Cloud Publications
International Journal of Advanced Remote Sensing and GIS
2014, Volume 3, Issue 1, pp. 669-680, Article ID Tech-274
ISSN 2320 - 0243

Research Article | Open Access

Study on Potential Application of Geographic Information Systems (GIS) to find out Suitable Aquaculture Site in Pune - Maharashtra, India

Raushan Kumar Raman[1, 2] and Nikunj B. Gajera[2]

[1]Symbiosis Institute of Geoinformatics, Pune, Maharashtra, India
[1, 2]Gujarat Institute of Desert Ecology, Bhuj, Gujarat, India

Correspondence should be addressed to Raushan Kumar Raman, ramankt@gmail.com; gajeranikunj@gmail.com

Publication Date: 4 August 2014

Article Link: http://technical.cloud-journals.com/index.php/IJARSG/article/view/Tech-274

Abstract GIS and remote-sensing provides better options for managing resources and enhancing the productivity. This study is carried out to access the optimum Aqua farming or Aquaculture sites in Pune area. Using the different essential parameters for selecting sites provides the optimum sites in the project area that will help Aqua farmers and results in overall progress in Business. The present study has predicted that about 0.25% (64.22453 ha) of the total land area of Pune city are optimum aqua sites with availability of market and better network connections. Pune has fresh water sources that leads to huge production of fishes and will also contribute profits for aqua farmers. The implementation of GIS technologies in finding suitable site for aquaculture will give a great result in the market productions and profits. Rivers channels and Road networks analysis is the two important factors for selecting the Aqua sites. The analysis is done using LISS-III satellite imagery and aster image. The methodology adopted is based on standard scientific processes. Weighted overlay technique is used in order to frame the exact model surface buildup criteria for the optimum sites throughout the project area.
Keywords *Aquaculture; Weighted Overlay; GIS; Model; LISS-III; Aster*

1. Introduction

GIS and Remote-Sensing is such a technology that caters the solutions systematically and gives optimum solution scientifically considering time, quality and risk factors. The increasing population requires much food today to sustain. Hence Aquaculture will provide add on to the increasing food demand.

Aquaculture means the farming of aquatic organisms like fish, aquatic plants etc. It includes cultivation of fresh and salt water populations under controlled conditions [1]. Mostly the aquaculture producers also farms ornamental fish for the aquarium trade, and growing plant species used in a range of food,

pharmaceutical, nutritional, and biotechnology products. Aqua farming or Aquaculture has a potential to create huge job opportunities, and food.

There are mainly two types of aquaculture i.e. Marine aquaculture and Fresh water aquaculture. Marine aquaculture includes farming of species especially lives in the ocean while Fresh water aquaculture includes farming of species which is found in rivers, channels, lakes especially on land water bodies or man-made aquaculture structures.

GIS and Remote-Sensing technology will give the proper solution for the site suitability for aquaculture. It includes the parameters containing road network, rivers, channels, streams etc. Aquaculture depends upon the market availability for selling fish and other essential conditions for survival of aquatic organisms. The analysis of the proper site will result in better productivity and also good for business.

India is a large producer of inland fish, ranking next only to Japan. Pune city is the seventh largest metropolis in India, the second largest in the state of Maharashtra.

For, the city like Pune there is big demand of food in the market and aqua farming will provide better options for food.

Fish culture in ponds and reservoirs were contributing above 60% of the overall inland fish production i.e. over 3.6 million metric tons per year [2]. There are two types of ponds i.e. seasonal and perennial. Seasonal ponds can retain water for at least four to five months and used for short term fish culture and also easy to harvest fish while perennial ponds can be used since water dries up and that are suited for fish culture on a larger scale. Therefore, finding suitable sites through GIS and remote-sensing provides the overall analysis for finding suitable aquaculture sites in the study area.

1.1. Standards for this Project

For identifying suitable sites for the aquaculture we consider certain standard parameters i.e. Pond shape and size, water resources nearby aquaculture site, best suited road networking from aquaculture site to market, good soil (Clay soil) and suitable water quality that more appropriate to sustain and better yields [3].

1.2. Objectives

- Demarcation of important zones in Pune
- Suitable Aquaculture site selection

1.3. Study Area

Pune City Coordinates: 18°28′25″N 73°47′52″E

Pune City is located in Pune district of the State Maharashtra, India. It is having urban Population of 6,226,959 as per census 2011. It is one of the greenest urban areas in India. The climate of Pune is temperate and it is mainly having summer, monsoon and winter season. It is also one of the greenest urban areas in the country. The city is surrounded by hills. The availability of water sources like small ponds and river streams of Bhima River adds on different landscapes throughout the city. Further, details about location and selected study area are given in Figure 1 and Table 1.

