Evaluation of Vegetation density of the Mangrove forest in South Andaman Island using Remote Sensing and GIS techniques

Yuvaraj E., Dharanirajan K., Saravanan and Karpoorasundarapandian N.
Department of Disaster Management, Pondicherry University, Port Blair, INDIA

Abstract

The gregarious distribution of mangroves forms the habitat on the large extent in the coastline of Andaman Islands. Southern part of South Andaman Island was taken for this study where the mangroves are threatened by anthropogenic activities and natural calamities. Remote Sensing and GIS techniques were used to evaluate the vegetation density of mangrove forest in this area. The LISS IV satellite image was used to map the mangrove forest using visual interpretation technique. Mangroves were delineated from the inland forest cover and other land cover features. NDVI method was used to evaluate the forest density cover of mangroves. Based on the canopy cover percentage it was classified into dense, moderate, sparse and degraded forest. The total mangrove canopy cover occupies 1842.89 ha which is 74.5% of total area of the mangrove forest, nearly 54.11% of canopy comes under moderate vegetation of mangroves and it occupies maximum of the mangrove forest in this island. Whereas dense vegetation occupies 283.10 ha indicating fine health status of the forest. Sparse forest occupies around 501.34 ha indicates the encroachment activities in this forest. Degraded vegetation was observed in the urban landuse and tsunami impacted areas that occupies around 101.40 ha were confirmed in the field survey. This preliminary cost benefit study was used to evaluate the status of vegetation density of mangrove forest of Southern Andaman Island which is in use to monitor the forest.

Keywords: Mangroves, Andaman, remote sensing, vegetation density, NDVI.

Introduction

Mangroves are salt tolerant trees and shrubs; which are globally distributed along the coast of tropical and subtropical regions[1,2]. It forms important intertidal ecosystems of tropics that links terrestrial and marine ecosystems[3]. It act as spawning ground for fishes, crabs, etc. and also provides valuable ecosystem goods and services[4]. Mangroves also stabilize shorelines from erosion and act as barriers to protect the coast from tsunami, storm and cyclone[5,6]. Mangrove forest covers up to 75% of tropical and subtropical shorelines located between 30°N and 30° S latitudes[7]. The total area of mangroves in the year 2000 was 137,760 km^2 in 118 countries of the world[8].

India occupies about 4639 sq.km of mangrove forests; within that about 18% of mangroves are distributed in Andaman and Nicobar Islands (ANI) with gregarious diversity which includes 90% of species[9]. ANI was deeply indented coastlines of 1962 sq.km[10] that provide innumerable creeks and bays facilitating in the development of rich and extensive mangroves. Mangroves constitute 9.4% of total area of ANI which is a natural treasure for this island. Diversity of mangroves in this island varies from 25 true mangals and 93 mangrove associates in this island[11] which provide enormous fishery wealth, tourism attraction and several other socioeconomic wealth to the local people.

Remote sensing of mangrove vegetation analysis: Remote Sensing and GIS are the inevitable tools to be essential in monitoring and mapping the highly threatened wetland ecosystems[12,13]. Remote Sensing and GIS provide quantitative information on understanding the spatial distribution of mangrove forests[14]. Studying the density of mangrove forest determined by the percentage of mangrove canopy closure is the qualitative approach to examine the mangrove forest[15]. The NDVI is widely employed as a pre-classification step to separate mangrove vegetation[16]. Mangrove density extent is based on pattern metrics of forest such as patch size, density of patch, fragmentation, and isolation pattern[17]. The vegetation density maps or canopy closure charts provide additional information on the health status of mangrove vegetation[18]. In this study canopy cover of mangrove forest in South Andaman Island were classified to identify the vegetation density of mangrove forest.

