HEALTH ASSESSMENT MODELLING OF PURNA MANGROVES, NAVSARI, GUJARAT USING REMOTE SENSING AND GIS

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ABSTRACT

In the coastal environment, Mangrove swamps are considered as one of the most valuable resources. They are recognized widely for their ecological and economic services. Due to spurt in anthropogenic activities as well as increased frequency of natural episodic events, mangrove coverage and health gets vastly affected. Thus, keeping the importance of mangroves in mind, it is of utmost importance to monitor the health of existing mangroves. The main objective of this study is to assess the ecological health of various mangrove species of Purna River in Navsari district of south Gujarat. Mangroves health assessment model developed by Space Application Centre (ISRO), Ahmedabad, is simulated by analyzing the important indicators such as Canopy cover, Stand size, Drainage density, Reclamation activities and anthropogenic stress. The magnitude of each parameter is given based on its relative importance in mangroves health. The entire study area is overlaid with a grid of 1 × 1 hectare. Each parameter is calculated and mapped using Resourcesat-2 satellite imagery of different time frames between 2007 and 2015 as well as in-situ measurements. The final output of the model is in the form of the map which shows present health of the mangroves. The study area is also classified based on retrieved index into pristine, vulnerable, degrading and degraded. The result showed approx. 0.60 sq.km areas is degraded, 0.35 sq.km showed degrading health condition. Approximately 12.50 sq. km area showed pristine health condition and 0.80 sq. km showed vulnerable health condition. Here, it can be concluded that the possible causes for mangrove degradation are aquaculture practices and high turbidity in this region. This, in turn, can lead to the decision makers as well as community developers to plan such activities in regions so as not to affect the mangrove health in any way.

INTRODUCTION

Mangrove swamp is the most productive ecosystem of coastal wetland. They are mainly located in areas alternately inundated and drained by tidal action. They serve as unique habitats for enumerating wildlife and act as a reservoir for many small organisms (Zhang, 2015). Therefore, it sustained a large number of the local fishing community associated with the coast. Mangroves also play a vital role in stabilizing shoreline position by trapping the sediment and also act as a barriers against storm surge etc (Kannan, 2014). These social and ecological services of mangrove are well putative in literature. (Yoshiro,1997; Thomas, 2006) On the other side, the coastal areas are one of the most preferred site for human development activities such as port, aquaculture pond, salt pan, embankment etc. Unfortunately, directly or Indirectly these human-induced activities cause a major threat to the mangrove forests (Taylor, 2015).

Gujarat has a long coast line of 1650 km. It ranks second and covers approx. 1103 sq. km. of the mangroves area. As per the FSI report of 2013, Gujarat showed an enhancement in mangroves cover up to 45 sq.km**.** (Indian state of forest report , 2013)**.** More than 10 species have been reported in Gujarat and 7 species out of them are present and reported in the south Gujarat. Primarily, *Avicennia marina* and *Rhizophora Mucronata* are the more dominating species among them because of high salinity (Bhatt, 2009). However, in some of the areas, the mangroves are declining at an alarming rate due to irrational activities anthropogenic activities. Large scale harvest of mangroves forest take place for timber, fodder, fibers and other products like honey (Walters, 2008, Ramachandran, 1998). Large scale harvest of mangroves forest take place for timber, fodder, fibers and other products like honey (Walters, 2008, Ramachandran, 1998). Severe impact due to excessive sediment, lack of rainfall or freshwater, obstruction in natural flow are serious threats to mangroves. To overcome all these threats and to perform practices in the nearby areas, appropriate information related to its spatial distribution, structure, and composition is required (Satyanarayana, 2011).

