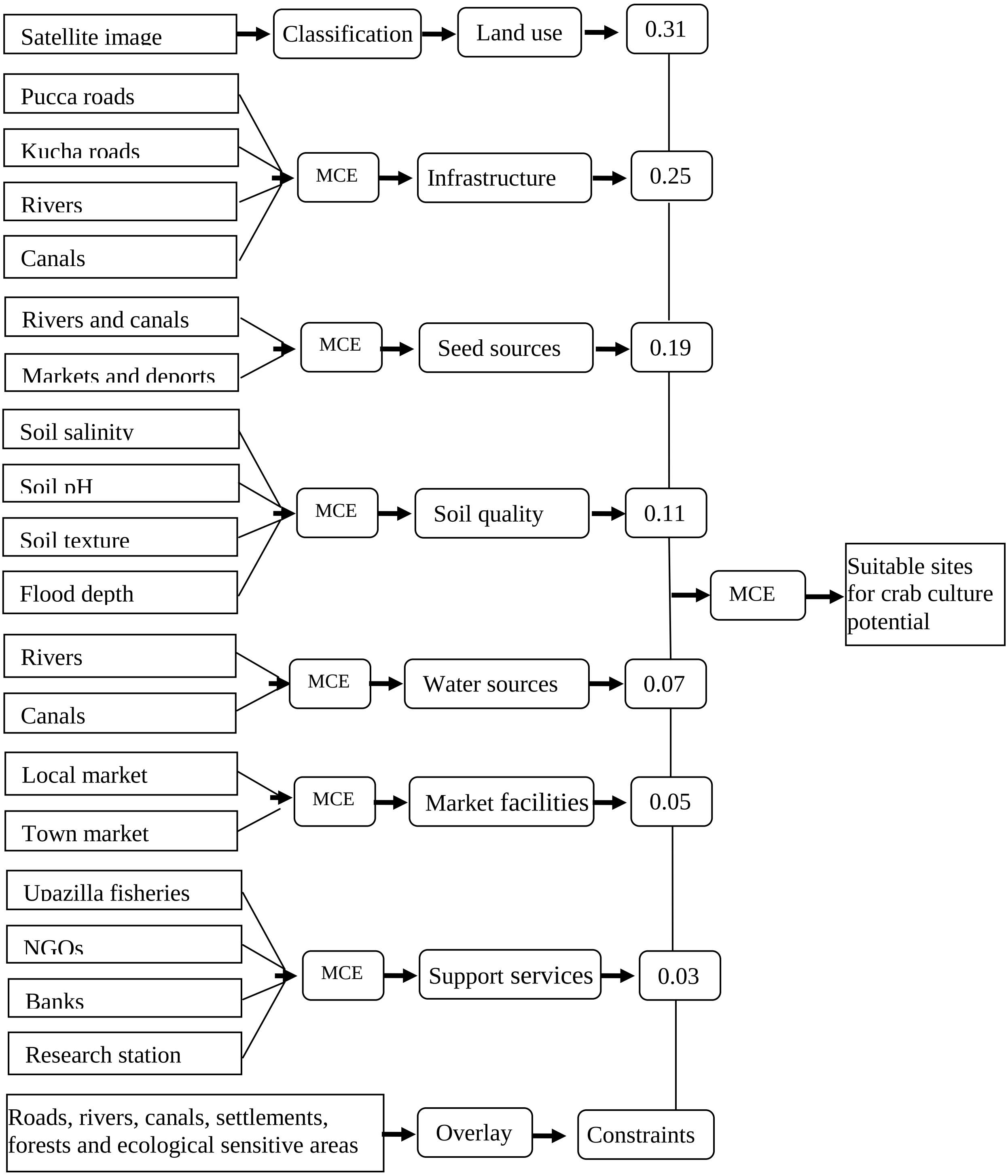

Fig. 2. Shows the integration of seven sub-models and constraint image for crab culture potential in the study area.

