CIBA Technology Series - 4

Identification of Potential Brackishwater Aquaculture Areas Using Remote Sensing and Geographical Information System

केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिशद)

75, सन्थोम हाई रोड, राजा अण्णामलैपुरम, चेन्नई – 600 028

Central Institute of Brackishwater Aquaculture

(Indian Council of Agricultural Research)

75, Santhome High Road, R.A.Puram, Chennai - 600 028

1

2

1. IRS LISS III Image of Upputeru, Nellore District.
2. Shrimp farm.

Identification of Potential Brackishwater Aquaculture Areas Using Remote Sensing and Geographical Information System

M. Jayanthi
P. Ravichandran, A.G. Ponniah, M. Muralidhar and P. Nilarekha

March 2010

केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)
75, सन्थोम हाई रोड, राजा अण्णामलैपुरम, चेन्नई – 600 028

Central Institute of Brackishwater Aquaculture
(Indian Council of Agricultural Research)
75, Santhome High Road, R.A.Puram, Chennai - 600 028

Published by : Dr. A.G. Ponniah
Director, CIBA

Edited by : Dr. S.M. Pillai
Dr. Shiranee Periera

Background

Increasing health consciousness of the growing global population has increased the demand for aquatic foods. As the capture fishery production is stagnating, aquaculture is seen as the alternative to bridge the widening gap in demand and supply. In recent years, aquaculture has become the world's largest food industry with the annual growth rate of 10-15 %. This rapid growth has raised some environmental concerns such as conversion of important coastal ecosystems like lakes, mangroves and agricultural lands to aquaculture farms and salinisation of soil and drinking water resources adjacent to aquaculture farms. These environmental issues have raised questions about the sustainability of shrimp farming and unless these concerns are addressed, further growth in brackishwater aquaculture will not be possible.

Importance and Necessity

India with a coastal length of 8118 km has vast resources for mariculture and brackishwater aquaculture. Brackishwater farming had its origin in age-old systems confined mainly to the *bheries* (manmade impoundments in coastal wetlands) of West Bengal and *pokkali* (salt resistant deepwater paddy) fields along the Kerala coast. Shrimp aquaculture was started in late eighties and has grown tremendously by utilizing around 1,75,000 ha of coastal land in India. The rapid growth of brackishwater aquaculture was due to the combined effects of scientific farming, creation of infrastructure facilities and changing consumer preferences due to the increasing awareness of healthy foods.

The shrimp farming areas are mainly located in the coastal states of Andhra Pradesh, West Bengal, Kerala, Orissa, Tamil Nadu, Karnataka, Maharashtra, Gujarat and Goa. The giant tiger shrimp *(Penaeus monodon)*, continues to be the leading cultured species. Out of the total

3.5 million ha brackishwater area available, 1.20 million ha is said to have the potential for development of brackishwater aquaculture. Of this, 25 % in the East coast and 4 % in the West coast was developed. As a whole, only around 15% has been developed into brackishwater aquaculture which includes 4% of traditional farming in West Bengal, Kerala, Goa and Karnataka. Even with this 15 % of brackishwater area being utilized for aquaculture, many environmental issues have been raised in coastal areas due to improper planning and lack of proper site selection. There are vast unutilized brackishwater resources which are yet to be tapped for development of sustainable aquaculture. If these are to be developed, economic viability, food-safety, environmental soundness, social acceptability, equity and conservation of resources have to be addressed.

Coastal Aquaculture Authority Act 2005, regulates the development of brackishwater aquaculture. Coastal Aquaculture Authority (CAA) has framed guidelines for the development of sustainable aquaculture which prohibits construction of new farms within 200m from high tide line, use of agricultural lands and mangroves and provides buffer-zones (Given in box) between different land types.