Study area: The Andaman group of islands have a diverse coastal environment with various ecosystems and an extremely rich biodiversity and productivity. The South Andaman Island is endowed with extent of mangroves forest which acts as harbour host for the island. Southern part of South Andaman Island was chosen as a study area that is stretching from 11°47' N to 11°28' N and 92°31' E to 92°47' E which is shown in the figure 1. Here gregarious distribution of mangroves was observed that contribute significantly to the livelihood of coastal communities through products used for fuel wood, food, fishing, forage for livestock and medicines. It also act as a barrier that protects the coast from cyclones and tsunami waves, particularly during

2004 Mega earthquake and Tsunami, mangroves defended and protected many parts of South Andaman Island[19,20]. These catastrophic events still have impacts and changes on the mangrove forest and its health status in South Andaman Island[21].
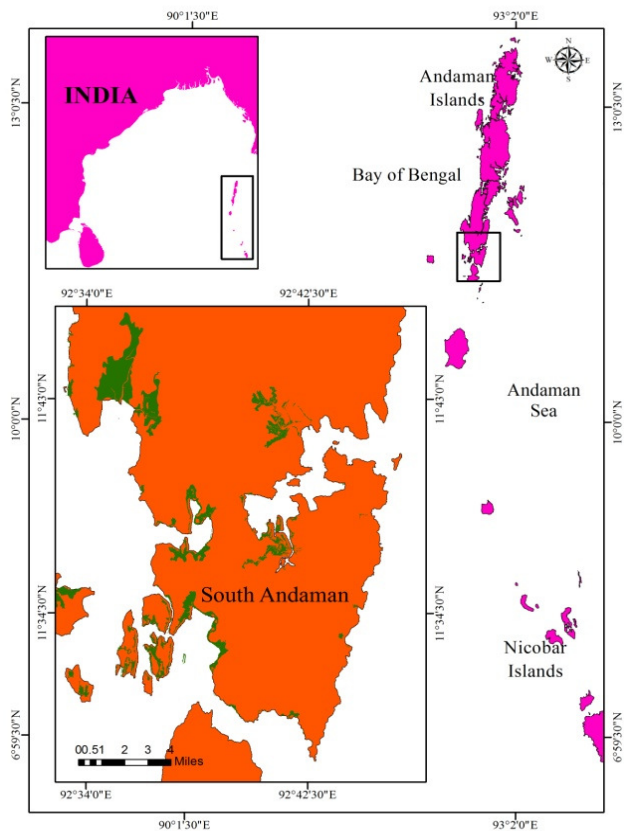

Figure-1
Study area map

Material and Methods

Survey of India (SOI) Toposheet (1979) with scale range of 1: 50,000 and IRS Resource-SAT image (2013) with the spatial resolution of 5-meter were used. Software packages such as ENVI 4.7 and ArcGIS 10 were used to process the image and mapping purposes respectively. Garmin Ertex GPS with accuracy of 5m were used for the field survey.

Basemap was prepared from Survey of India Toposheet. The raw satellite image was processed and geo-referenced with toposheet. The image was fixed to False Colour Composite (FCC) format and the mangroves were identified using visual interpretation technique[22]. Mangrove area was digitized and mask was built to delineate it from other forest covers[23] using ArcGIS 10 software. The mangrove associate features include mudflats or tidal flats, submerged mangroves and sand deposits were also taken as components of mangrove forest. The high resolution LISS IV satellite image has three bands (Green, Red and NIR) where the red and NIR bands were used to perform NDVI.

$$NDVI= NIR – Red/NIR + Red.................(Rouse\ et\ al)^{24}$$

NDVI was performed for estimating the vegetation cover[25] of the mangrove canopy; this indicates biomass of forest[26]. The NDVI data derived from satellite images was used to compute percentage of canopy closure from 0% to 100%[27,8] using ENVI 4.7 software. The classified mangrove vegetation was exported as polygon features to attribute above classification types. Field survey was carried out to confirm the classified forest types and to enhance the accuracy of the map. Finally the error was rectified and the mangrove vegetation density map was generated and area was calculated.

Results and Discussion

Mangrove forest of South Andaman Island found in the bays, lagoons and sheltered coasts in the form of forest, patches and clumps. In southern part of this island mangroves covers the area of 2473.58 ha .The canopy cover occupies 1842.89 ha in the mangrove forest of the study area which is about 74.5% of the total area of mangrove forest, whereas the mudflats and other mangrove associated habitats cover the area of 630.68 ha. The NDVI output shows the vegetation density index of mangroves which express the percentage of canopy cover of mangroves. The density of mangrove vegetation was classified into four classes based on SAC[28] standard classification of vegetation density for Indian mangrove forest. They are very dense (> 70 % cover), moderately dense (40-70 % cover), sparse (10-40 %) and degraded (< 10 % cover) which covers the area of 283.10, 957.05, 501.34, and 101.40 ha respectively (table 1). The mangrove forest extent in each area was separated by the adjacent village which used to estimate vegetation density in village wise (figure 2).