Table 4. Pairwise comparison matrix to calculate the relative importance of the sub-model

Factors	Land use	Infrastructure	Seed sources	Soil quality	Water sources	Market facilities	Support services	Weight
Land use	1							0.31
Infrastructure	1/2	1						0.25
Seed sources	1	1/2	1					0.19
Soil quality	1/4	1/3	1/2	1				0.11
Water sources	1/5	1/4	1/3	1/2	1			0.07
Market facilities	1/6	1/5	1/4	1/3	1/2	1		0.05
Support	1/7	1/6	1/5	1/4	1/3	1/2	1	0.03

Consistency Ratio (CR): 0.03; which is highly acceptable.

Focus group opinions

A more secure and ultimately more acceptable outcome can be developed by considering the opinions of experts in the relevant fields. For this, two focus groups were chosen; i) a group of staff from the Faculty of Fisheries (FoF), Bangladesh Agricultural University (BAU), Mymensingh who have experience in crab culture and ii) an aquaculture Masters student group consisting of 4 from the FoF, BAU and 4 from Fisheries and Marine Resource Technology, Khulna University, Khulna. The objective was to use the combined expertise and experience of the focus groups to rank the factors and compare this with that of the author. A standard form was prepared in which participants were first asked to rank the factors involved in crab culture from a list provided, and secondly participants were asked to assign weights to the ranked factors according to their relative importance for crab culture. Prior this exercise, a short introduction of the aim of the project was given (Table 5). The check list was completed in presence of the author and enough time was given to think about the situation.

Statistical analysis of questionnaires

The non-parametric Kendall coefficient of concordance (W) is commonly used to express the intensity of agreement among several rankings and was used to judge whether the ranking initially assigned by the author matched the rank scores of the focus groups. Non-parametric statistical analysis was used in this case because the use of an expert group means that the data was not random and the sample size was relatively small.

Kendall coefficient of concordance is based on the hypothesis:

H_0**:** The m sets of rankings are not associated

$H_{1:}$ The m sets of rankings are associated and is derived using the following formula:

$$W = \frac{\Sigma Ri^2 - \frac{(\Sigma Ri)^2}{n}}{\frac{m^2(n^3 - n)}{12}}$$

where, W = Kendall's coefficient of concordance; Ri = sum of the ranks assigned by focus groups; m = number of sets of rankings and n = number of individuals.

The value of W may range from 0 (when there is no agreement among the sets of ranks) to 1 (when there is a complete agreement among the sets of ranks). Therefore large valve of W rejected H_0 (Kendall, 1984a, b). Moreover, it was possible to compute Xr^2 = m (n-1) W, and compare it with the value of chi χ^2 = (n –1). If the Xr^2 was larger than chi-square, rankings were associated and therefore there was an agreement.

Verification

Outputs of the model were verified for both quality control of the data and testing the outcomes of the models (Nath *et al*., 2000). Model verification was carried out by making comparisons between the suitable sites identified in the model outcome and existing crab and shrimp aquaculture operation sites. The geographical location of existing crab and shrimp culture sites were collected during model verification using a Garmin hand held global positioning system (GPS) and overlaid with the suitability map of GIS model outputs to visualize the correspondence between suitable sites and the existing crab and shrimp culture sites in the region.