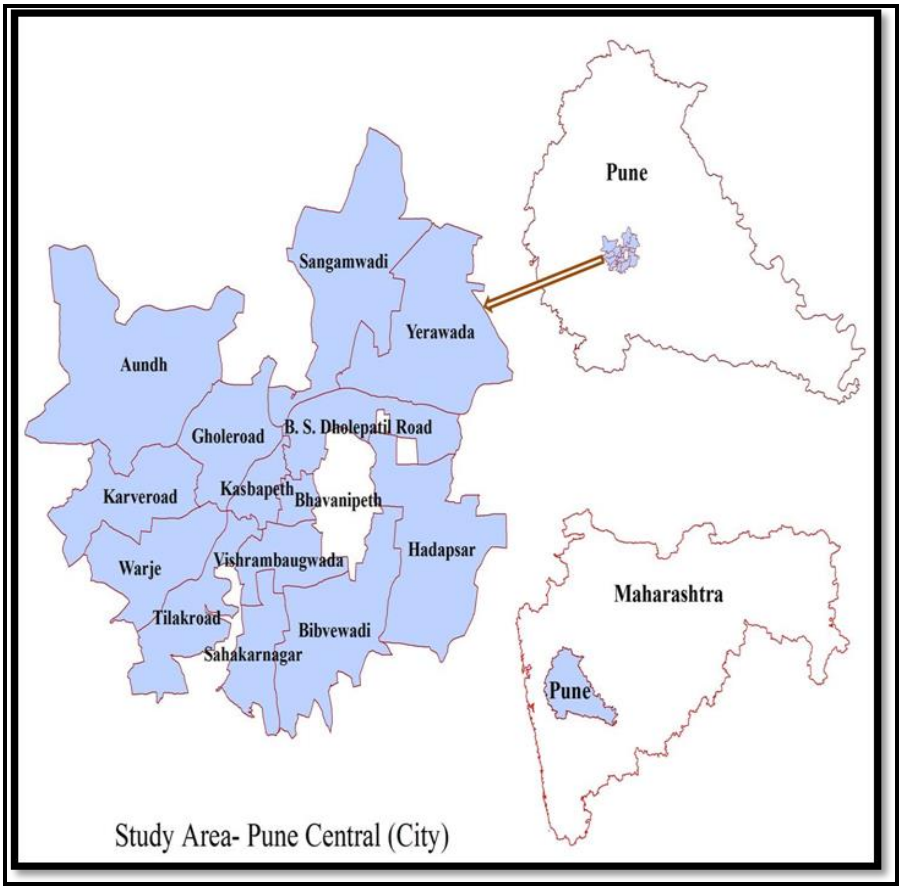


Figure 1: *Study Area Map*

Table 1: *Selected Wards for Suitable Aquaculture Site Selection in the Study Area*

Ward_Name	Area (Ha.)
Karveroad	1555.557462
Hadapsar	2690.746743
Gholeroad	1370.463265
B. S. Dholepatil Road	1323.417779
Bibvewadi	2279.945151
Bhavanipeth	281.079216
Aundh	4096.801666
Yerawada	2916.341831
Warje	1488.54416
Vishrambaugwada	861.35269
Tilakroad	1425.49164
Sangamwadi	3107.406085
Sahakarnagar	926.059662
Kasbapeth	459.559352
Total Area (Ha.)	24782.7667

1.4. Materials

Data: Linear Imaging Self Scanning System (LISS-III), No. of Spectral bands = 4, Spatial Resolution = 23.5 m, Roads Shapefile, River Shapefile, Hillshade and Slope data, Pune Aster Image.
Software's used for Analysis: ArcGIS 9.3.1, Erdas Imagine 9.1.

1.5. Methodology

The main theme for this project is to find the optimum sites in the Pune city for developing aquaculture in the area. The GIS concepts are applied for the basic of projects and the remote-sensing techniques are used for better calibration of data and result generation [3, 4].

2. Satellite Data Processing

First the layer stacking is done using Erdas and then atmospheric correction is made using actor extension of Erdas. After that the classification is performed using supervised technique by taking areas of interest based on signature files for making classes out of pixel values. For classifying different features the NDVI (Normalized Differential Vegetative Index) is used for vegetation mapping of the study area [5, 6, 7, 8].

$$NDVI = (NIR — Red) / (NIR + Red) \quad (i)$$

Where NIR stands for Near Infrared Region

Calculations of NDVI for a particular pixel always result in a number that ranges between one (-1 to +1) where the zero means no vegetation and close to (+1) indicates the highest possible density of green leaves.

The validation is done using ground control points and accuracy assessment is performed for final supervised classified imagery.

3. Data Merging Interpretation and Model Making

Non-spatial Data and Spatial Data is calibrated and based on the model parameters the data in used for further Process [9, 10, 11]. The methodology for making model is on satellite process using GIS and remote-sensing software's and finding suitable site for aquaculture depends upon weighted overlay. In weighted overlay, the maximum value is given to water and wasteland (Figures A & B).