Dense Vegetation: Dense mangrove shows good health status of mangroves which indicates tall trees, fine distribution, diversity extent and excellent local habitat for the mangrove growth[18]. The canopy cover of about 70% was taken as dense mangrove vegetation. It covers the area of about 283.10 ha (table 1) in the study area which occupies around 10.14% of canopy cover. Dense vegetation of mangroves found in the semi-enclosed and sheltered coasts of this island like areas of Colinpur, Mangultan, Saithankhari, Wandoor, and Sippighat. In addition to this Beachdera was also included in dense forest based on the percentage of dense vegetation of the total canopy (table 2). This dense vegetation observed in *Bruguiera*, *Rhizopora* and mixed *Rhizopora-Ceriops* forest of South Andaman Island which was confirmed in GPS field survey.

Moderate Vegetation: The canopy cover ranges between 70 and 40% which is taken as moderate vegetation of mangrove forest, the dominant variety in the entire mangrove forest of the study area. It highlights the moderate health of the forest and covers the area of about 957.05 ha and occupies around 54.11% (table 2) of total canopy cover of the study area. This type of

vegetation found in dense forest, linear stretch and dense patches of mangroves. *Xylocarpus, Ceriops, Rhizopora* and *Avicennia* community dominates in the moderate vegetation cover. *Nypa fruticans* species also shows this type of vegetation density.
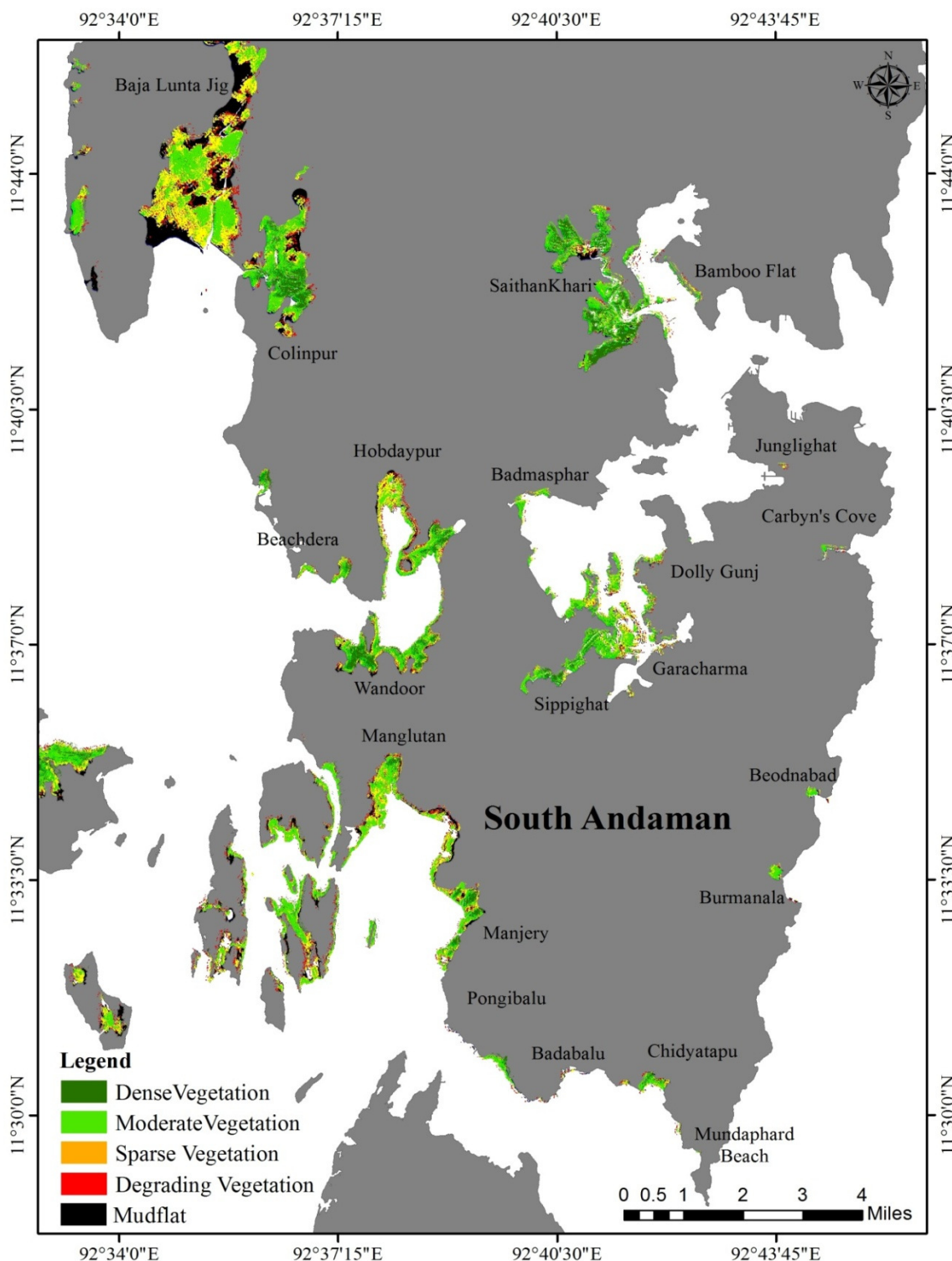