The conventional approach of selecting a site for shrimp farming does not have the analytical capability to incorporate different dimensions in decision-making. There is no available methodology to identify the areas for sustainable brackishwater aquaculture with the spatial restrictions imposed on use of various resources such as mangroves, agricultural lands and freshwater resources and which also considers the present land use, site specific parameters, and the extent of utilization of water resources from the identified water body. There is a need for a rational method that permits additional spatial data incorporation and advanced analysis to identify the suitable sites for the utilization of unused coastal resources for aquaculture development without multi-user conflicts.

CAA guide lines for the site selection of brackishwater aquaculture

- Mangroves, agricultural lands, saltpan lands, ecologically sensitive areas should not be used
- Buffer zone of 100 m from any human settlement of less than 500 population and beyond 300 m from any village/ hamlet of over 500 population.
- For major towns and heritage areas it should be around 2 km.
- Buffer of 100 m distance from the nearest drinking water sources.
- Farms should not be located across natural drainage canals/ flood drain.
- Buffer zone of 50 – 100 m from the nearest agricultural land.
- Buffer zone of 50 – 100 m canal or any other water drainage source.

Tools Used

Remote sensing is evolving rapidly as new sensors with greater reliability and spatial resolution (23.5 m [LISS III] to less than 1 m [Cartosat]) have become operational and easily available. The satellite data obtained from National Remote Sensing Agency (NRSA) is used in many fields such as crop area estimation, weather forecasting, crop yield estimation, environment impact assessment studies and conservation of resources. The capability of Geographical Information System (GIS) to derive real-time locations based on the satellite data has greatly aided spatial accuracy and in most cases replaced the use of conventional surveying techniques.

Globally, GIS has been extensively used for the planning and management of coastal aquaculture. The capability to perform several functions such as spatial data collection, storage, manipulation, analysis and geographical representation, distinguishes GIS from other information systems such as Computer Aided Design (CAD) and Data Base Management System (DBMS). GIS, as an analysis tool discerns relative locations by defining the spatial relationships among all map elements. Satellite image processing software ERDAS Imagine and GIS software Arc GIS can be used to delineate the various resources and perform the spatial analysis for the site selection of aquaculture respectively. GIS coupled with satellite data, provides accurate information over inaccessible and larger areas.

Methodology for the Delineation of Potential Sites for Brackishwater Aquaculture

1. Preparation of satellite data

The false color composite (FCC) digital images were georeferenced by co-registering the selected minimum 40 ground control points that are predominantly identifiable both from the image and also from the topographic maps. The district boundary is taken as the area of interest and the images were subsetted which resulted in district digital images. The subsetted images were enhanced to produce a crisp image and to reduce the noise, atmospheric attenuation and salt pepper effect, using different enhancement techniques (e.g. spatial, spectral, radiometric) available in ERDAS Imagine. These images were projected to UTM WGS 84 co-ordinates before the delineation of different land use classes.

2. Mapping of land resources

Different land use classes such as, agriculture, aquaculture, river, canal, mud flat, reserve forest, degraded forest, mangroves, coastal plantation, lake, lake liable to be flooded, salt pan, sand, scrub land, waste land, settlement, tank and abandoned aquaculture farms were identified using visual interpretation keys such as colour, tone, texture, pattern, size, shape and its associated features. After the digitization, the digitizing errors, label errors, node, polygons that are not closed, polygons that do not have label points and polygons having too many label points or user ids that are not unique were corrected in order to have a correct spatial data. The topology creation, class coding and labeling were carried out.