Renewable resources like mangroves are better mapped, characterized and quantified by implementing advance remote sensing techniques. It became an indispensable mean for the acquisition, characterization and quantification of many critical parameters (Kuenzer,2011, Cracknell, 1999). Various studies observed that mangrove forest can demarcate separately because of its smooth texture and low radiance in comparison of other swamp or vegetation forest. Moreover, its association is mainly found in the intertidal zone (Hirose, 2004) and therefore mapping and characterization of mangrove forests can be efficiently achieved by remote sensing techniques. Some studies

demonstrate that mangroves exhibit low reflectance value in SWIR region compare to any other non-mangroves forest (Tamura, 2008) .
The primary objective of this study is to assess the current health condition of Purna mangroves. Five major parameters have been identified such as canopy cover, stand size, anthropogenic stress, obstruction, sedimentation patterns of waterways and reclamation of mangrove forest as indicators to measure the ecological health of mangroves of Purna estuary. This paper provides the method to analysis various parameters using multispectral satellite imagery. All the parameters are analyzed on the grid of 1 × 1 hectare, the weightage value has been assigned for each segment of grid as per their significance. The model used for simulation in this study is prepared by the Space Application Centre, (ISRO).

STUDY AREA AND DATA USED

The study area selected for the study is mangrove forests located at Purna estuary of South Gujarat, India. The geographical location of the study area is shown in fig 1. The Purna river originates from Saputara hills and meets in the Arabian Sea. Its length is 180 km. and 2431 sq.km. catchment area(Water Resources Department). The dam has been constructed on the upward catchment of a river near Navsari. The region facing the diurnal tidal fluctuation in a day. The 500m of intertidal mudflat exposes during the low tide. The coastal wetland of Purna comprises varieties of mangroves, salt marshes, grasses etc. The area is diversified into small patches of mangroves island. The region is rich in black soil contain more silt and clay. Resourcesat- 1 and 2 (LISS IV) satellite imagery data is used to analysis a temporal change. Cartosat-2 satellite data with 2.5 m mono bands is also used to improve the spatial resolution of multispectral imagery by applied fusion technique.

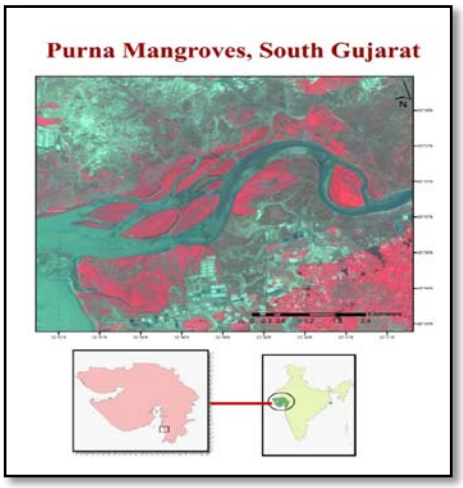

Figure 1. Study area

METHODOLOGY

Pre-Processing

Four sets of satellite data are used as per the requirement of parameters. All satellite data are stacked to generate RGB and converted to the Universal Transverse Mercator (UTM) projection on the World Geodetic Datum of 1984 (WGS 84) with zone no 42 North LISS IV images of 2007 and 2015 are co-registered with respect to orthorectify Cartosat (2.5m). Both the LISS IV images are fused with high-resolution panchromatic data using Modified HIS (intensity, hue, saturation) Resolution Merge technique (Jia Xu, 2008). A vector layer grid of 1×1 hectare has been overlayed on the imagery of study area. With the particular unit size, the grid value has assigned as per the weightages for each different parameters.

Canopy Cover

Normalized Difference Vegetation Index (NDVI) is computed for each pixel of the study area by using two bands: Red and NIR. NDVI value are classified into two categories: changed and unchanged. Later, these categories are distributed into very dense mangroves, dense mangroves and sparse mangroves with weightage values 100, 75 and 40 respectively. One more category is degraded mangroves, which is analyzed by visual interpretation on both the images having a value 10. The rest of the grid value contains the other features is multiplied by 0 to ignore its calculation.

Stand Size

Temporal data is used to analyzed and map the change in the stand size of mangroves and its vegetation pattern. A Change such as mangroves to saline blanks as well as dense to sparse or sparse to degraded.