Figure-2
Classification of vegetation density of mangrove forest in southern part of South Andaman Island

Sparse Vegetation: The canopy cover between 40 and 10% is taken as sparse vegetation of mangrove forest. It occupies around 501.34 ha (table 1) of total canopy of mangrove forest in the study area which is around 29.86%. These are distributed as small fragmented patches and it includes species of *Rhizopora, Avicennia, Sonneratia* and *Phoenix paludosa* are dominants. Encroachment activities in Baja Lunta Jig, Bamboo flat, Dollygunj, Garacharma, and in some areas of Colinpur and Sippighat leads to this type of forest. Clearing of mangroves for the agricultural activities are common in these areas. Cutting of mangroves for animal feed and for fuel wood are occasionally spotted in the field visit. The landuse activities and other anthropogenic impacts in the mangrove cover of Junglighat shows fragmented sparse vegetation which occupies about 63% in this area (table 2). Mangroves forest of Mundaphard and Bamboo Flat are affected by the tsunami which also shows maximum of this vegetation type (figure 3).

Degraded Vegetation: The degraded forest denotes the loss of canopy cover, lower-stand density and degrading forest habitat due to changes in environmental conditions in and around the forest[15]. The canopy cover less than 10% indicates the degraded mangroves which occupies 5.89% of the mangrove forest in the study area. Both the salt tolerant and riverine mangroves are present in this vegetation type and cover around 101.40 ha (table 1) in the areas of Junglighat, Mundaphard and Baja Lunta jig, which shows the maximum percentage of degradation of mangroves (figure 3). Degraded mangrove forest of Mundaphard, Bamboo flat and Sippighat indicate the tsunami impacts on this fragile ecosystem[20]. Mangrove patches of Junglighat and Carbyns cove were affected by the landuse and other anthropogenic activities.

Table-1
Area calculation of Mangrove forest and its canopy cover in South Andaman Island

