Statistical analysis of spectral separability of mangroves in visible and infrared region: a case study in tada talav village near Khambhat, Gujarat

Alpana Shukla[+], Manish Thaker+, S.S. Manjul* And H.B. Chauhan*

+ M.G. Science Institute, Ahmedabad,India
*Space Applications Center, Ahmedabad, India E-mail:- alpana.botany@gmail.com

ABSTRACT

Mangroves are trees of various species of several families occurring at the tropical or sub tropical seas, in the bays, lagoons and estuarine region (Gerlech, 1973) They are a very important ecosystem, having many economical and ecological uses. The Mangroves are threatened by the expansion of human settlements, the boom in commercial aquaculture, the impact of industries, recreational activities, etc. Such threats are leading to an increasing demand for detailed mangrove maps for the purpose of measuring the extent of the decline of mangrove ecosystems. Remote sensing, because of its repetitive, synoptic, multi-band, multi-sensor capabilities becomes an ideal choice for mapping and monitoring the mangroves. It allows information to be gathered from the forbidding environment of mangrove forests, which otherwise, logistically and practically speaking would be extremely difficult to survey. Because of high reflectance in IR band it is used with green and red band for identification of mangroves. SWIR in Middle IR is used for recording water content in the leaf. In the present study, two Ground Truth Radiometers (GTR), indigenously built at SAC and having visible, NIR and MIR bands, were used to further identify specific bandwidth to separate mangroves from mudflats. Tada talav area in the Bhavnagar taluka was selected for the present study and Radiometer readings were taken at the mangrove patches present. Observations were analyzed and radiance values were plotted against the different bands. It was observed that in NIR region, wavelength 754nm (BW 720nm-788nm) gives better separation of mudflat and mangrove than 863 nm (BW 825nm – 900nm). In the MIR region, Bands 1500 (BW 50nm) and 1640 (BW 30nm) give better separation than Band 1625 (BW 63). This shows that the bands with narrow bandwidth and higher number of bands are more useful for separating coastal features like mangroves, mudflats and other vegetations. Further, applying Statistical Analysis measures like ANOVA and 't'-test, it could be seen very clearly that radiance value of mud is significantly higher than that of land with mangroves and mixed vegetation. Statistics indeed has a positive effect on scientific research which ultimately leads to decisions for the betterment of the Society.

Keywords: Mangroves, Ecosystem, Remote Sensing, Band, Coastal, Radiometer

INTRODUCTION

Mangroves are the most interesting but endangered salt tolerant higher groups of plants (Angiosperms) found in coastal regions, generally inundated during high tides and exposed during

the low tides. They grow on the waterlogged soils that are often lacking in oxygen, in regions of Estuaries and Broad Muddy Tidal Flats. In the field they are distinguishable due to their Aerial Root Systems, which is an adaptation to the environment for their successful growth.

They provide habitat for other flora and fauna like algae, crabs, fishes, marine invertebrates, mollusks, etc. They also stabilize the coastline which is otherwise subject to erosion and loss. They act as Natural Barrier against storm-tide that would otherwise have a more damaging effect on low-lying land areas. They are very important "land builders" which help form islands and extend shores. Mangrove Forests help in maintaining the quality of the coastal water by extracting chemical pollutants from the water. World over, the coastal population depend on mangroves for their day to day living.

Mangroves are a source of several important items like, wood, medicines, alcohol, cigarette and cigar substitutes, condiments, cooking oil, cork, dyes, fodder, glue, herbal teas, paper tannins, vegetables, vinegar etc. (IUCN, 1993).

The distribution of Mangroves on the Gujarat coast line indicates major areas in Kori creek, Gulf of Kachchh, and Gulf of Khambhat. Mangroves in Kori creek area are fully grown and other than this area, average height of the mangrove in Gujarat coast is not more than 1 to 1.5 m. Density wise also, generally it is moderately dense, making it difficult to properly demarcate mangroves in muddy substrate.

Mangroves are under constant threat of natural or man-made activities. Man made threats likes Industries Development. Port Activities, Construction, Sewage treatment, Recreational activities, Aquaculture activities and energy development are highly affecting mangroves. Natural threats likes, Change in salinity, Sedimentation, Sea-level rise, Change in temperature are also affecting mangroves. Since Mangroves are an integral part of human life directly or indirectly, sustainable & integrated development is necessary.

Remote Sensing data has been used for the study of the threat on the mangrove, because of its repetitive, multispectral and synoptic nature has proved to be extremely useful in providing information on various components of the coastal environment, including Mangroves.

The Mangroves are under constant threat- natural or man-made.

Man-made threats	**Natural threats**
• Industry Development	Change in temperature
• Port Activities	Change in salinity
• Construction	Sedimentation
• Sewage treatment	Sea-level rise
• Recreational activities	
• Aquaculture activities	
• Energy development	

Objective and study area

- The present work aims to study the spectral separability of Mangroves in visible and infra red region.
- It also aims to study the impact of Statistics on the observations and inferences. • The area of study-Tada Talav, is situated near Khambhat in Gujarat. (Fig.1) • L a r g e stretch of mudflats and mangrove are present in this region.
- Mainly it has Avicennia sp. but Rhizophora sp. also is present.
- As it was not possible to physically reach Rhizophora, readings of only Avicennia sp. were recorded.