Drainage Density

Drainage density of the stream is estimated by creating a polygon shapefile for each and every channels of a stream. Later, total percentage area of creek present in each hectare of a grid is calculated. Then weightage is assigned to a respective grid value on the basis of percentage of drainage area present in a particular hectare. If a creek area is more than 20% then weightage is 100, 20% to 10% is 60 , 9% to 5% is 40 and less than it is 20.

Sedimentation Patterns of Waterways

Obstruction is observed using analysis of temporal satellite data for 6 months to 1 year. The obstruction is demarcated visually on the image of during high tide. Sedimentation pattern of a creek is analyzed by computing Normalized difference turbidity Index (NDTI) using two bands: Red with wavelength: 0.63 µm to 0.69 µm and Green having wavelength 0.52 µm to 0.60 µm. The pixel value is then classified into three categories: High, Moderate and Less Turbidity. The classified image is then intersected with grid and weightages assign to them are 20, 70 and 100 respectively.

Anthropogenic Pressure

Distance from the habitat: Habitation present in close proximity of the mangrove area is identified and digitized manually. The boundary of the mangrove area is also digitized separately. The distance between the polygons of mangroves and habitat is calculated using the nearest distance tool in ArcGIS. More the distance from the mangrove stand less will be the stress.

Reclamation of Mangrove Forest: In this category, the other changes such as conversion of mangrove strand into aquaculture, salt pan, residential or any other development activity has been observed by comparing two different years' data of 2007 and 2011. In the model, the value assigned to this category is 10 and for the rest of grid is zero.

To calculate the overall impact of all parameters on mangrove swamp different weightage is assigned from the opinion of experts. The weightage is in the descending order as per the significance of that parameter on the mangroves health. The value of each thematic cell of a grid are again multiply with the actual weightage of a assigned parameter and then the value are divided by the total value of all weightage parameter. (Ajai, 2011).

RESULT AND DISCUSSION

The five indicator maps are generated which include canopy cover, stand size, drainage density, sedimentation pattern, distance from habitation and reclamation activities for assess the health of mangroves. Normalized Difference Vegetation Index (NDVI) has been computed in order to differentiate mangroves with respect to other features. The NDVI trend of Purna mangroves is seems to be increased from 2007 to 2015. The NDVI value for the same pixel of mangroves varies from 0.3 to 0.7. 61% of the total mangroves area excluding creeks and mudflats are occupied very densely. Dense and sparse mangroves occupy the 29% and 30% of canopy cover respectively. The degraded mangroves are estimated using temporal data which accounts nearly 7% of total cover. The mangroves are lost from the border of creek due to reclaimed of aquaculture pond.

