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Satellite-based identification of Aquaculture Farming using Neural Network Method over Coastal Areas around Bhitarkanika, Odisha

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Abstract: Aquaculture is the farming of fish, crustaceans, molluscus, aquatic plants, algae, and other aquatic organisms. Aquaculture farming in coastal areas of India plays key role in economy, which contributes 1. % of GDP. In Odisha, aquaculture system exports 26% of its products to foreign countries. Artificial neural networks have a feature of pattern recognition, which uses training dataset to identify pattern of any feature from satellite images. The term pattern recognition considers a wide range of information and processing problems of great practical significance. This study have been carried over two coastal districts namely, Bhadrak and Kendrapada in Odisha state. Here, Landsat-8 satellite data (OLI sensor) has been used and training sites have been generated. The pattern recognition feature of neural network have been used to extract aquaculture features from satellite image. We have analyzed the area that have been converted to aquaculture from 2002 to 2017 using the neural network classification. There was two-fold increase in aquaculture activities from year 2002 to 2017 in the two coastal districts. The increases in aquaculture activities indicated that aquaculture plays important role in socio-economic developmental of coastal people.

Keywords: - Artificial neural network; Pattern recognition; Aquaculture

1. INTRODUCTION

With the burgeoning coastal population in India, food demands have been increased over the years. Sea food is very popular in coastal regions and to meet the demand, aquaculture systems were growing very fast. Aquaculture was used to produce food and other commercial products that were extracted from fishes, prawns, shrimps, mussels, and other marine life. There are two types of aquaculture- marine and freshwater. The Marine aquaculture focuses on the production of shrimps, fishes, mussels, oysters, and seaweeds. India has a coastline of 7,517 km, therefore, it has huge potential for marine aquaculture. In India, the annual fisheries and aquaculture production has increased from 0.75 million tonnes in 1950-51 to 9.6 million tonnes in 2013-14 [1] with regard to annual fisheries and aquaculture production, India stood second next to China [1]. Over 10% of the global fish diversity can be found over the Indian subcontinent and >14.5 million people depend on fisheries activities for their livelihood. The total export value of aquaculture products in 2015-16 was over 4.7 billion euros [2].

Artificial neural network is a computing system, which was designed after the operation of neurons in human brain. Neural networks were used for complex signal processing or image recognition [3]. Examples of commercial use of neural network were handwriting recognition, speech to text transcription, oil exploration, data analysis, and facial recognition. As humans recognize any

object through their experience, computers also have capability to identify any object based on its example data set. This feature is called pattern recognition and used for computer vision [4]. Computer understands the pattern of pixels in example data set and then recognize the object from other images.

The satellite images and the extracted thematic maps provide higher level information to recognize, monitor, and management of resources [5]. Image classification depends on the spectral characteristics of feature. It is important to refine techniques to improve the accuracy of image classification for deriving land use and land cover maps [6]. Popular methods of satellite image classification are mainly based on digital value of example data set. Neural Network classification method typically based on digital values as well as their pattern. River, ocean, lagoon, and aquaculture all these features give similar reflectance in satellite image, the only difference between all these features was aquaculture, which has regular geometrical shapes. Other features such as river, ocean, etc. were usually irregular pattern.

Odisha is a coastal state of India with a coastline of 480.4 km. There are 13 ports and 57 fish landing centers in Odisha [7]. Bhadrak and Kendrapara districts were in coastal regions, wherein aquaculture practices were increasing rapidly over the last two decades. These activities are one of the major source of income of middle-class people. Foreign export of these products makes this activity even more profitable, while the risk component may not be neglected. As Odisha government is promoting aquaculture practices via 'Fish Pond Yojna', people have started aqua farming [8]. The main objective of this study are to extract aquaculture from multi-spectral satellite images based on neural network classification method and to estimate the dynamics of land use and land cover changes owing to aquaculture.

2. STUDY AREA & DATA USED

The study area comprises the two coastal districts (Bhadrak and Kendrapara) of Odisha, India. Bhadrak district is located between 21˚0'N to 20 °59' N & 86˚17'E to 86 ◌̊ 53' E. Its area is 2,505 km^2. Its population is 1,506,522 and population density is 601 per km^2. Dhamra port is located on the banks of river Baitrani. Kendrapara district is located between 20˚20' N to 20 ◌̊ 37' N & 86˚14' E to 87 ◌̊ 01 E. Its area is 2,644 km^2. Total population there is 1,439,891 and population density is 492.38 per km^2. Bhitarkanika National Park is also there. It is a famous tourist place in Odisha. The location of Bhadrak and Kendrapara district are shown in Figure 1.

The Landsat 7 ETM+ and Landsat-8 images were obtained from USGS (www.earthexplorer.usgs.gov). The ETM+ images are acquired for the year 2002 while the landsat-8 OLI images were used for the year 2017. Landsat 7 has six spectral bands in the visible to SWIR range with the spatial resolution of 30 m and temporal resolution of 16 days. It has two sensors: OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor). It has eleven bands with Visible to SWIR bands having spatial resolution of 30 m and temporal resolution of 16 days.