3.1. Detailed Methodology Flow Chart

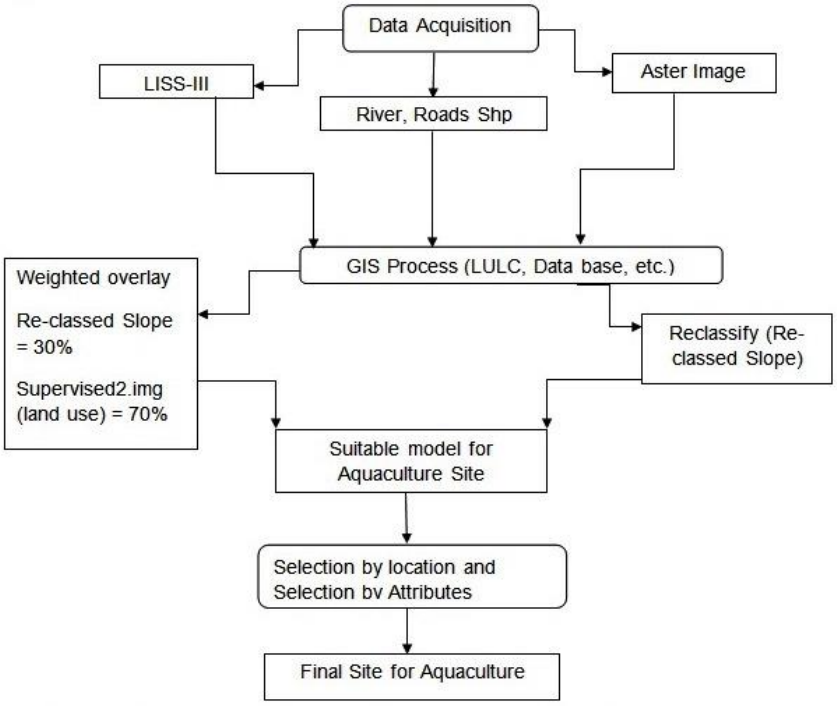


Figure A: *Methodology Flow Chart*

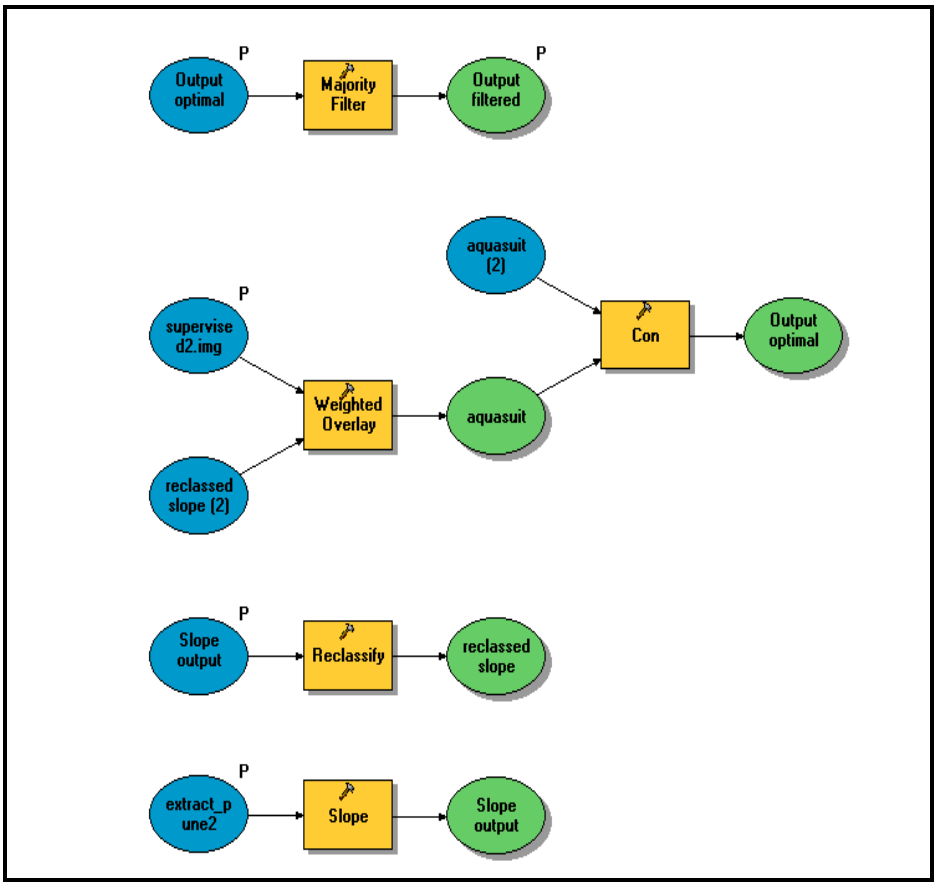


Figure B: *Aquaculture Site Model Process*

This is the final model for Aquaculture Site with different model parameters developed during study. The P stands for model parameter. The model making system involves the majority filter technique, weighted overlay and conditional probability for finding potential sites.

4. Results and Discussion

Scientifically, the study carried out using GIS and Remote-Sensing technique. The different parameters like water for site buildup, proper road network for market availability, river streams for fresh water etc., is considered for the model making and finding suitable site for the project [12, 13, 14] (Figures 2 & 3).