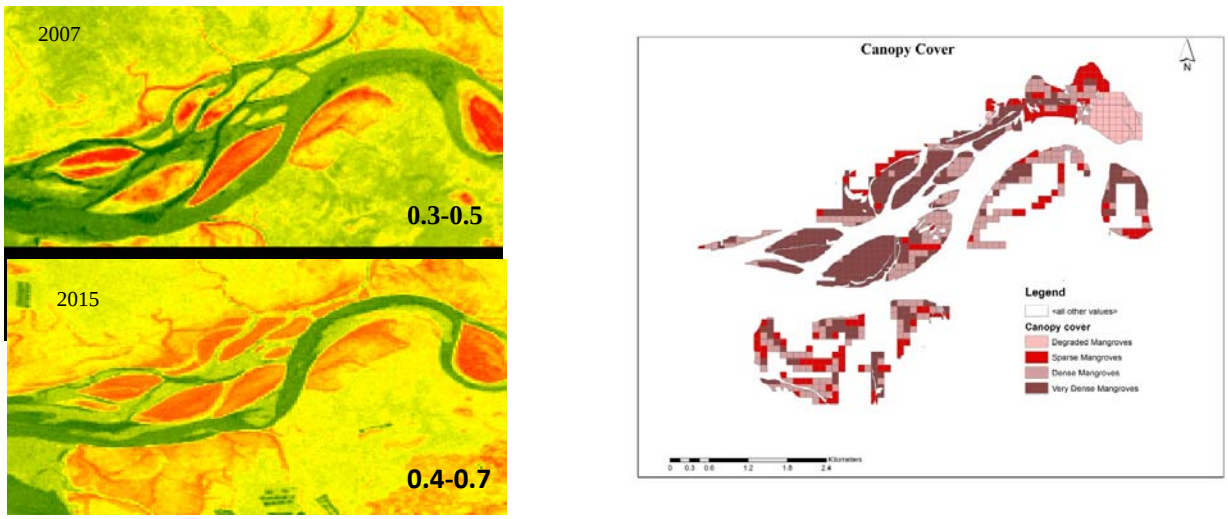

Figure 2 NDVI values of 2007 and 2015Canopy cover map for Purna river

Stand Size

The stand size is observed by near the construction of aquaculture pond otherwise small patches of the island shows the good natural regeneration. But it was impossible to collect the information in the inner side of forest because of inaccessibility of the terrain. Some of the grid value in this parameter is assigned by using NDVI values. The satellite imagery shows the very vast difference in the stand size of island. Mostly the middle portion of island shows the conversion from the sparse to dense vegetation.

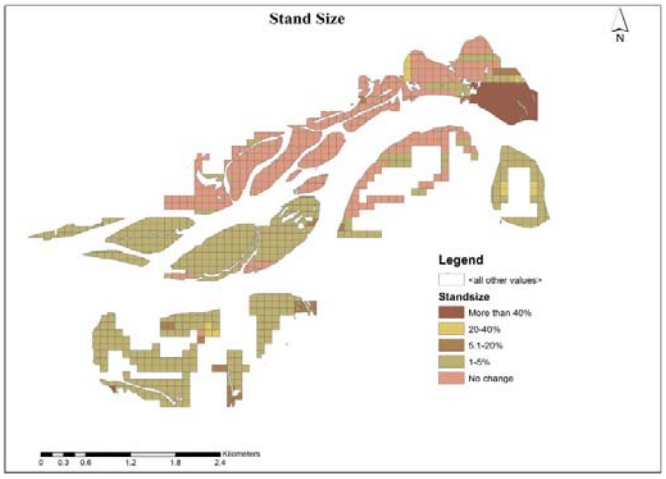

Figure 3 Stand size map for Purna river

Drainage Density

Mangroves are the salt tolerant plants but they need fresh water to grow. Construction of dam and irrigation reduce or diverse the flow of fresh water and increase the salinity level of coastal water. This can also leads to mangroves drying out. The generated map shows the percentage of creek area per hectare of a grid. The map shows the good creek network.

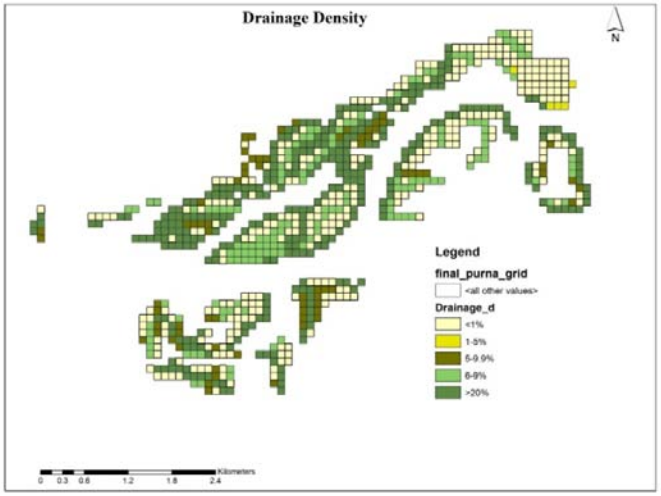

Figure 4 Drainage density map for Purna river

Sedimentation Pattern

Sedimentation in the mangrove areas can be a harmful or beneficial for it. Sediment get accreted and create a new mudflat at the bottom area then it provides a good substratum to the roots of mangroves. If sediment gets a deposit on the aerial roots of existing mangrove, then it blocks the gaseous exchange. It can cause an effect on the physiological process of mangroves. The fig. shows the area with high, moderate and low turbidity.