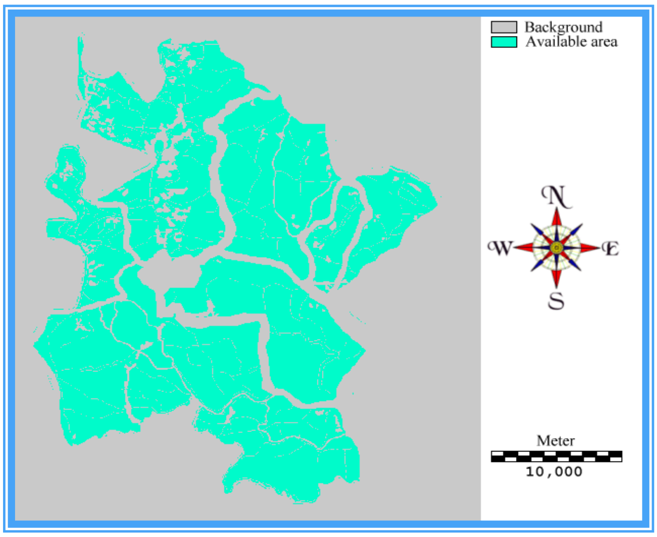

Fig. 3. Shows the integration of six sub-models and constraints for crab culture potential in the study area.

Table 5. The relative ranking and weighting of the factors by focus groups for crab culture development in Paikgachha sub-district, Khulna, Bangladesh.

Criteria	*A*	*F-1*	*F-2*	*ΣRi*	*Mean*	*A*	*F-1*	*F-2*	*ΣRi*	*Mean*
Land use	1	1	2	4	1.33	0.31	0.35	0.35	0.90	0.30
Infrastructure	2	5	6	13	4.33	0.25	0.24	0.24	0.75	0.25
Seed sources	3	4	1	8	2.67	0.19	0.16	0.16	0.52	0.17
Soil quality	4	2	3	9	3.00	0.11	0.10	0.10	0.35	0.12
Water sources	5	3	4	12	4.00	0.07	0.07	0.07	0.23	0.08
Market facilities	6	6	5	17	5.67	0.05	0.04	0.04	0.15	0.05
Support services	7	7	7	21	7.00	0.03	0.03	0.03	0.09	0.03
Total						1.0	1.0	1.0		1.0

Terminology: Kendal's W = 0.78, p<0.01; A = Author, F-1 Teachers and F-2 MS students

3. Results

Land use classification of Landsat TM image

Unsupervised classification showed that 34% was shrimp farms, 9% bare land, 11% agricultural crops, 35% was homestead vegetation and the remaining 11% comprised the natural water bodies in the area. The reclassified suitability image for crab culture showed that nearly half of the land mass falls under very suitable (44.42%) category for crab culture potential. On the other hand 33.05% land area considered currently unsuitable principally comprising either areas where three crops are produced annually, or settlements. Moreover, both moderately and marginally suitable category consists only 11% land mass to consider crab culture in the study area (Table 1 and Fig. 4).

To have the comprehensive understanding of the outcomes of the GIS modeling, the results are presented first in sub-models and then in final output. The percent of potential landmass in each sub-model is summarized in Fig. 5 and the corresponding spatial distributions of the land parcels are shown in Figs 6 a-f.