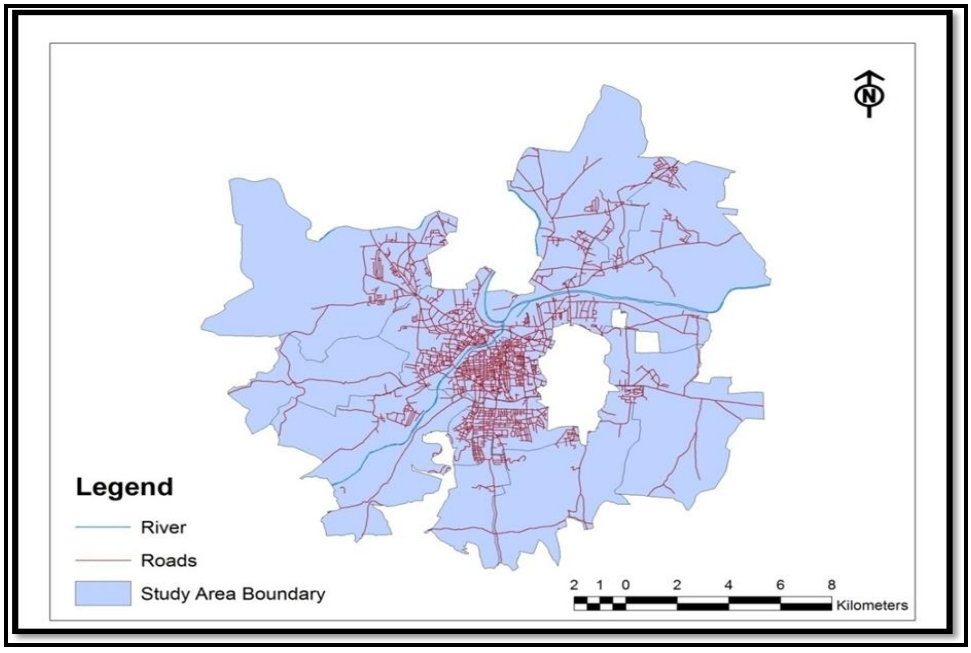


Figure 2: *Shape File Integrated Study Area Map*

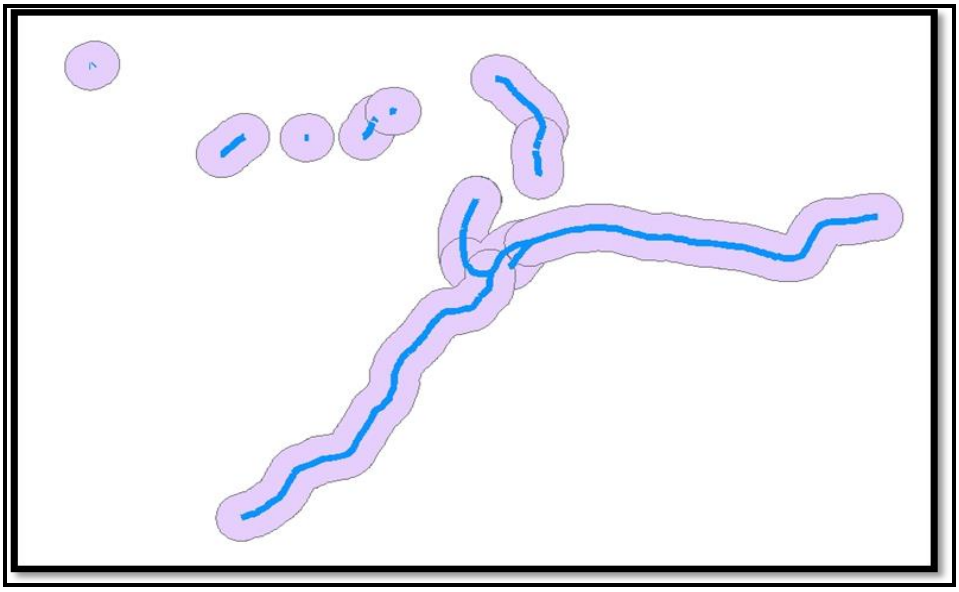


Figure 3*: River Buffer Shape File*

Integration of data: the satellite imagery of Pune (LISS-III), Aster Images, shape files into geo-database resulted in baseline of the study. Supervised classification is performed based on the priori knowledge and the process is carried out in Erdas Imagine software by taking different pixel values for classes like Agriculture, Vegetation, Plantation, Water, Urban, Shrub and Wasteland [15, 16, 17]. (Figure 4).

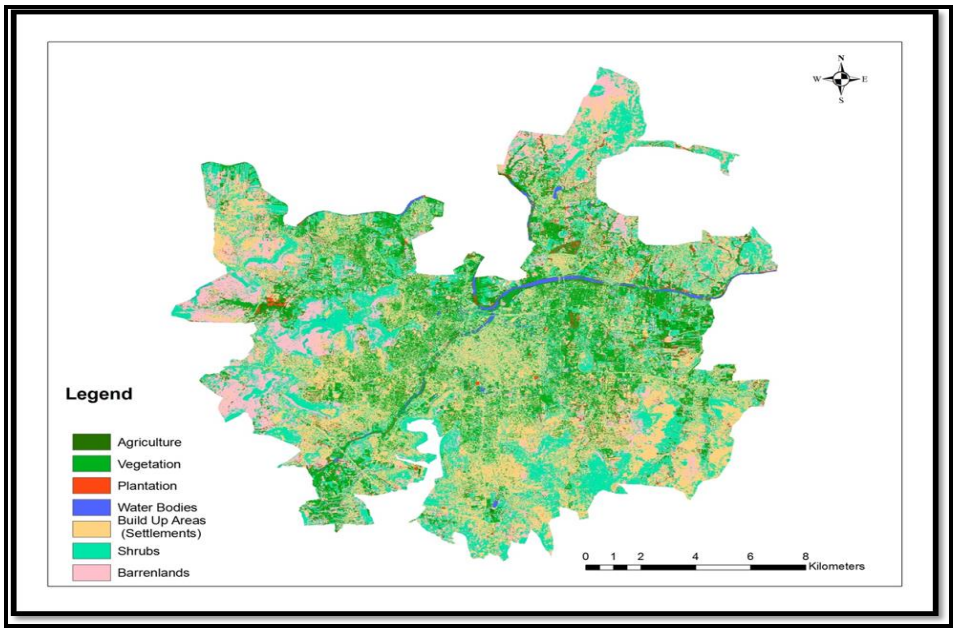


***Figure 4**: Supervised Map*

The use of overlay method includes the weighted mechanism where the individual classes are having different weightage. Further the model is framed based on the weighted overlay method, where Water is given maximum weightage for aquaculture site selection. As the water is the necessity for setting the Aqua- farming.