Location	Classification of Canopy cover (ha)				Total canopy cover (ha)	Mudflat (ha)	Mangrove Forest (ha)
	Dense	Moderate	Sparse	Degraded			
Badmasphar	0.51	8.07	2.87	0.33	11.79	0.70	12.49
Baja Lunta Jig	4.04	244.88	227.62	44.75	521.29	377.55	898.84
Bambooflat	0.06	3.34	3.05	0.36	6.82	1.21	8.03
Beachdera	6.53	13.97	5.90	1.23	27.63	3.85	31.47
Beodnabad	0.06	3.37	1.20	0.12	4.75	0.34	5.08
Burmanala	0.07	7.22	2.06	0.44	9.79	0.68	10.47
Carbynscove	0.00	1.98	0.97	0.16	3.11	0.15	3.26
Chidyatapu	3.13	10.83	4.24	1.13	19.33	2.60	21.93
Chouldari	0.21	2.64	1.10	0.11	4.07	0.07	4.13
Colinpur	61.00	135.26	38.01	9.00	243.27	67.77	311.05
Dollygunj to Garacharma	0.60	9.00	5.85	1.09	16.54	1.38	17.92
Hobdaypur	14.41	63.10	41.73	9.76	129.00	30.06	159.07
Junglighat	0.00	0.27	0.77	0.18	1.22	0.58	1.80
Mangultan to Manjery	25.23	120.72	63.23	12.99	222.17	70.67	292.84
Mineebay	0.13	3.74	2.76	0.49	7.13	1.36	8.48
Mundaphard	0.00	0.48	0.76	0.21	1.45	0.42	1.88
Pongibalu to Barabalu	2.89	8.70	2.93	0.95	15.47	4.18	19.65
SaithanKhari	102.72	140.04	32.18	6.26	281.20	28.62	309.82
Sippighat	20.74	114.76	40.23	6.54	182.27	15.44	197.71
Wandoor	40.77	64.65	23.86	5.31	134.59	23.06	157.65
Total	**283.10**	**957.05**	**501.34**	**101.40**	**1842.89**	**630.68**	**2473.58**

Table-2
Percentage of classified mangrove canopy vegetation density in South Andaman Island