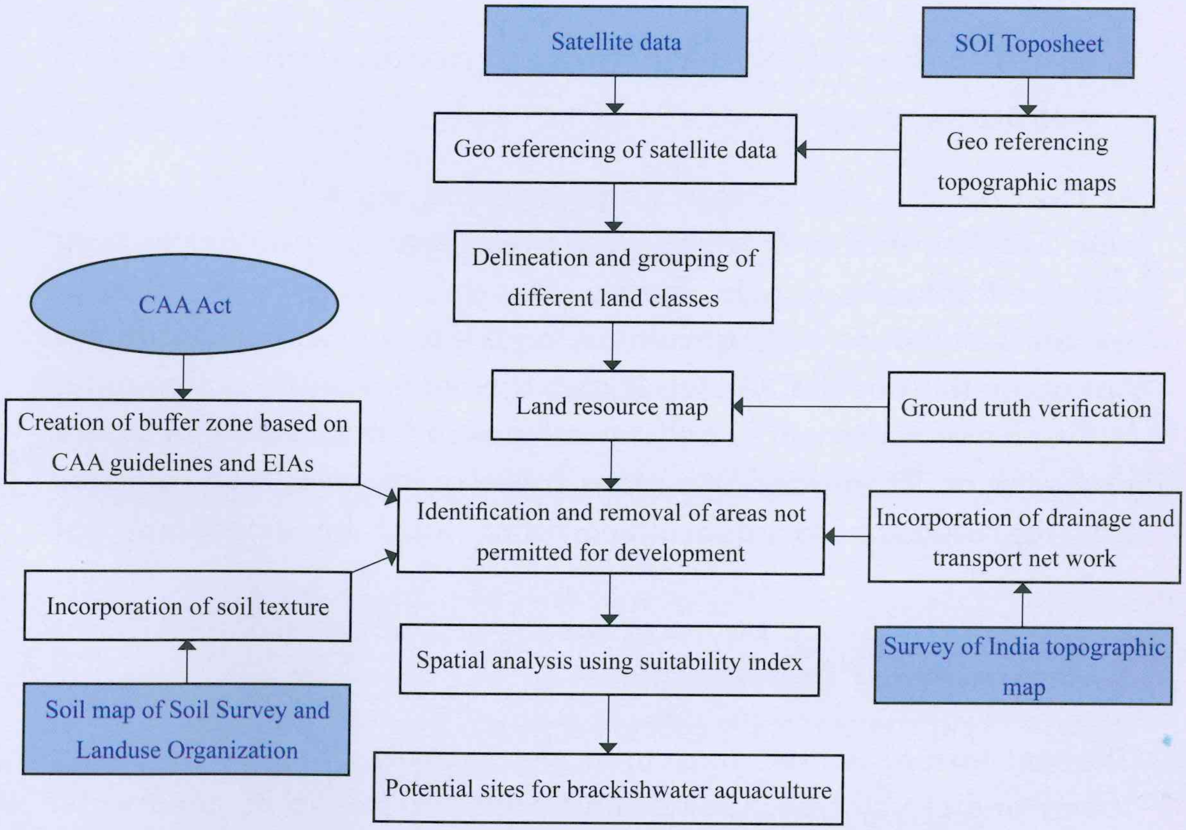

Fig. 1. Flow chart for the delineation of suitable sites for brackishwater aquaculture

3. Ground truth verification

Field surveys were carried out with Global Positioning System (GPS) after classifying land resources through satellite data and also to assess the accuracy of interpretation. The latitude and longitude of the different classes were verified with its extent and doubtful areas were mapped in ARC Pad and corrected using ARC GIS through GPS readings. The number of check points and their location for ground-truth were decided based on the visual separability between classes. The geographic coordinates of the doubtful areas/points were noted from the classified digital image and checked in the field with GS5^{+} GPS. Data collected from the checkpoints were used for the accuracy assessment.

4. Elimination of non-permitted areas from the land resource map

As per CAA Act, no new farms are permitted within 200 m from the high tide line and such areas were delineated as 'no development zone' in the land use map. Further conversion of mangrove forests, wetlands, salt pans and agricultural lands into aquaculture farms are not permitted under CAA Act. It also stipulates specific buffer zones between aquaculture area and agriculture land, drinking water source and villages. From land-use maps these areas were also removed and the area where aquaculture farms could be developed was delineated.

