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GIS based aquaculture farm site suitability analysis along the coastal areas of Raigad District, Maharashtra, India

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Abstract
The beaches, mangrove swamps, intertidal areas as well as upstream areas are used for coastal aquaculture. Careful selection of environmentally suitable sites is important for the success of aquaculture. This study aimed to analyze and identify suitable sites for aquaculture in Raigad District. More closeness of ponds causes spread of disease from one pond to other very rapidly. In the study area many aquaculture farms are very close to each other and lead disease spread; finally farming had to close. Hence, the success of a fish farming project largely depends on the site selection. Therefore, to identify suitable sites, with considering the local physical conditions by using this technique is useful for the development of aquaculture. In addition, the analysis can be used as an effective tool to diversify existing clustered farms into suitable areas for the successful shrimp farming.

Keywords: Raigad, coastal aquaculture, site suitability, AHP, diversification

1. Introduction
Raigad district is one of districts of Konkan region of Maharashtra state and due to its geographical location, it has a great potential for different residential, recreational, industrial and commercial activities (District collector, Raigad Maharashtra, 2017). Brackish water fish farming cannot be practiced everywhere on the banks of the creek. Only a few locations in the study area are ideal and are best suited for fish farming. The geomorphology of the coast of Raigad district of Maharashtra influences the ingress of tidal water in the numerous creeks and estuaries of the region. The tidal range, the salinity of the water and the morphology of the intertidal zones, all these factors are site specific and create a specific estuarine environment. The field studies, it is found that the people are preferring the areas of Mhasla creek and Shriwardhan bay areas for brackish water fish farming. Therefore, an attempt was made to assess the potential and prospect of brackish water fish farming in these areas.

Presently, the rapid growth of aquaculture in unregulated manner, excessive and unwanted concentration of fish farms in a given location has been responsible for environmental problems created in the areas around aquaculture sites. Location or the selection of site is the crucial factor in all aquaculture practices, especially in the case of brackish water aquaculture. The site selection should normally be area specific considering the ecology of that region. Therefore, for the assessment of potential sites of aquaculture in the study area Analytical Hierarchy Process (AHP), developed by Saaty (1980) and Multicriteria variable technique are used in the combination. The advantage of AHP is its ability to rank the alternatives on the basis of their importance over other. Hence, it is an important technique used for site suitability analysis by following the pairwise comparison and reliable judgements.

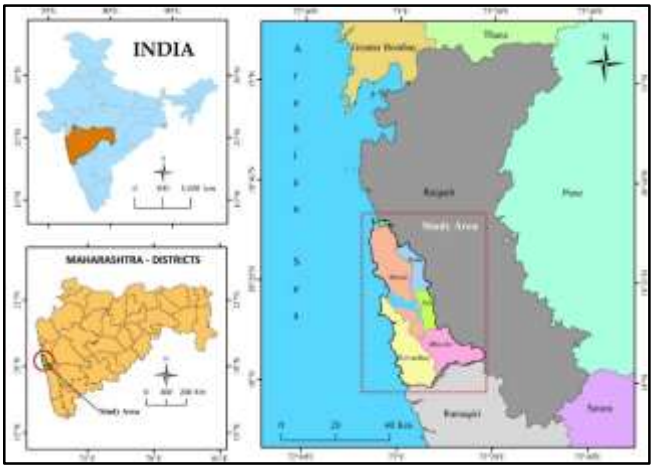
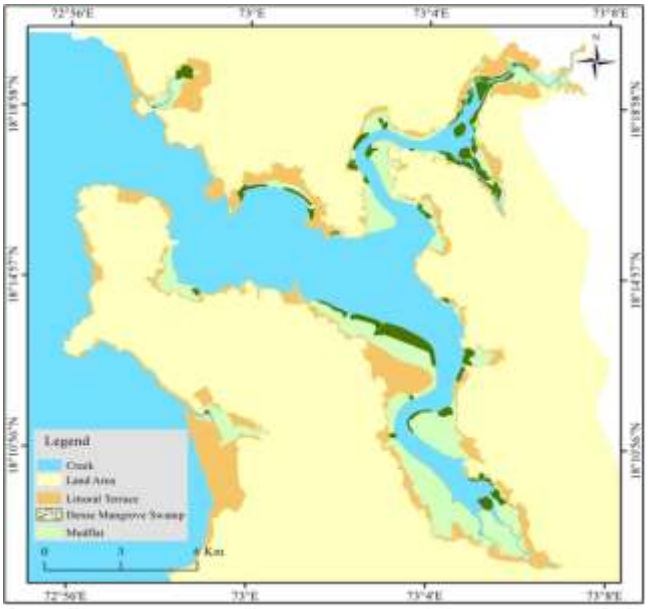