| Location	Dense %	Moderate %	Sparse %	Degraded %	Total %
Badmasphar	4.35	68.48	24.36	2.82	100
Baja Lunta Jig	0.77	46.98	43.66	8.58	100
Bambooflat	0.87	49.04	44.79	5.31	100
Beachdera	23.64	50.57	21.34	4.44	100
Beodnabad	1.24	71.04	25.17	2.54	100
Burmanala	0.70	73.73	21.04	4.52	100
Carbynscove	0.00	63.51	31.32	5.17	100
Chidyatapu	16.21	56.03	21.93	5.83	100
Chouldari	5.09	65.03	27.17	2.72	100
Colinpur	25.07	55.60	15.62	3.70	100
Dollygunj to Garacharma	3.63	54.44	35.35	6.57	100
Hobdaypur	11.17	48.92	32.35	7.56	100
Junglighat	0.00	22.02	63.19	14.79	100
Mangultan to Manjery	11.36	54.34	28.46	5.84	100
Mineebay	1.80	52.52	38.77	6.92	100
Mundaphard	0.00	32.95	52.52	14.53	100
Pongibalu to Barabalu	18.66	56.26	18.96	6.11	100
SaithanKhari	36.53	49.80	11.45	2.22	100
Sippighat	11.38	62.96	22.07	3.59	100
Wandoor	30.29	48.04	17.73	3.95	100
Average canopy cover	**10.14**	**54.11**	**29.86**	**5.89**	**100**
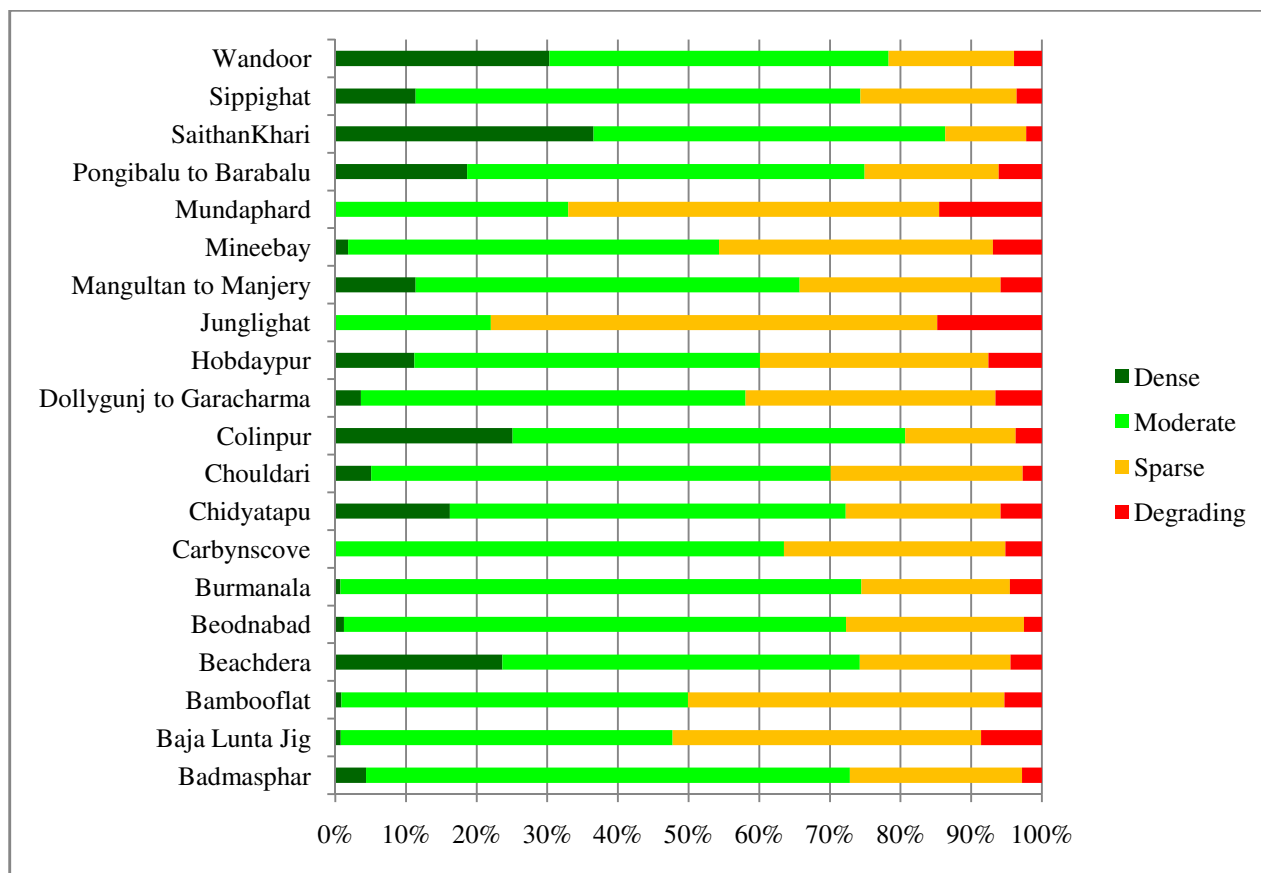
Figure-3
Chart shows the health status of mangrove forest canopy in South Andaman Island

Mudflats and other associated habitat: The mangrove associate habitat includes mudflats or tidal flats, submerged mangroves and sand flats. These associated features show zero value in NDVI due to absence of vegetation cover. Mudflats occupies maximum of associated habitat in this island which covers around 630.68 ha. These mudflats are submerged during high tide and partially emerged during low tide.

The vegetation density shows the health status of the forest[26] which depends on the percentage of the canopy cover of the mangrove forest in the area. While Baja Lunta Jig mangrove forest is vast around 898.84 ha but the canopy cover is not dense which occupies only 521.29 ha and manifests the fragmented condition of forest. Whereas the dense vegetation percentage of Beachdera was about 23% but the area of forest occupies only around 31 ha. The maximum of moderate vegetation was found in the entire mangrove forest of the study area. The mangrove forest near the urban area such as Junglighat, Carbyn's cove, Sippighat, Garacharma and Dollygunj are vulnerable to sewage discharge and landuse activities. Whereas the fragmented mangrove forest in rural areas includes Colinpur, Saithankhari, Manjery and Wandoor are vulnerable to clearing and encroachment activities mainly for agricultural purposes. The degraded forest indicates situation of damaged and unhealthy condition by impacts of tsunami, other natural and anthropogenic stress.