5. Mapping of Soil Texture

The soil texture in the study area was broadly classified as sandy, loamy and clayey type. Clay is most preferred due to its good water retention capacity and sand is least preferred due to its high seepage characteristics. The soil map was digitized from the soil texture map of "Soil Survey and Land Use Organization" for further GIS analysis.

6. Drainage pattern and transport network

The area suitable for aquaculture development should have proper drainage system as the volume of water released from the aquaculture farm pond is around 10 million litres /ha during harvest time. Hence, drainage pattern of the area was mapped from the topographic maps.

The area to be developed as aquaculture farm should be well approachable, even during monsoon. Transport network was derived from the topographic maps of Survey of India (SOI) for further analysis.

7. Site suitability index for brackishwater aquaculture

Site suitability index was developed to classify the suitable sites into three classes namely highly suitable, suitable and moderately suitable based on the land use (waste lands, abandoned aquaculture farms, scrubland and mud flats), distance from water source, soil texture, drainage and transport facilities as detailed in Table1. The weightage factor was assigned to each category based on its importance. The weightage factor and category will vary depend on the species requirement, technology used for site selection and culture type. Highly suitable sites will require less investment due to its proximity to water source, availability of good transport and drainage facilities. The sites with moderate suitability will require more investment due to high expenditure on water intake, drainage system and need for seepage control measures in the farm ponds.

Table1: Suitability index adopted for the delineation of potential sites for brackishwater aquaculture

Category	Weightage factor	Site suitability		
		Highly suitable (3)	Suitable(2)	Moderately suitable (1)
Land use	45	Abandoned aqua farms, Waste land	Scrub land, Mud flats	Scrub land, Mud flats
Distance from water source	30	Less than 1 km	1 – 2 km	2 - 5 km
Soil	15	Clay	Loam	Sandy
Transport	5	Any two	Any one	Not present
Drainage	5	3rd order	2nd order	1st order

8. Identification of potential sites

The information so generated was analysed using multi criteria evaluation function in Arc GIS for the delineation of potential areas under three categories namely highly suitable, suitable and moderately suitable.

Case Study for Methodology Evaluation

The developed methodology was evaluated for its utility to identify potential sites suitable for the expansion of sustainable brackishwater aquaculture, taking Nellore District of Andhra Pradesh as a case study. The satellite data of IRS P6 and IRS 1D of LISS III sensor was used to identify the suitable sites for aquaculture.

The satellite data was georeferenced using ground control points from SOI topographic maps of Nellore district. The georeferenced and subsetted satellite data (Fig. 2) is used to delineate the land resources.