The River Buffer created for the water availability and the analysis is done during the study for the essential conditions for Fresh water Fish breeding and other aquatic organisms (Figure 5 (a & b), 6, 7, 8).

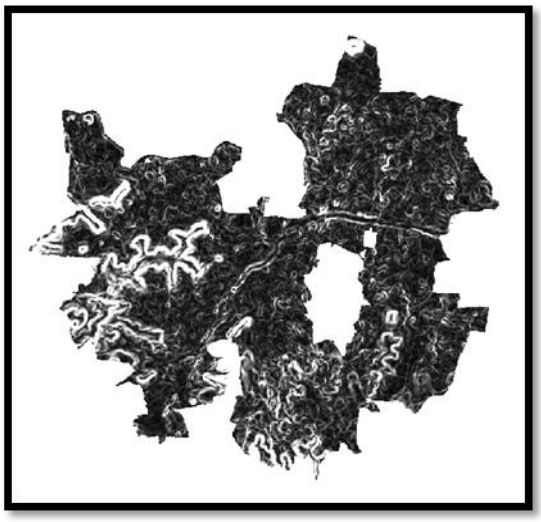


***Figure 5 (a):** Aster Slope of the Study Area*

***Figure 5 (b):** Reclassed Slope*

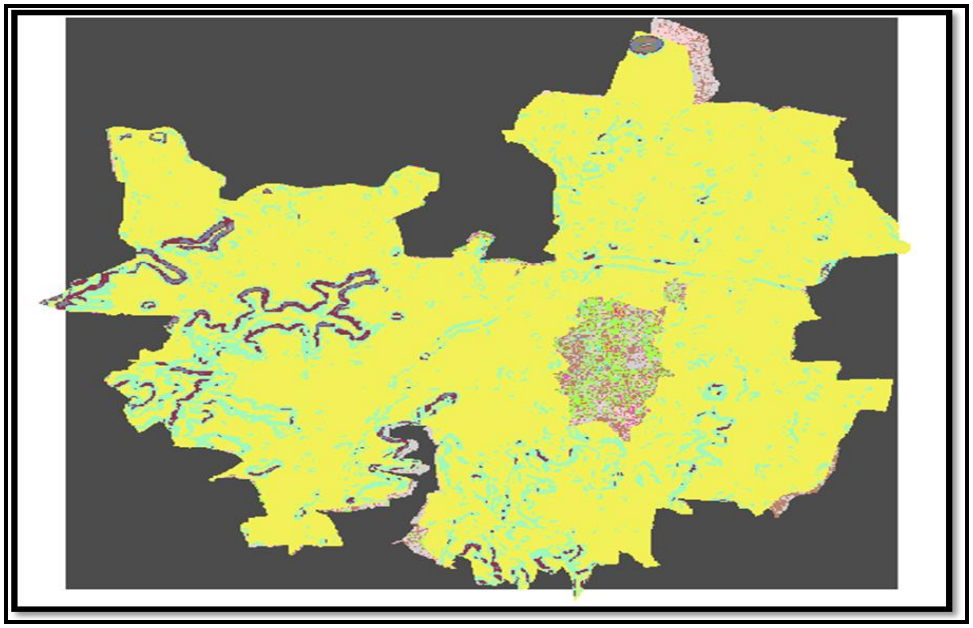


Figure 6: *Re-Classed Slope Pattern*

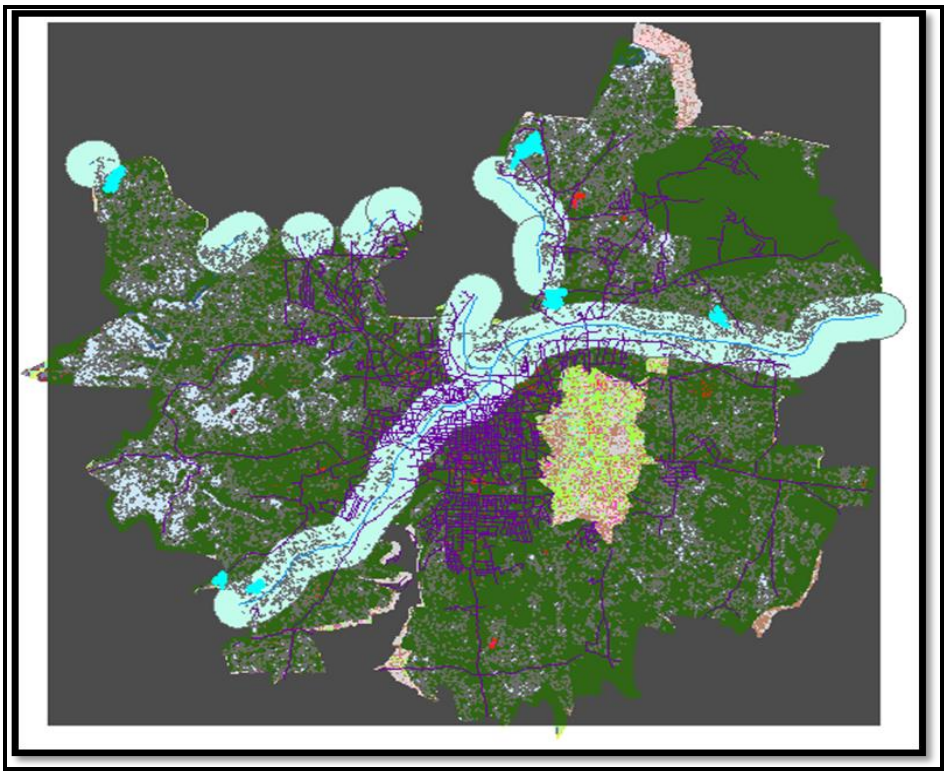


Figure 7*: Final Site for Aquaculture Cyan Spot Including Buffer Area around Rivers*