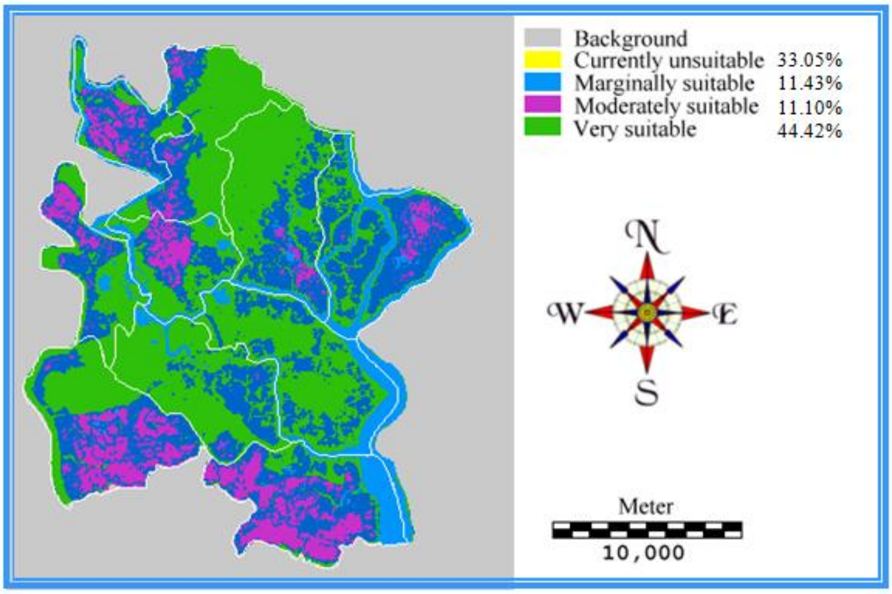

Fig. 4. Land use sub-model for crab culture potential in Paikgachha sub-distract, Bangladesh.

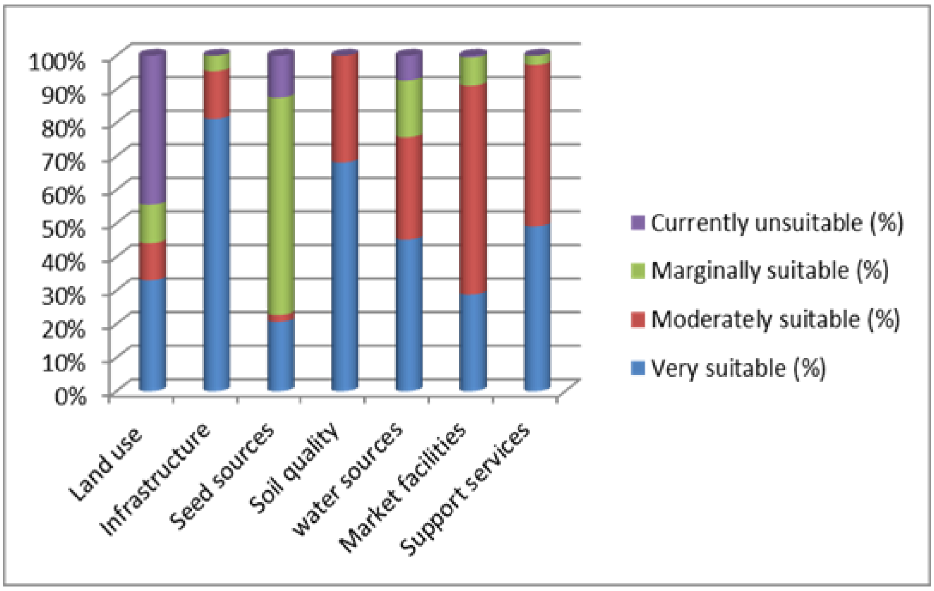

Fig. 5. The percentage of potential areas for each sub-model for crab culture in Paikgachha sub-district, Bangladesh.

It is easily comprehended from the Fig. 6a that the highest amount (81.12%) of very suitable land parcel contained by infrastructure sub-model followed by soil quality 68.19%, support services 49.13% and water sources 38.41% sub-models (Figs. 6c,6f and 6d) respectively. Moreover, relatively similar amount of very suitable land mass covered by land use (33.05%) and market facilities (28.82%) sub-models for crab culture potential in the region (Figs 4 and 6e). In addition, the seed sources sub-model contained least amount of very suitable (20.64%) land parcels for crab culture potential in the area. By contrast, majority of the available land parcel in market facilities sub-model fall under moderately suitable category (62.23%) followed by support services (49.13%), water sources (25.95%), infrastructure (14.26%) and land use (11.0%) sub-models distinctly. Furthermore, only 2.06% land parcel fall under moderately suitable category in seed sources sub-model (Fig. 6b). Conversely, only the seed sources sub-model contained higher amount of marginally suitable land mass (64.69%) followed by water sources (14.37%) and land use (11.0%) sub-models respectively. Besides, only the land use sub-model contained the highest percentage (33.05%) of land mass in unsuitable category which is mostly settlement and built up areas that will ultimately be eliminated as constraint, other sub-models hold insignificant amount of unsuitable land parcel which is far away from the landing center, market facilities, rivers and road communication which will not have substantial impact on the final output of this study.