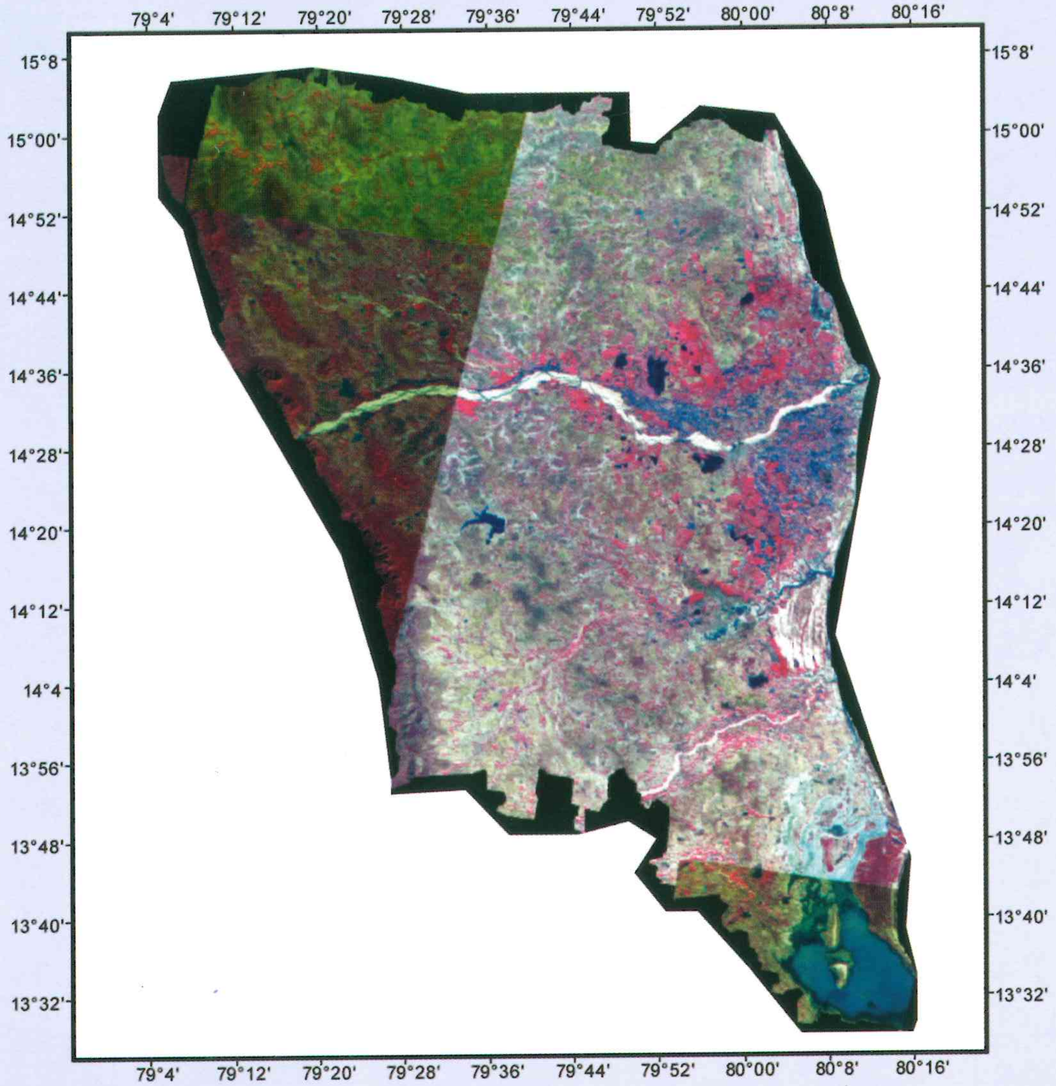

Fig. 2. Georeferenced and subsetted digital image of Nellore District from LISS III sensor

Different land classes such as, agriculture, aquaculture, river, canal, mud flat, reserve forest, degraded forest, mangroves, coastal plantation, lake, salt pan, sand, scrub land, waste land, settlement, tank and abandoned aquaculture were identified (Fig 3) using visual interpretation keys developed by Space Application Centre (SAC) such as colour, tone, texture, pattern, size, shape and its associated features.