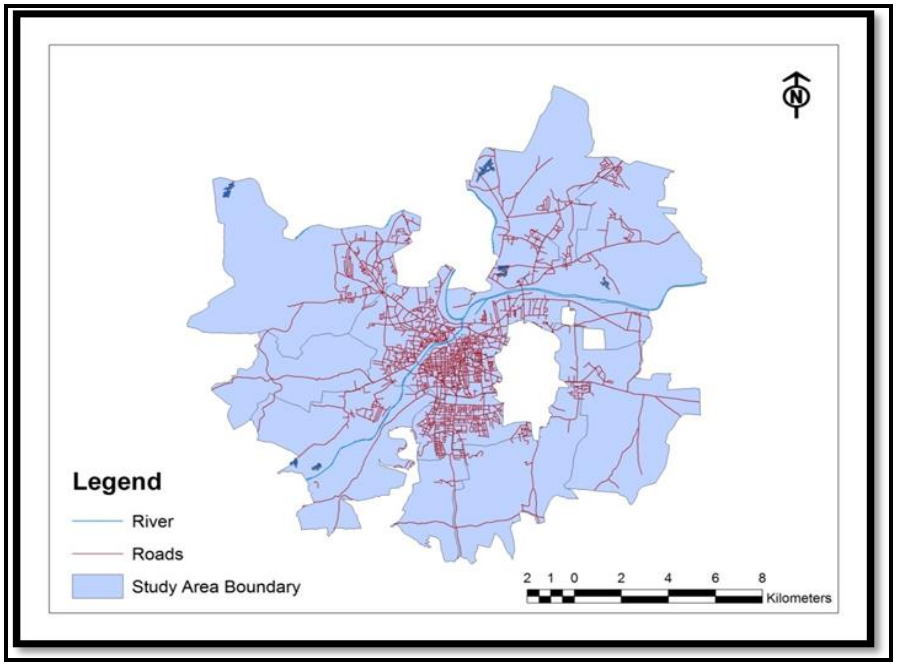
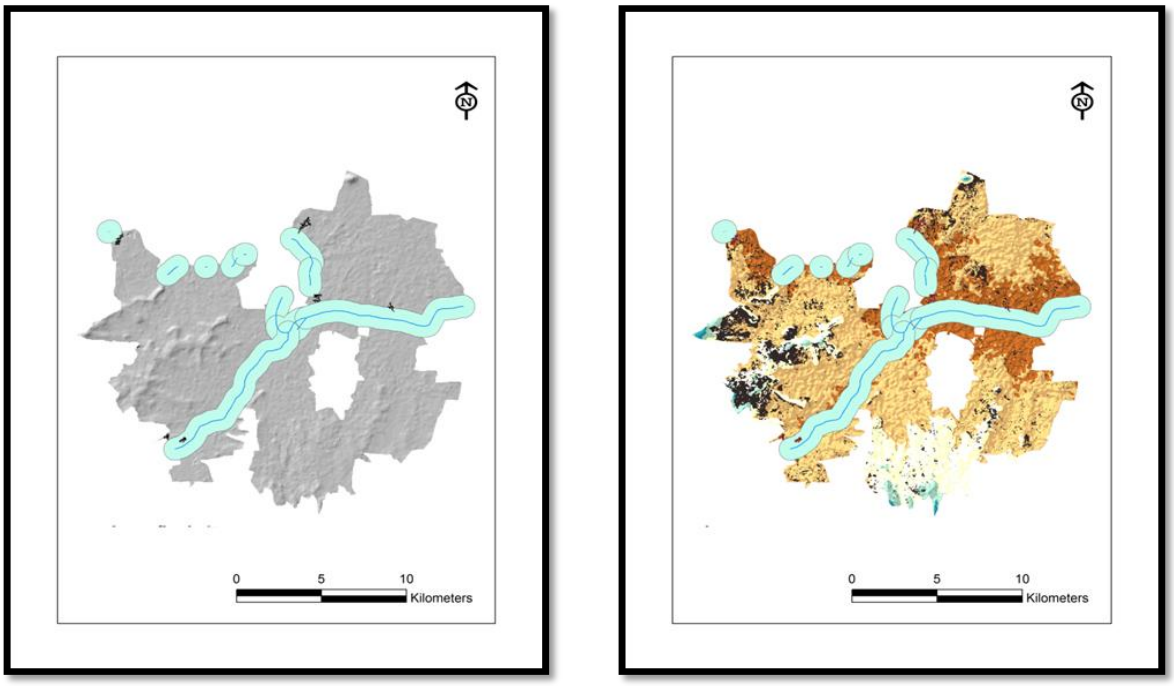


Figure 8: *Suitable Aqua Farming Site with Roads and Rivers*

The final suitable site for aquaculture in Pune city area is shown in the developed model. Basically the model gives us the exact place with site specific area where aqua farming will be highly suitable and yields maximum output [18, 19] (Table 2) (Figure 9 (a & b), 10). Since the model helps finds the optimum locations throughout the area for setting the aqua farming sites. It will improve the productivity as well as options for future.