Fig 1: Location map of study area

2. Database and Methodology
The geomorphic assessment of the Mhasla creek and Shriwardhan bay area was done on the basis of field observations and satellite image analysis. It's important to get geographical information about the shoreline terraces, slope, mangrove cover and road links. For this Landsat ETM 2004, 2005 and LISS III 2010, 2011 and 2016 satellite data sets and Google earth satellite images of the year 2016 have been used. The survey of India (SOI) topographical maps 47 – B/15, 47 – F/3, 47 – F/4 with scale 1:50000 have been used. The acquired satellite images were used for the image analysis and to identify increasing aquaculture activities in the study area.

For the analysis major four criteria variables which are very much important in aquaculture has taken into consideration that are proximity to mud flats, area of mangrove cover, terrace

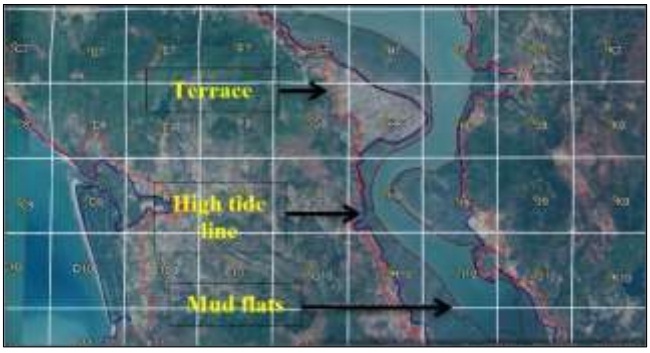
elevation below 10 meters and road links. With the help of image analysis, identification of criteria variables have been done which are selected for assigning fish farming priority to different sites along the Mhasla creek and Shriwardhan bay area.



***Source*:** Based on Landsat 8 images

Fig 2: Geomorphology of Mhasla Creek

A grid with the 2 km^2 area was superimposed on the satellite image of the area. Four major criteria variables given below were used to assign suitability count for each grid area (Fig. 3).



***Source*:** Google Earth satellite image 2015

Fig 3: Grid of AHP

Table 1: Criteria variables of AHP

Criteria 1	Proximity to mud flat
Criteria 2	Area of mangrove cover
Criteria 3	Terrace elevation below 10 m
Criteria 4	Road links

2.1 Criteria variables of AHP

a) Proximity to Mudflats (C1): - The inter-tidal mudflats are more conducive for the construction of earthen bunds of aquaculture ponds. Rectangular ponds can be easily built as little space is wasted between the ponds (Landau, 1992) [22]. The intertidal mudflats are suitable to pump the water in and to discharge it back to the sea. Areas of mudflats are calculated using high and low tide lines with the help of topographic maps and Google Earth images.

b) Area of mangrove cover (C2): - Aquaculture should not be practiced at the cost of mangroves forest because it can destroy nursery grounds for fish and prawns. Moreover, these low-lying areas will demand high reclamation costs. The area of mangrove cover has calculated by carrying out NDVI analysis. The values between 0 to 0.4 have been observed in the study area and higher values indicate higher the area of mangrove cover.

c) Terrace elevation below 10m (C3): - The flat land below 10 m elevation is found to be most suitable for the construction of ponds. The same can be demarcated from topographic maps of 1:50000 scale.

d) Road links (C4): - Facility of road links for the quick transport of farm fishes is very essential. For the analysis, in AHP the distance upto the road is measured from high tide line through Google Earth images.