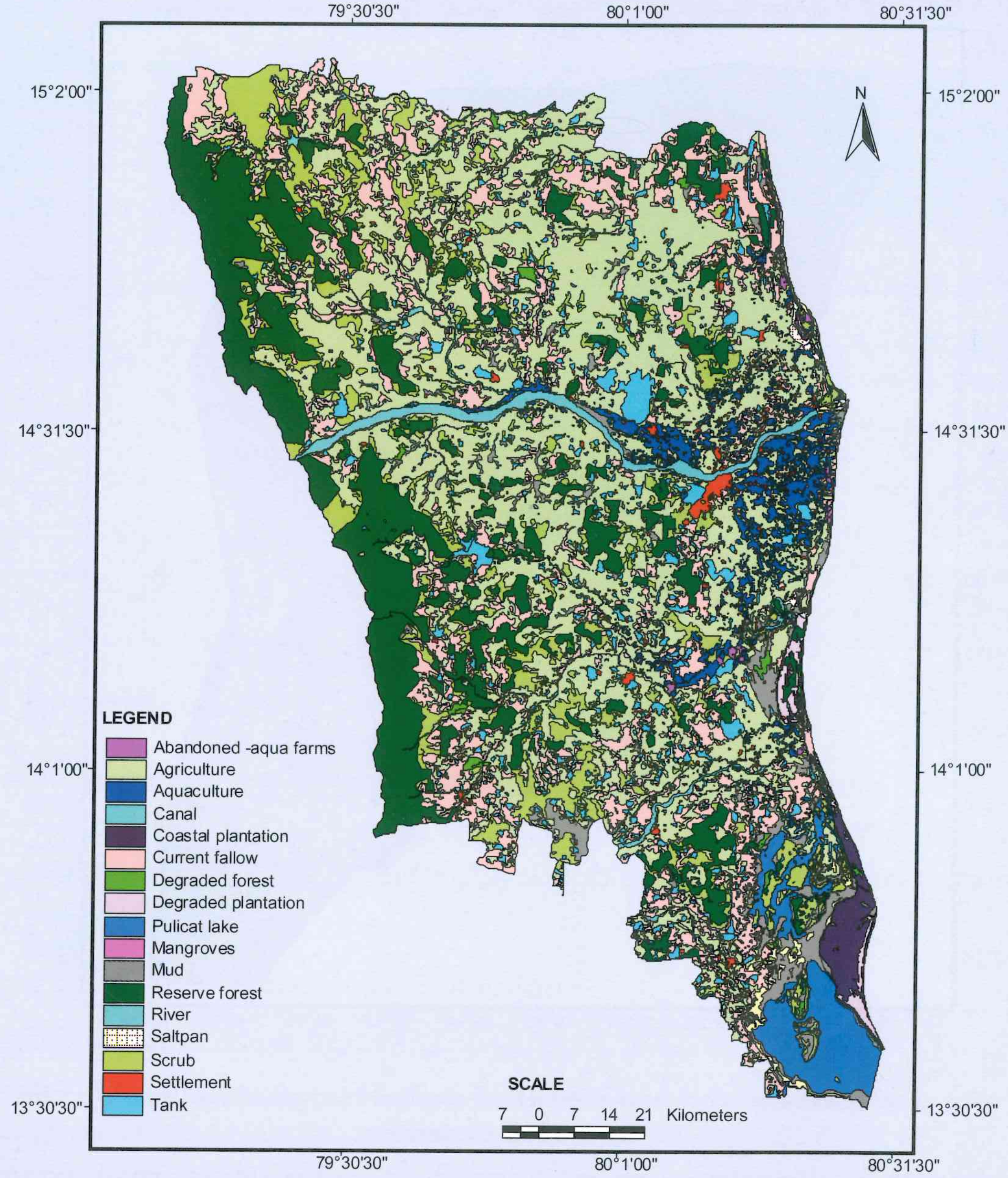

Fig. 3. Delineation of different land classes in Nellore district

Sites with land use classes such as agriculture, coastal plantation, forest, mangroves and freshwater sources were removed from the land use map. The other categories such as waste land, abandoned aqua farms not in earlier agricultural lands, and scrub lands were considered (Fig. 4) for suitable site analysis