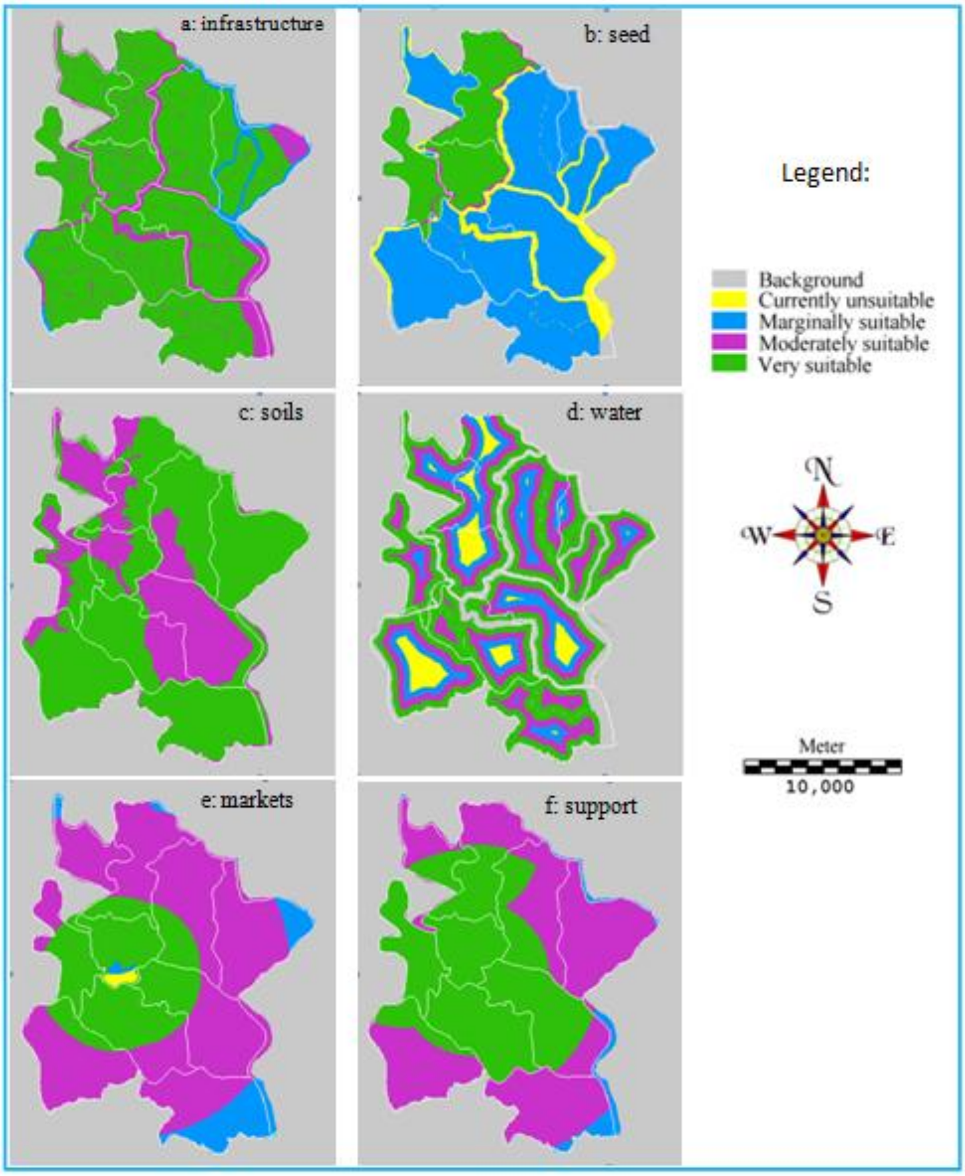

Fig. 6. Distribution of outcomes in the six sub-models for crab culture potential in Paikgachha sub-district.