Conclusion

High resolution satellite image was used in this study to evaluate the vegetation density of mangrove forest in Southern Andaman Island. Visual interpretation techniques were used to map the mangrove forest. In the study area the mangrove forest occupies an area of 2473.58 ha. NDVI is the valid method used to differentiate the vegetation density of the mangrove forest. The total canopy cover of mangrove occupies about 1842.89 ha and it was classified into dense, moderate, sparse and degraded. The status of mangroves in the each mangrove forest extent elaborates the health status of mangroves in each area. Different species dominates various vegetation types but overall *Rhizopora* community dominates the mangrove forest of this area. Moderate vegetation dominates the overall mangrove forest of South Andaman Island and it covers around area of 957.05 ha. Followed by sparse vegetation which is 501.34 ha this shows fragmented condition of mangrove forest mainly by the landuse and encroachment activities. The NDVI value of above 70% indicated dense vegetation which occupies 283.10 ha in the study area. The dense vegetation cover was maximum in Saithankhari which is 102.72 ha followed by Wandoor, Colinpur and Beachdera occupies subsequent dense canopy percentage which indicates good health status and fine distribution of mangroves. The degraded vegetation was maximum in landuse and in tsunami impacted areas such as Junglighat, Sippighat, Mundaphard and Sippighat. It covers the area of 101.40 ha and shows the stressed mangrove forest in the study area. This cost benefit study shows the status of mangrove

vegetation density in the Southern Andaman Island. NDVI is an indispensible model to delineate the vegetation density of the mangrove forest which is useful to identify the health status of forest. This study recommends to decade wise vegetation density changes and to monitor the fragile mangrove ecosystem.

Acknowledgement

References

1. Tomlinson P.B., The botany of mangroves.Cambridge University Press, Cambridge **(1986)**

2. Pawar Tushar Anant, Study of Mangrove flora along the Zuari River (Case study on Curtorim Village – Goa- India), *International Research Journal of Environment Sciences*, **1(5)**, 35-39, **(2012)**

3. Heumann B.W., Satellite remote sensing of mangrove forests: Recent advances and future opportunities, *Progress in Physical Geography*, **35(1),** 87-108 **(2011)**

4. Manson F.J., Loneragan N.R., Skilleter G.A. and Phinn S.R., An evaluation of the evidence for linkages between mangroves and fisheries: A synthesis of the literature and identification of research directions. In Oceanography and Marine Biology: An Annual Review; Gibson, R.N., Atkinson, R.J.A., Gordon, J.D.M., Eds.; Taylor and Francis: London, **43,** 485-515 **(2005)**

5. Peter J., Hogarth, The Biology of Mangroves and Seagrasses, Second edition, Oxford University Press, New York **(2010)**

6. Das S., The role of natural ecosystems and socio-economic and storm surge, *Nat Hazards,* **64,** 531–546 **(2012)**

7. Spalding M., The global distribution and status of mangrove ecosystems, *Int. NewsLett. Coast. Manage,* **1,** 20-21 **(1997)**

8. Giri C., Bruce Pengra, Zhiliang Zhu, Ashbindu Singh and Larry L., Tieszen, Monitoring mangrove forest dynamics of the Sundarbans in Bangladesh and India using multi-temporal satellite data from 1973 to 2000, *Estuarine Coastal and Shelf Science,* **73,** 91-100 **(2007)**

9. Naskar K., Manual of Indian Mangroves, Daya Publishing House, New Delhi 220 **(2004)**

10. Jayaraj R.S.C. and H.V. Andrews, Andaman and Nicobar Islands Union Territory Biodiversity Strategy and Action Plan, Andaman and Nicobar Islands Environmental Team, Madras Crocodile Bank Trust, Tamil Nadu, India **(2005)**

11. Dam Roy S., Krishnan P., Grinson George, Kaliyamoorthy M. and Goutham Bharathi M.P., Mangroves of Andaman

and Nicobar Islands. Central Agricultural Research Institute, Port Blair **(2009)**

12. Roby T.J., Nair P.V. and Joyce Jose, GIS techniques for Mapping highly Fragmented ecosystems- A case study on the Myristica swamp forests of Southern Kerala, India, *Research Journal of Recent Sciences*, **3(ISC-2013)**, 110-119 **(2014)**