Table 1: Details of Data used and the corresponding path and row

Details	**Year 2002**		**Year 2017**	
Data Acquisition	16-12-2002	29-10-2002	04-03-2017	04-03-2017
Path	139	139	139	139
Row	45	46	45	46

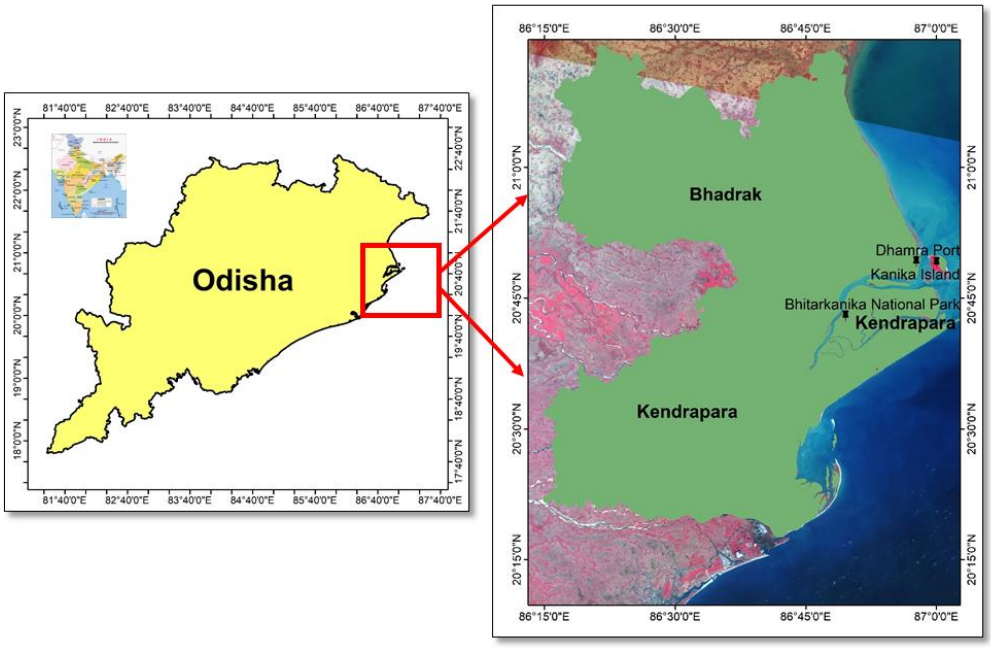

Figure 1: The location map of two coastal districts, namely, Bhadrak and Kendrapara in the state of Odisha, India

3. METHODOLOGY

To view changes between 2002 and 2017 Landsat satellite imageries have been used. Two tiles of Landsat images were downloaded for each year and further they were mosaicked using the image processing software. The flow chart of methodology has been shown in Figure 2. Firstly, the radiometric calibration performed by applying FLAASH settings in ENVI for four bands i.e. blue, green, red & NIR band. Then dark pixel subtraction was performed to eliminate the effect of atmospheric scattering. This is an atmospheric correction method as dark objects include a substantial component of atmospheric scattering. Neural network (NN) classification tool in ENVI software was used to classify the image into five classes, namely Aquaculture, River, and ocean, Mangrove, Wet land, and other remaining features. The NN technique has used the standard backpropagation method for classification. More attention was given towards the ROI selection for aquaculture and river class. The classified images were used fir area calculation for each class. The Accuracy assessment has been performed with the help of Google Earth Images.

Table 2 Specifications of neural network classifications

Parameter	Value
Training threshold contribution	0.900
Training rate	0.2
Training RMS exit criteria	0.1
No. of hidden layers	1
No. of training iterations	1000

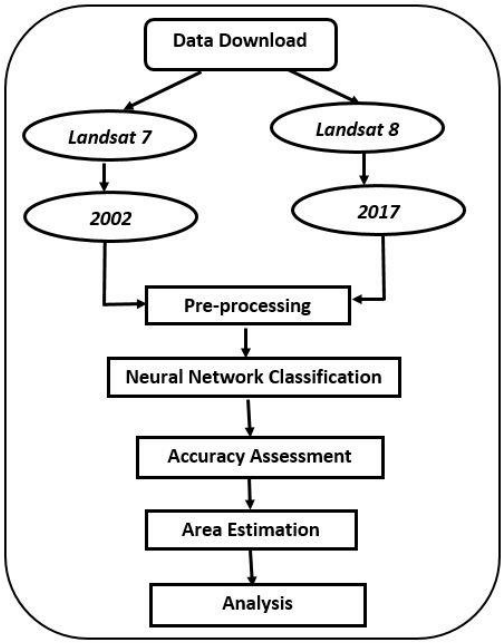

Figure 2: Methodology showing the detailed steps used in NN classification.

4. RESULTS & DISCUSSION

The satellite images were classified into five major classes using the NN method. The classified maps were shown for years 2002 and 2017 in Figure 3. Results indicate that there was increase in mangrove area over the period 2002 to 2017. Since there is abundance of other vegetation in 2002, mangrove area has been classified as others. Aquaculture have increased from 20.76 km^2 in 2002 to 44.86 km^2 in 2017.