2.2 AHP Methodology

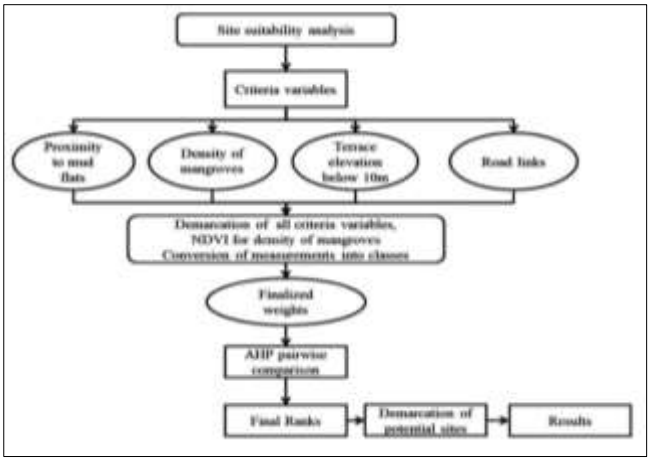


Fig 4: AHP Methodology

For the assignment of suitability count, first demarcation of high tide line, low tide line, mud flats, mangroves, terraces and road links have done with the help of Google Earth images of the year 2016. NDVI analysis is carried out and the values of the year 2016 are used to classify and map mangrove areas. Average measurement of all criteria variables of each grid has recorded and all these measurements of each criteria variable have been divided into 1 to 5 classes on the basis of minimum and maximum values as mentioned below:

Table 2: Classes of criteria variables

C1 (m)		C2 (NDVI values)		C3 (m)		C4 (km)	
5	0-300	1	0-0.1	1	0-2	1	0-0.05
4	300-600	2	0.1-0.2	2	2-4	2	0.05-0.1
3	600-900	3	0.2-0.3	3	4-6	3	0.1-0.5
2	900-1200	4	0.3-0.4	4	6-8	4	0.5-1
1	1200- > 1200			5	8-10	5	1-above

On the basis of these classes, final weights have been assigned to each grid and pairwise comparisons in AHP are performed. As per the AHP calculations, ranks have been assigned to each

criterion variables and total of the ranks of all four variables have been considered as a final rank of each grid. The same procedure has been followed for all the grid squares and the results have been validated with ground conditions during the field visits. Finally, the suitable aquaculture sites along the Mhasla creek and Shriwardhan bay area have been demarcated.

3. Results and Discussion

Type of terrain is an important factor in the selection of aquaculture sites. It is a crucial factor in brackish water aquaculture (Landau, 1992) [22].

Aquaculture farms in the study area are built in the inter-tidal and tidal flat areas of the creek or on the nearby terraces. It has been revealed from the field survey that there is a twofold increase in aquaculture sites since the year 2010. The farm owners have hardly considered the parameters of sustainable farming and to gain profit unwanted concentration of fish farms in a given location has been responsible for environmental problems created in the areas around aquaculture sites.

Selection of such sites is now possible with the use of Google Earth image of an area and the multi-criteria locational query technique and AHP. The effectiveness of site selection depends on the criteria variables used (Saaty, 1980). The criteria variables used (Table 3 and 4) and the total count 10, 9 and 8 suggests the most suitable sites for the aquaculture practices. A decrease in the response (count 8 to 1) suggests less suitability of the area for aquaculture. Further, the sites are classified on the basis of priority.

Mhasla creek and Shriwardhan bay area

Priority 1 Sites: These sites are the best sites for aquaculture and fulfil all the requirements designed by criteria variables. Count 10 sites are included in this category. The sites are located on the supra tidal flats, mainly on the southern and eastern banks of the creek. Along Mhasla creek out of 57 sites, 18 aquaculture sites (31.58%) (Table 3, 4 and Fig. 5, 6) and in Shriwardhan bay area out of 23 sites, 7 aquaculture sites (30.43%) are included in this category.

Priority 2 Sites: The sites with count 9 are included in this category. These are most frequent in both of the areas. The location of such sites is on the narrow terraces bordering the creek and also in mangrove areas. Along Mhasla creek out of 57 sites, 36 aquaculture sites (63.16%) (Table 3, 4 and Fig. 5, 6) and in Shriwardhan bay area out of 23 sites, 12 aquaculture sites (52.17%) are included in this category.