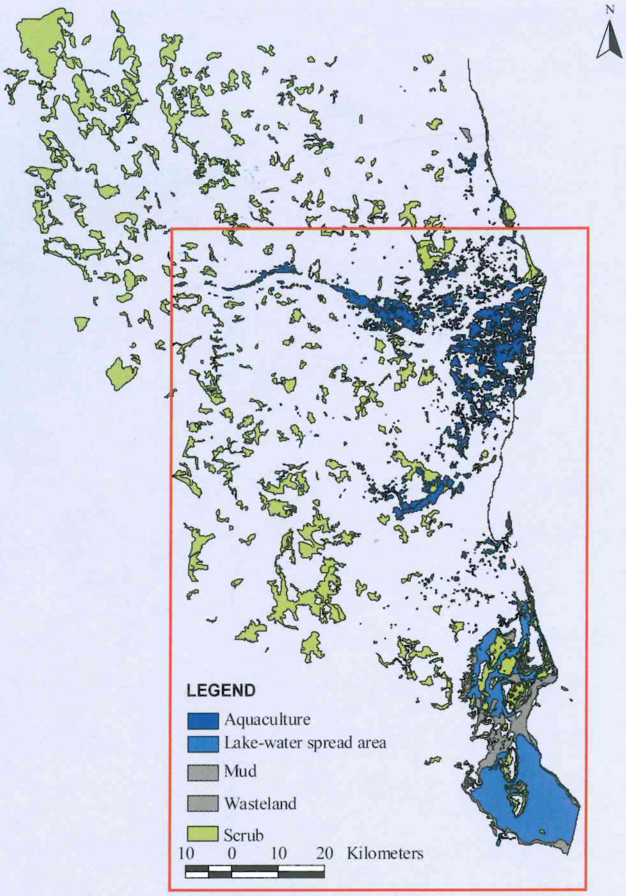

Fig. 4. Separation of spatial constraints/ restricted land classes

GIS analysis was carried out to identify the suitable lands from the abandoned aquaculture farms, waste lands, scrub land and mudflats. From the areas suitable for aquaculture, soil texture, drainage net work and transport facilities were incorporated. The sites for development of brackishwater aquaculture was classified under three groups such as highly suitable, suitable and moderately suitable. Fig. 5 indicates the existing aquaculture farms and potential sites located in the study area (boxed in Fig. 4). In addition to the existing aquaculture farms, to expand aquaculture in a sustainable manner, potential sites of 8468 ha were identified in Nellore District from waste land, mudflats, scrub land and abandoned aquaculture farms.