(a) **(b)**

Figure 9 (a): *Potential Aqua Sites with River Buffer Shapefile on Hill shade Image*
Figure 9 (b): *Potential Aqua Sites with River Buffer Shapefile on Reclassed Slope Image*

Land use/Land Cover (LULC) defines landscape patterns. Land use is typically defined as human modifications land as agriculture land, infrastructural development etc [20, 21]. While land cover is natural like forest, hills etc. Land use is constrained by environmental factors like climate, topography, soil characteristics etc. Supervised classification is used in the study based on prior knowledge.

Table 2: *Final Aquaculture Site with Area*

Aqua Site_ FID with Ward Name	Area in Hectares
P - Sangamwadi	19.95246792
Q - Aundh	12.30836041
R - Sangamwadi	13.02339584
S - Yerawada	6.471747332
T - Warje	6.123757878
U - Warje	6.34479615

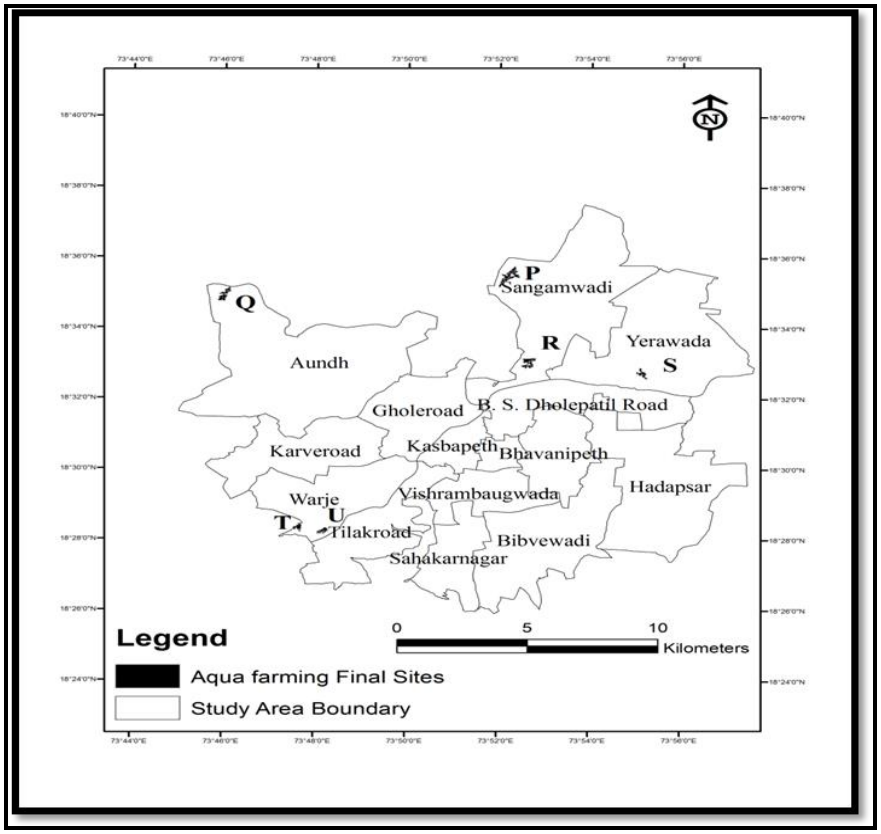


Figure 10: *Suitable Aqua Farming Site*

5. Conclusion

Latest GIS and remote sensing technique allows users to integrate spatial as well as non-spatial information to model the current scenario of the study concerned. So, it is expected that during the aquaculture development process the near water body area is much suitable for the aquaculture result to optimum production in fish marked which helps farmers for net benefits. The present study also focuses on the different parameters for a suitable aquaculture site with the ease of routing patterns based on network analysis. If model will be implemented than it is sure that one can achieve good result in terms of production and market.

Acknowledgement

The authors acknowledge special thanks to Director and Add. Director (Gujarat Institute of Desert Ecology). We also expresses thanks to Director Symbiosis Institute of Geoinformatics, Pune and also thankful to friends and staffs of Symbiosis Institute of Geoinformatics. We are also expresses thanks to entire Scientists and Scholars of Gujarat Institute of Desert Ecology, Bhuj for their support.

References

[1] Raj Chandar and Karuppasamy. *Marine Fishery Information System and Aquaculture Site Selection Using Remote Sensing and GIS*. International Journal of Advanced Remote Sensing and GIS. 2012. 1 (1) 20-33.

[2] Pounraj and T., Rathakrishnan. *Adoption Behaviour of Fish Farmers in Critical Inland Fish Culture Technologies in Tamil Nadu.* Madras Agric. J. 2011. 98 (7-9) 286-290.

[3] R., Ramesh and R., Rajkumar. *Coastal Aquaculture Site Selection and Planning in Tamilnadu Using Remote-Sensing and GIS*. Asian Pacific Remote Sensing and GIS Journal. 1996. 9; 39-49.