13. Everitt J.H., Yang C., Sriharan S. and Judd F.W., Using high resolution satellite imagery to map black mangrove on the Texas Gulf Coast, *J. Coast. Res.,* **24,** 1582-1586 **(2008)**

14. Giri C. and Muhlhausen J., Mangrove Forest Distributions and Dynamics in Madagascar (1975–2005) *Sensors,* **8,** 2104-2117 **(2008)**

15. Claudia Kuenzer, Andrea Bluemel, Andrea Bluemel, Tuan Vo Quoc and Stefan Dech, Remote Sensing of Mangrove Ecosystems: A Review, *Remote Sensing,* **3,** 878-928 **(2011)**

16. Green E.P., Clark C.D., Mumby P.J., Edwards A.J. and Ellis A.C., Remote sensing techniques for mangrove mapping, *Int. J. Remote Sens,* **19,** 935-956 **(1998)**

17. Seto K.C. and Fragkias M., Mangrove conversion and aquaculture development in Vietnam: A remote sensing-based approach for evaluating the Ramsar Convention on Wetlands, *Glob. Environ. Change,* **17,** 486-500 **(2007)**

18. Ramsey E.W., III and Jensen J.R. Remote sensing of mangrove wetlands: Relating canopy spectra to site-specific data, *Photogramm. Eng. Remote Sensing*, **62,** 939-948 **(1996)**

19. Dam Roy S. and Krishnan P., Mangrove stands of Andamans vis-à –vis tsunami, *Current Science*, **89(11),** 1800–1804 **(2005)**

20. Dharanirajan K., Pandian P.K., Gurugnanam B., Narayanan R.M. and S. Ramachandran, An Integrated Study for the Assessment of Tsunami Impacts: A Case Study of South Andaman Island, India Using Remote Sensing and GIS, *Coastal Engineering Journal,* **49(3),** 229-266 **(2007)**

21. Yuvaraj E. and Dharanirajan K., Status of Mangroves in Flat Bay coast after eight years ahead the catastrophic events in Andaman Islands, *IOSR Journal of Envi. Sci. Toxicology and Food Technology,* **2(6),** 47-54 **(2013)**

22. Aschbacher J., Ofren R., Delsol J.P., Suselo T.B. and Vibulsresth S., An integrated comparative approach to mangrove vegetation mapping using advanced remote sensing and GIS technologies: preliminary results, *Hydrobiologia,* **295,** 285-294 **(1995)**

23. Simard M., Zhang K., Rivera-monroy V.H., Ross M.S., Ruiz P.L., Castañeda-moya E. et al., Mapping Height and Biomass of Mangrove Forests in Everglades National Park with SRTM Elevation Data, *Photogrammetric Engineering & Remote Sensing*, **72(3),** 299-311 **(2006)**

24. Rouse J.W., Haas R.H., Schell J.A. and Deering D.W., Monitoring vegetation systems in the Great Plains with ERTS. In3rd ERTS Symposium, NASA SP-351 I, 309–317 **(1973)**

25. Satyanarayana B., Mohamad K.A., Idris I.F. and Husain M.-lokman et al., Assessment of mangrove vegetation based on remote sensing and ground-truth measurements at Tumpat, Kelantan Delta, East Coast of Peninsular Malaysia, *International Journal of Remote Sensing*, **32(6),** 1635-1650 **(2011)**

26. Mohan P. Tiruveedhula., Joseph Fan., Ravi R. Sadasivuni., Surya S. Durbha., and David L. Evans. Biomass and Health Based Forest Cover Delineation Using Spectral Un-Mixing. ASPRS 2009 Annual Conference Baltimore, Maryland March 9-13, **(2009)**

27. Jensen J.R., Lin H., Yang X., Ramsey III, E.W. Davis B.A. and Thoemke, C.W. The measurement of mangrove characteristics in southwest Florida using SPOT multispectral data, *Geocarto Int.,* **6,** 13-21 **(1991)**

28. SAC (Space Application Center), Coastal Zones of India (Sponsored by Ministry of Environment and Forests, Govt. of India) Space Applications Centre, ISRO, Ahmedabad **(2012)**