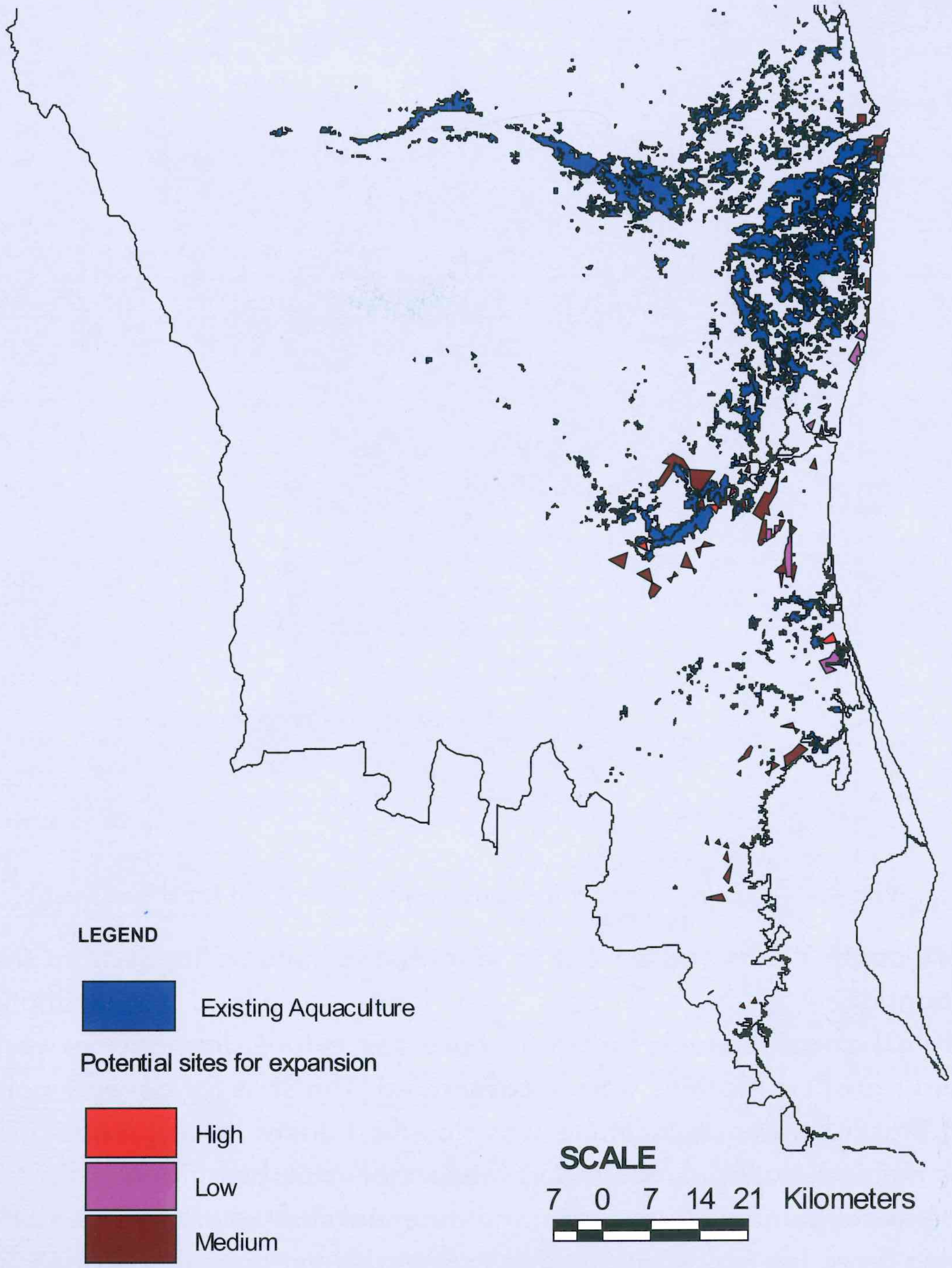

Fig. 5. Existing aquaculture farms and potential sites for future expansion of sustainable aquaculture

The study showed that there are still resources available for the sustainable development of aquaculture even in the districts where aquaculture is well developed.

Utility of Method

- The potential use of remote sensing, GIS and GPS techniques for the estimation of aquaculture farm area and site selection in a fairly accurate manner is proven.
- It will facilitate identification of unutilized waste lands for the development of coastal aquaculture and economic upliftment of coastal poor and at the same time ensure protection of environment.
- The information from larger areas can be processed for macro level planning of aquaculture development with the possibility of regular updating of the information periodically in an accurate manner with minimal cost using the satellite data.
- Aquaculture development at a national level is possible by identifying appropriate sites in all coastal states using multi land objective allocation criteria and this will help to avoid future conflicts among different stakeholders.

Transfer of Technology

This methodology can be transferred to important stakeholders including planners and policy makers of various departments of State and Central governments, environmental conservationists and farmers' associations for the effective utilization of coastal resources.

For details please contact

The Director

Central Institute of Brackishwater Aquaculture

75, Santhome High Road, R.A.Puram, Chennai – 600 028

Phone : (044) : 24618817, 24616948, 24610565; Fax: 91-44-24610311

E.mail : director@ciba.res.in

HEADQUARTERS

Central Institute of Brackishwater Aquaculture
75 Santhome High Road, Raja Annamalaipuram
Chennai - 600 028.

Telephones	: 91-44-24617523 (Director)
	91-44-24616948, 24618817, 24610565
Telegram	: MONODON
Fax	: 91-44-24610311
E-mail	: director@ciba.res.in
Web site	: www.ciba.tn.nic.in

RESEARCH CENTRES

Kakdwip

Kakdwip Research Centre of CIBA
Kakdwip 743 347, West Bengal
Telephone : 03210-255072

Muttukadu

Muttukadu Experimental Station of CIBA
Kovalam Post, Muttukadu 603 112, Tamil Nadu
Telephone : 91-44-27472425

Printed at Chennai Micro Print (P) Ltd. Chennai - 29