[4] Peter C., Longdill, Terry, R., Healy and Kerry, P., Black. *An Integrated GIS Approach for Sustainable Aquaculture Management Area Site Selection. Ocean & Coastal Management*. 2008. 51; 612-624.

[5] Zainul Hidayah. *Application of GIS for Assessing Prawn Farm Development in Tully-Cardwell, North Queensland.* Jurnal Kelautan. 4 (2) 62-67.

[6] Nyoman Radiarta, Sei-Ichi Saitoh and Akira Miyazono. GIS-Based Multi-Criteria Evaluation Models for Identifying Suitable Sites for Japanese Scallop (Mizuhopecten Yessoensis) Aquaculture in Funka Bay, Southwestern Hokkaido, Japan. Aquaculture. 2008. 284; 127-135.

[7] C., Silva, J.G., Ferreira, S.B., Bricker, T.A., DelValls, M.L., Martín-Díaz and E., Yáñez. *Site Selection for Shellfish Aquaculture by Means of GIS and Farm-Scale Models, with an Emphasis on Data-Poor Environments*. Aquaculture. 2011. 1-14.

[8] W., Brian Szuster and Hatim Albasri. *Site Selection for Grouper Mariculture in Indonesia*. International Journal of Fisheries and Aquaculture. 2010. 2 (3) 87-92.

[9] Reyahi Khoram, Shariat, Moharamnejad, Azar and Mahjub. *Ecological Capability Evaluation for Aquaculture Activities by GIS.* Iran. J. Environ. Health. Sci. Eng. 2005. 2 (3) 183-188.

[10] Brian W., Szuster and Hatim Albasri. *Mariculture and Marine Spatial Planning: Integrating Local Ecological Knowledge at Kaledupa Island, Indonesia*. Island Studies Journal. 2010. 5 (2) 237-250.

[11] M., Abdus Salama, Lindsay G., Ross and C.M., Malcolm Beveridge. *A Comparison of Development Opportunities for Crab and Shrimp Aquaculture in Southwestern Bangladesh, Using GIS Modeling*. Aquaculture. 2003. 220; 477-494.

[12] P., Mahalakshmi, N., Kalaimani, M., Krishnan and T., Ravisankar. *Use of Information Technology in Aquaculture Research and Management*. Fishing chimes. 2004. 24 (9) 50-53.

[13] R., Sivakumar, Mrs. A.M., Kiruthika and S., Suresh Babu. *Remote Sensing and GIS Application in Brackish Aquaculture in Northern Part of Andhra Pradesh from Srikakulam to West Godavari.* International Journal of P2P Network Trends and Technology. 2012. 2 (2) 42-49.

[14] K., Nageswara Rao, G., Murali Krishna, D., Ramprasad Naik and B., Hema Malini. *Remote Sensing and GIS Applications in the Identification of Aquaculture Hotspots at Village Level*. Journal of the Indian Society of Remote Sensing. 2003. 31 (2) 71-80.

[15] P., Mynar Babu, G., Jai Sankar and V., Sreenivasulu. Impacts of Aquaculture on Water Resources Utilization and Land Resources of Krishna District Using With Remote Sensing and GIS Techniques. International Journal of Engineering Trends and Technology (IJETT). 2013. 4 (7) 3201-3206.

[16] I., Nyoman Radiarta, Sei-Ichi Saitoh and Hajime Yasui. *Aquaculture Site Selection for Japanese Kelp (Laminaria Japonica) in Southern Hokkaido, Japan, Using Satellite Remote Sensing and GIS-Based Models*. ICES Journal of Marine Science. 68 (4) 773-780.

[17] R., Filgueira, J., Grant, R., Stuart and M.S., Brown. Ecosystem *Modeling for Ecosystem-Based Management of Bivalve Aquaculture Sites in Data-Poor Environments.* Aquaculture Environ Interact 2013. 4; 117-133.

[18] M., Shadat Hossain, Nani Gopal Das. *GIS-Based Multi-Criteria Evaluation to Land Suitability Modelling for Giant Prawn (Macrobrachium Rosenbergii) Farming in Companigonj Upazila of Noakhali, Bangladesh*. Journal Computers and Electronics in Agriculture. 2010. 70 (1) 172-186.

[19] Claudio Silva, Maria A., Barbieri, Eleuterio Yanez, Juan C., and Tomas Angel DelValls. *Using Indicators and Models for an Ecosystem Approach to Fisheries and Aquaculture Management: The Anchovy Fishery and Pacific Oyster Culture In Chile: Case Studies.* Lat. Am. J. Aquat. Res. 2012. 40 (4) 12 955-969.

[20] Rumana Yasmin, Mehady Islam and Md. Jobaer Alam. *A Study on Potential Application of Geographic Information Systems (GIS) in Fisheries and Aquaculture of Bangladesh*. World Journal of Fish and Marine Sciences. 2012. 4 (6) 609-619.

[21] Abdulaziz Guneroglu, Ercan Kose, Coskun Eruz, Ersan Basar, Sebnem Erkebay and Fevzi Karsli. *Use of Geographic Information System to Select Fish Cage Farming Sites in Surmene Bay, Black Sea*. The Israeli Journal of Aquaculture–Bamidgeh. 2005. 57 (2) 81-89.