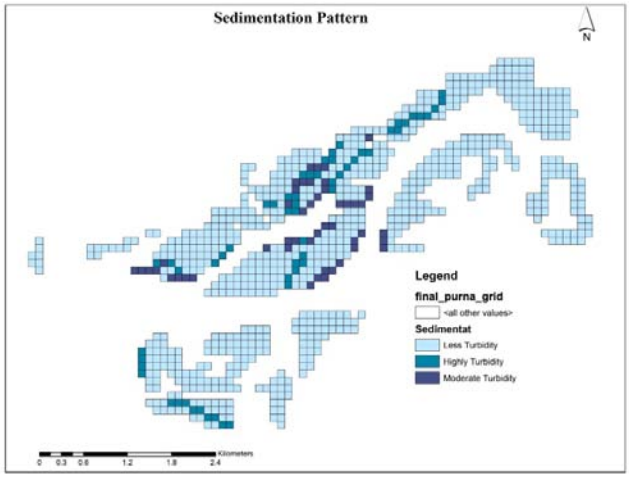

Figure 5 Sedimenation pattern map for Purna river

Anthropogenic Stress

Reclamation activities: The Aquaculture activity is a significant concern in this area. The upward side of the river is reclaimed for it. Patchy ponds constructed in the area of approx. 75 ha that has been mapped from a satellite image. The map is shown below in fig.6. No other reclamation activity has found so the value for rest of polygon in a grid is given as 100.

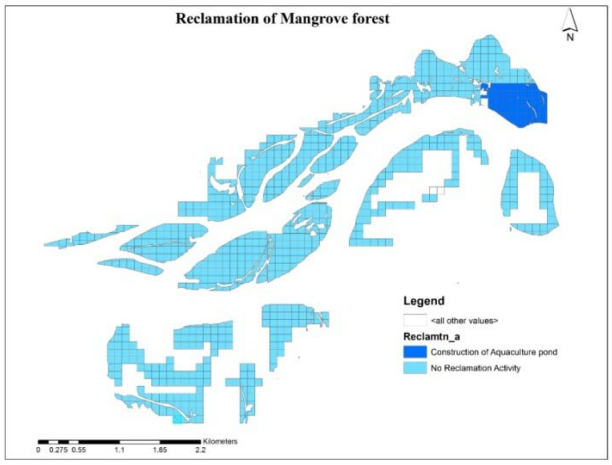

Figure 6 Reclamation pattern map for Purna river

Population Distance

There is no approachable road network present inside the forest. Samapor, Borsi, Vansi, Faliya, Karadi are the two three villages present in the periphery of 5 km from this mangrove. Small jetty is there near the mouth of the river at Borsi. The small islands of mangroves are inaccessible to reach and to make any ground verification.

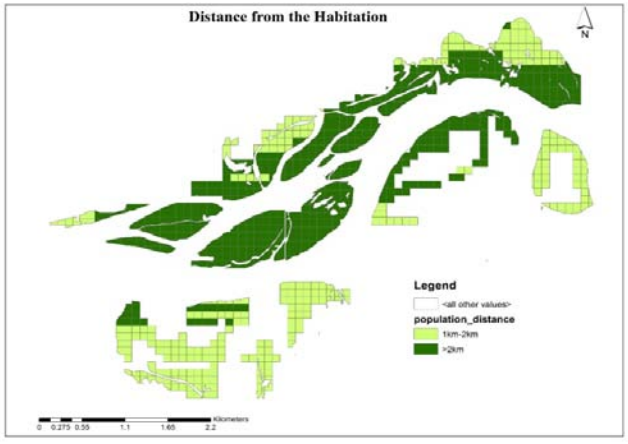

Figure 7 Population distance map for Purna river

Model Output

Health Assessment Modeling for Purna mangroves is done by overlaying the five indicator maps and by applying the above mentioned health assessment calculation to finally obtain the map shown in figure 8. Health index value are ranked in specific range as shown in figure 8. The result shows that approx. 0.60 sq.km. of areas is degraded, 0.35 sq.km. is degrading. Larger portion of study area shows a pristine health of approx. 12.50 sq.km. and 0.80 sq.km. is vulnerable.