The final result of crab culture potential was obtained through MCE module with Weighted Linear Combination (WLC) of seven resulted sub-models of preliminary MCE analysis such as land use, infrastructure, soil quality, seed sources, water sources, market facilities and support services sub-models. Fig. 7 represented the potential sites for crab culture potential in Paikgachha sub-district without incorporating and with combining

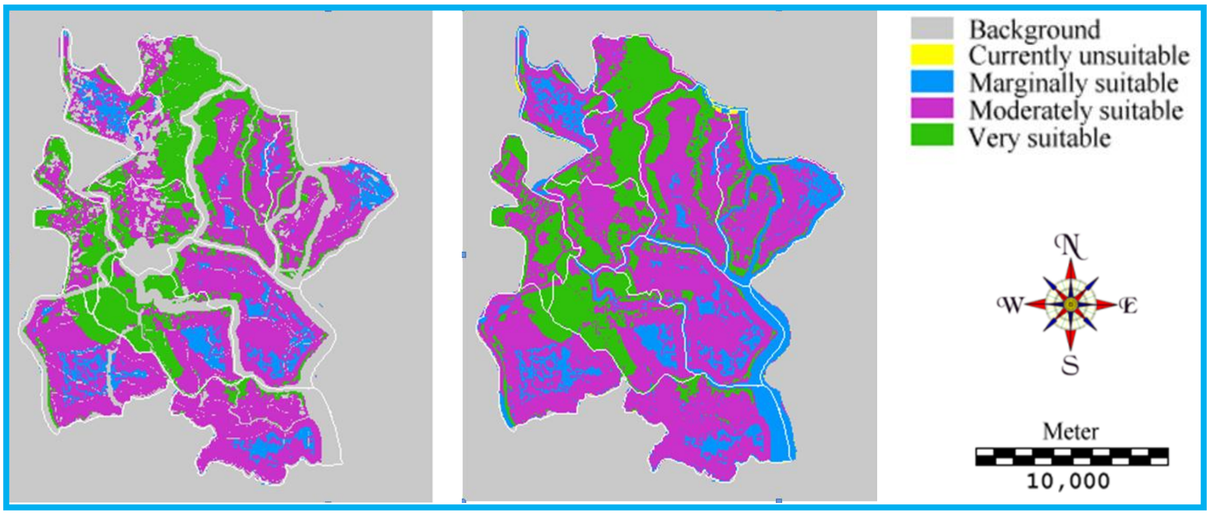

Fig. 7. Potential sites for crab culture in Paigkgachha sub-district, Bangladesh, without (right) and with (left) application of constraints.

constraint image. The image analysis clearly explained that most of the very suitable areas are situated at northwestern and southwestern part of the study area and rest of the very suitable areas are randomly dotted throughout the study area due to all or most of the facilities for crab culture are coincided there. GIS modeling has identified 8,157.49 ha very suitable landmass that covered 28.33% of the study area. On the other hand, majority of the areas (62.22%; 17,913.36 ha) are under moderately suitable category which is scattered all over the study area due to absence of some criteria there. These areas can be brought under very suitable category if those criteria can be met. There are about 2,720.60 ha (9.45%) areas are under marginally suitable those sprinkled thoroughly in the sub-district. There is currently no unsuitable area for crab culture potential in Paikgachha sub-district. Moreover, it can be mentioned here that if the constraints image (Fig. 3) is incorporated in final results then the result varied when constraints image was not considered.