Table 3 area statistics for different land use and land cover classes for years 2002 & 2017

Type	2002		2017	
	Area(in km^2)	**Percentage (%)**	**Area(in km^2)**	**Percentage (%)**
Aquaculture	20.76	0.36	44.86	0.79
River	832.37	14.68	863.19	15.23
Wet land	135.92	2.38	100.63	1.77
Mangrove	155.10	2.74	212.16	3.74
Others	4523.91	79.81	4447.28	78.46

Table 4 Accuracy assessment of classified maps for the years 2002 and 2017.

Type	2002		2017	
	Percentage (%)	Kappa	Percentage (%)	Kappa
Aquaculture	77.4	0.72	86.1	0.82
River	88.6	0.84	87.1	0.84
Mangrove	79.4	0.74	85.7	0.82

Wet land	75.0	0.74	85.7	0.83
Others	80.9	0.74	82.6	0.76
Overall	81.2	0.75	85.2	0.81

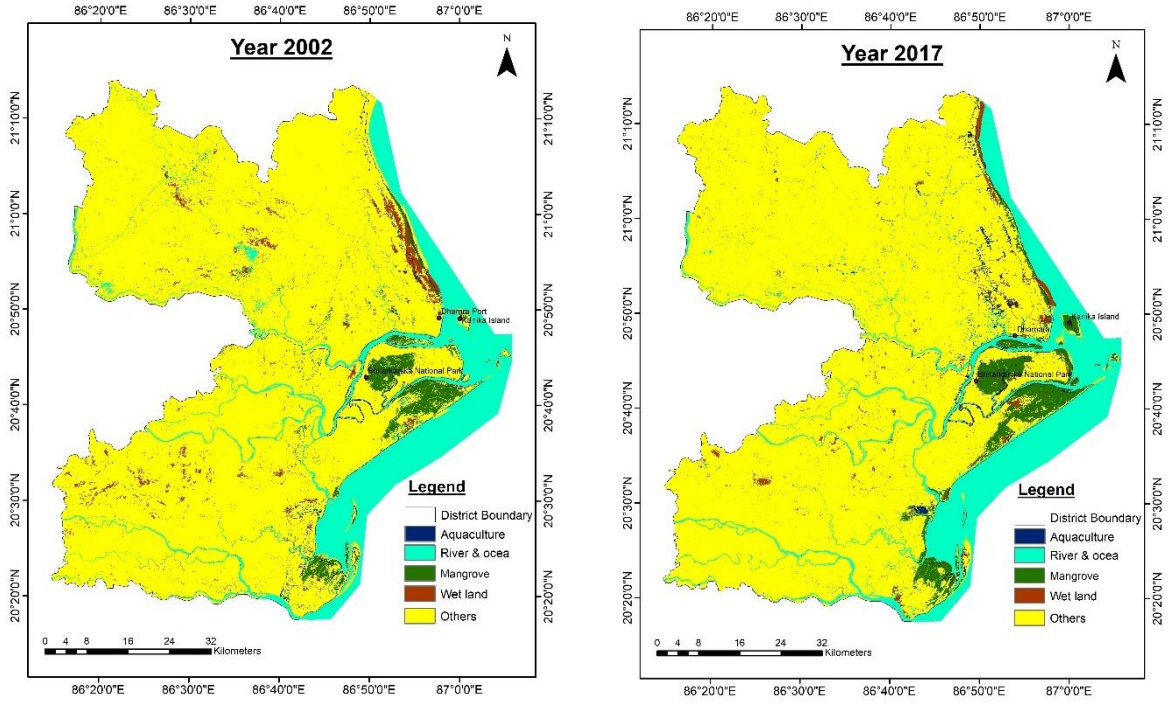

Figure 3: Classified maps of land use and land cover for Bhadrak and Kendrapara districts for the years 2002 & 2007

The Area under aquaculture have increased from 0.36% to 0.79% over 15 years. The increase in aquaculture was about two-fold. There was large increase in aquaculture activities in Bhadrak district compared to Kendrapara.

The overall accuracy of classification in year 2002 was 81.2% and accuracy of classification of year 2017 image was 85.2%. Accuracy of aquaculture is 77.4% in year 2002 as the aquaculture class were classified as river because of the signature of water was same for both river and aquaculture. Accuracy of aquaculture increases up to 86.1% in 2017. Wide streams and ocean are accurately classified but narrow streams are classified into some other classes. Kappa value for 2002 classified image is 0.75 and for 2017 the value is 0.81.

5. CONCLUSION

Neural network (NN) classification method has been very helpful in delineation of aquaculture. Other popular classification methods such as nearest neighborhood, parallel piped methods won't give satisfying accuracy, while classification of similar reflectance features. The NN classification method has given up to 86% accurate results, when it comes to extraction of aquaculture. There was a problem with narrow streams and thus the higher resolution satellite images may resolve these errors. The NN method takes more time for training but when it comes to differentiation between similar textured features when only shape or pattern is different, this method gives satisfying results.

There was increase in aquaculture up to two-fold 216.08% over the years 2002 to 2017. Remote sensing and GIS have been very helpful in estimating the increase in aquaculture.

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