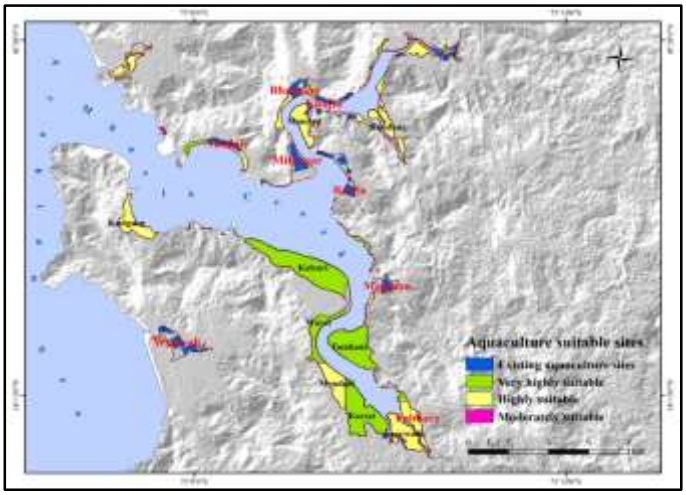
Priority 3 Sites: Most of the sites with count 8 are included in this type. These sites have narrow mudflats, covered by mangroves but can be used for aquaculture, by properly maintaining the salinity and temperature of the pond water. Along Mhasla creek out of 57 sites, 3 aquaculture sites (5.26%) (Table 3, 4 and Fig. 5, 6) and in Shriwardhan bay area out of 23 sites, 4 aquaculture sites (17.39%) are included in this category.

Table 3: Suitability count of Mhasla creek

Criteria	Total Rank	Priority	Total count	Area %
Very highly suitable	10	1	18	31.58%
Highly suitable	9	2	36	63.16%
Moderately suitable	8	3	3	5.26%

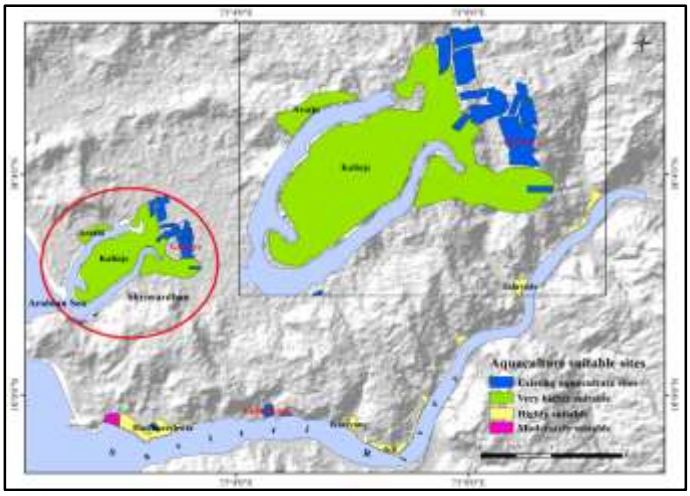
Table 4: Suitability count of Shriwardhan Bay area

Criteria	Total Rank	Priority	Total count	Area %
Very highly suitable	10	1	7	30.43%
Highly suitable	9	2	12	52.17%
Moderately suitable	8	3	4	17.39%



***Source*:** ASTER DEM and Field work

Fig 5: Aquaculture suitable sites of Mhasla creek



***Source*:** ASTER DEM and Field work

Fig 6: Aquaculture suitable sites of Shriwardhan Bay area

4. Conclusion

The multicriteria, locational query technique with AHP could be used effectively for the selection of aquaculture sites. It is found that, the computer assisted image analysis and AHP technique have many advantages over conventional methods.

The identification of criterion variables is easier on the Google Earth images. Various terrain details could be identified, separated, mapped and confirmed in the field afterwards. The site selection which is a crucial factor in aquaculture was best achieved by using these methods combinely. It also helped in assigning the priority counts to the sites.

Aquaculture is terrain sensitive activity which requires mainly mud flats, estuary location, terrace elevation below 10m, no or sparse mangroves and road links. There are potential sites on the western bank of the Mhasla creek; if the mangrove areas are

reclaimed then replantation of mangroves should be done in the suitable areas of mangroves. On the eastern bank of the Mhasla creek many sites are very close to each other. To avoid disease spread, aquaculture with sustainable farming methods can be diversified on western bank of the creek.

On the basis of this analysis, it is suggested that, the Mhasla creek area has a great potential (Fig. 5) than the Shriwardhan bay area (Fig. 6) for its development as a brackish water aquaculture centre in Raigad District.