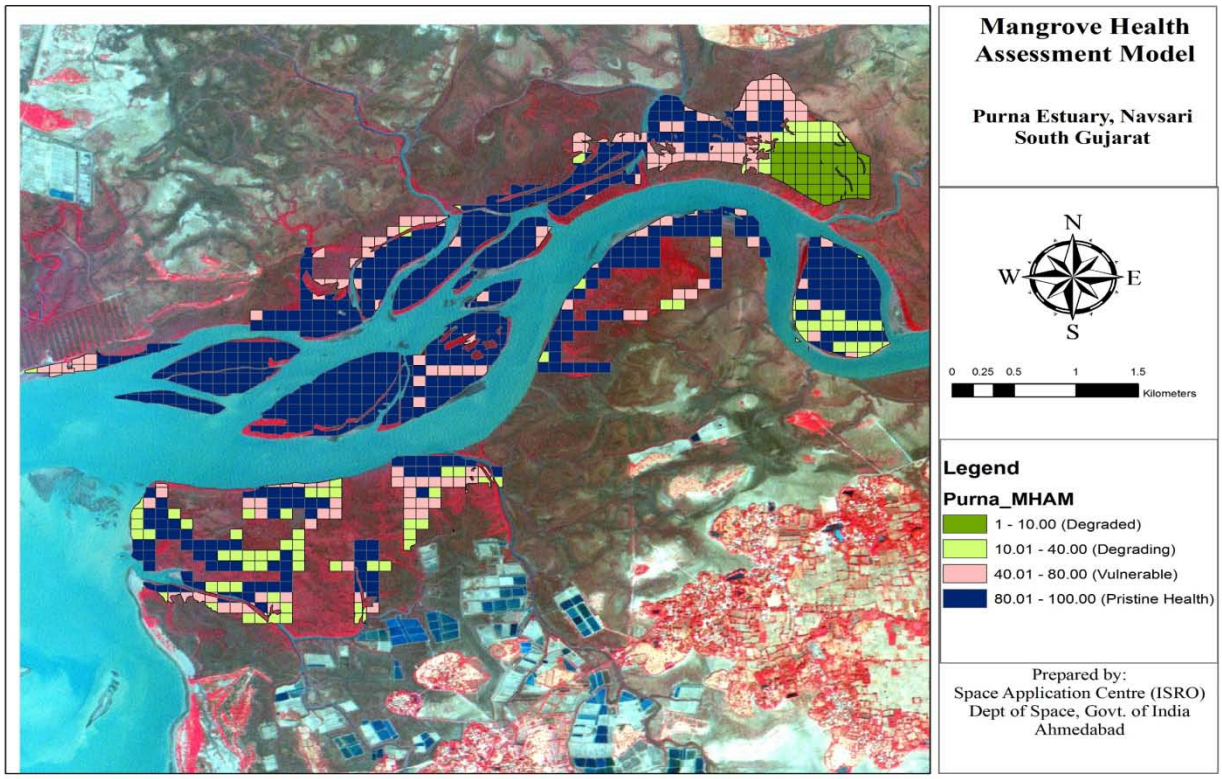

Figure 8 Final Output of Model

CONCLUSION

After applying the model for five parameters the overall outcomes reveal that the mangroves are present in the small patches of an island are in very good condition. But the mangroves located towards the landward side are in pristine health. Some of the mangroves patches are totally degraded due to a construction of the aquaculture ponds. Mangroves along the creek are in the good health condition. But mangroves towards the upward side of high mudflat are showing sparse behavior. No major obstruction is noticed during a field visit near the creek. The study recommends that anthropogenic activity should be under controlled. Because these are the area where mangrove swamps can be grown potentially. Such studies can give us an accurate idea of the depleting mangrove health and further, the reasons and causes of this may be worked out to sustain these resources for a long-lived.

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