4. Discussion

The crab culture potential sites cannot be verified physically as this culture practice is in rudimentary state in the area. However, GIS predicted suitable outputs were partly verified with the presence of shrimp farms in the area based on satellite image analysis and published data. The crab culture areas are increasing with the time as farmers are shifting from shrimp culture to crab culture due to high market demand, hardy nature of crab, easy to handling during culture operation comparing to shrimp, less susceptive to disease outbreak, icing and processing is not required prior to export, can export life and less competition in the international market than shrimp (Overton and Macintosh, 1997 and

Salam *et al*., 2003). The discrepancy between some of the predicted and actual shrimp farm locations was attributed to the fact that the farms have not been established using any systematic application of scientific knowledge but rather on the availability of water and the influence of neighbouring farmers. Much of the area ranked as suitable for brackish water crab culture is situated near the riverbanks in the tidal zone, ensuring easy access to saline water. However, most of these areas were only ranked as moderately suitable because lack of other facilities, presence of fresh water and lack of proper drainage facilities. Large water bodies, which contain fresh water, were not considered as potential due to low or absence of salinity. Natural forest and wildlife refuges the Sundarbans, roads, rivers, urban areas and rural settlements were also excluded from consideration for crab culture.

Agriculture, which is the traditional income source for the farmers in the region, has not yet been affected significantly by the brackish water aquaculture. By contrast, although new source of income has been created by crab culture in the region, there has been a significant reduction of livestock and poultry rearing in the coastal areas (Rahman *et al*., 1995; Khan and Hossain, 1996). It is noticeable that only one crop of shrimp or crab can be cultured in most of the land in winter as the water salinity falls to zero from June to December when upstream fresh water flows through the rivers from north to south. This is the suitable time for rice cultivation and freshwater prawn and fish production (Rahman *et al*., 1995). However, crab was an incidental crop of rice, carp, tilapia, shrimp and prawn culture in the region in all the year round (Overton and Macintosh, 1997). Salam *et al*. (2003) assessed simple economic benefit of shrimp, freshwater prawn, crab, fish and rice farming in the region and showed that rice farming scored rather poorly in comparison to the other land use activities considered. They showed that the highest financial return came from freshwater prawn followed by brackish water shrimp and crab culture from same amount of land. They also showed that the highest employment could be generated by prawn culture, followed by crab, shrimp, carp, tilapia and rice cultivation respectively. Hambrey (1996) obtained similar results in a comparative economic study of seven land use options in the mangrove areas of Indonesia. Crab culture has not been expanded that much as expected in Bangladesh and there is substantial scope for expansion as model predicted. Crab culturists could change their social and economic status easily than shrimp culturists if they follow the systematic culture procedure and intensified culture method as suggested by the scientists (Cholik and Hanafi, 1992; Overton and Macintosh, 1997). Moreover, crab culture is more environmental friendly than shrimp culture, as it can be integrated with horticulture, forestry, rice farming and polyculture with fish (Chong, 1993; Chandrasekaran and Perumal, 1993). However, at present mud crab culture is totally dependent on wild seed collection in the country. Therefore, crab hatchery establishment is very much essential to provide continuous supply of seed and protect the natural stock (Salam and Ross, 2000).

Crab culture is influenced by many aspects, including environmental, biological, physical as well as socio-economic factors (Largo and Ohno, 1993; Kingzet *et al.*, 2002). The GIS model used in this study for selecting suitable sites for crab culture potential focused on the importance of land use, infrastructure, soil quality, water sources, seed sources, market facilities and support services. Combining these parameters through GIS modeling provides appropriate investigation for decision-makers than only individual parameters alone. Hence, the most potential sites for crab culture are those where all most all the parameters coincide well.

Once crab was an incidental product of shrimp culture. However, with the disease outbreak all most every year farmers are losing their crops partly or fully and becoming helpless with the shrimp culture and gradually sifting to crab culture as these landmass are not suitable for other crop cultivation. In addition, some farmers have moved to traditional trapping and holding multi species culture with tilapia in the *gher* for their sustenance. Climate induced impact also make the farmers' livelihood vulnerable in the coastal region of the country. Hence, crab culture could be an alternative of shrimp culture in the region to overcome from disease outbreak and adaptation to climate change.

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