5. Acknowledgement

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6. References

1. Andrew P. Economics of Brackish water Shrimp Culture. Daya Publishing House, Delhi, 1999, 134.
2. Boyd CE, Fast AW. Pond monitoring and management, In: Marine Shrimps culture, problems and prospects A.W. Fast and I. Lesher (Eds.), Elsevier Pub, 1992, Pp. 497-568.
3. Canter Larry W. Environmental Impact Assessment, Second edition, McGraw Hill Publishing Company, Inc., New York, 1996.
4. Carter RWG. Coastal environments, Academic press, London, 1988, Pp. 1-617.
5. Central Marine Fisheries Research Institute, (CMFRI) Report. Environmental Impact Assessment in the shrimp farming areas of Nagapattinam district', Tamil Nadu, ICAR, Kochi, 1995.
6. Chua TE. 'Coastal aquaculture development and the environment', In: marine pollution. Bull. 1992; 25(1-4):98-103.
7. Clark RB. 'Marine Pollution', Clanedon Press., Oxford Science Publications, Oxford1986, Pp. 185-215.
8. Clay JW. 'Towards sustainable aquaculture', Journal of World Aquaculture. 1997; 28(3):32-37.
9. De SP. 'Impacts of Waterbodies and aquaculture on the environment', In: Impacts of Environment an animals and aquaculture', Manna, G.K. Jana, B.B. (Eds), 1990, Pp. 323-326.
10. Dikshit K. Forests of Maharashtra, In: J. Diddee, S.R. Jog, V. S.Kale, V. S. Datye, (Edt.), Geography of Maharashtra, Rawat publications, Jaipur, 2002, Pp. 120-133.
11. Egna S, Boyd CE. 'Dynamics of and Aquaculture' Egna S. and Boyd C.E. (Eds.) Auburn University Alabama, C.R.C Press Boca, Raton New York, 1997, Pp. 53-69.
12. FAO. The State of World Fisheries and Aquaculture, FAO Fisheries and Aquaculture, Food and Agriculture Organization of The United Nations, Rome, Italy, 2010.
13. Frankic A, Hershner C. Sustainable aquaculture: developing the promise of aquaculture, Aquaculture International, 2003; 11:517-530.
14. GESAMP. 'Reducing environmental impact of coastal aquaculture', Rep. Home. Italy. FAO, 1991; 47:1-35.
15. Gowan RJ, Rosenthal H, Maekinen T, Ezzi I. 'Environmental impact of aquaculture activities', In: Business - Joins - Science, Depauw, N. Billards R. (Eds.), 1990; 12:257-283.
16. Iwama G. 'Interactions between aquaculture and the environments', Critical Review in Environ. Contr, 1991; 21:177-216.
17. Jog S, Wakhare A, Choudhari S, Unde M, Pardeshi S. Maharashtra Landscape: A perspective, In: Deddee J Jog S. Kale V. Datye V. (Edt.) Geography of Maharashtra, Rawat Publications, Jaipur, 2002, Pp. 19-57.
18. Kale V. Tertiary and Quaternary Geology of the Deccan Traps of Maharashtra. India, In: J. Diddee, S.R. Jog, V. S.Kale, V. S. Datye, (Edt.), Geography of Maharashtra, Rawat publications, Jaipur, 2002, Pp. 3-18.
19. Karlekar SN. Coastal geomorphology of India, Diamond publications, 2017, Pp. 1-158.
20. Klee G. The Coastal Environment, Prentice Hall, New Jersey, 1999, Pp. 1-245.
21. Kutty MN. 'Aquaculture development in India from a global perspective', J Current Science. 1999; 76(3):333-340.
22. Landau M. Introduction to aquaculture, John Wiley and Sons, 1992, Pp. 3-38.
23. Mimura N. 'The rapidly changing environment of the Asia and Pacific region and its implications for sustainability of coastal zones' in Asia-Pacific coasts and their management in states of environment, Springer, Netherlands, 2008; 11:340-360.
24. Preston NP, Burford M, Jackson. 'Sustainable shrimp farming in Australia', In: proceed of the Paeon, Conf. on Sustainable Aquaculture, 1997, Pp. 308-316.
25. Priyanto A. 'The impact of human activities on coastal zones and strategies towards sustainable development, a case study in Pekalongan, Indonesia'. International institute for Geo-information science and Earth observation, 2010, Pp. 4-99.
26. Raja R Pramiladevi. Impact of aquaculture on coastal environment, PhD thesis, Anna University, Chennai, 2000.
27. Survey of the environment. The Hindu publication, 1998, Pp. 29.
28. The state of world fisheries and aquaculture report, 2016. Retrieved from http://www.fao.org/3/a-i5555e.pdf dated Feb.2017.