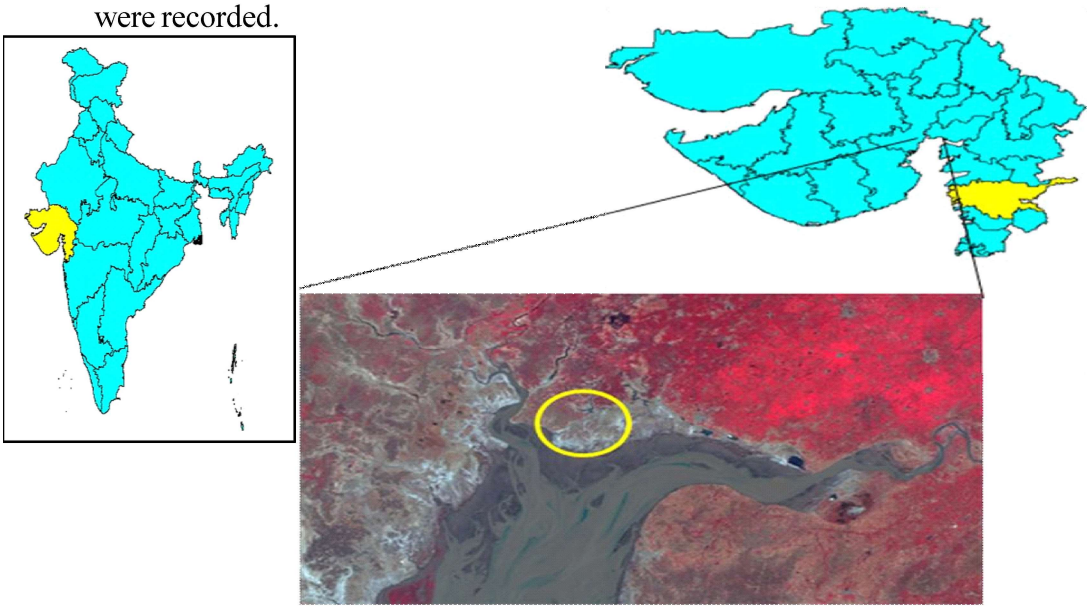

Fig-1 Location Map

Methodology

- Field visit was carried out for three times (Once every other month) during the low tide period.
- Every time in the field,
- Radiometer reading of reflected flat panel surface was taken first and then observation from Mangrove, mudflats, soil and Sueada sp. were taken.
- These observations were taken during 11.00 am to 12.00 noon.
- Ground truth radiometers namely Multiband GT

Radiometers, having 12 and 9 bands respectively, in visible and IR region were used. (Table-1 and 2)

Table-1 Band Specifications of Radiometer1:

Band Number	Center wavelength	Band width (nm)
B_1	90.000	46.000
B_2	302.000	162.000
B_3	863.000	543.000
B_4	1097.000	690.500
B_5	1920.000	1282.000
B_6	1555.000	1053.000
B_7	2314.000	1633.000
B_8	1415.000	1029.000
B_9	1419.000	1002.500
B_{10}	1056.000	704.000
B_{11}	1907.000	1272.500
B_{12}	1036.000	697.000

Table-2 Band Specifications of Radiometer2:

Band	Band width
B_1	444
B_2	478
B_3	578
B_4	668
B_5	754
B_6	445
B_7	517
B_8	715
B_9	863

Observations: These are as per Table-3.

IRS Ground Truth Radiometer(GTR) Readings					
Date : - Village : - Tada Talav					
Lat. : - 22°15'55.588N Long. : - 72°27'40.642E					
Band	**Mangroves (10^{-5})**	**Grass(10^{-5})**	**Suaeda(10^{-5})**	**Suaeda Purple(10^{-5})**	**Mud(10^{-5})**
B1	6.800	8.212	8.232	5.735	16.4
B2	13.200	13.225	13.262	8.451	28.3
B3	4.383	4.372	4.375	4.379	22.18
B4	2.585	2.578	2.578	2.581	24.83
B5	7.415	7.399	7.401	7.406	25.54
B6	3.269	3.260	3.26	3.263	24.81
B7	3.901	3.893	3.891	3.895	19.96
B8	1.689	1.684	1.684	1.686	16.95
B9	11.305	11.285	11.295	11.293	113.09
B10	0.061	0.066	0.054	0.02	0.4
B11	0.064	0.081	0.057	0.03	0.4
B12	0.077	0.09	0.062	0.045	0.44

Statistical analysis techniques:

- Analysis of Variance – ANOVA
- ANOVA, developed by Prof R.A. Fisher in 18th century, helps to test the significance difference among several means.
- If ANOVA gives significant results then Tucky-HSD a post hoc analysis is adopted to find which mean differs significantly from the rest.

RESULT AND DISCUSSION

The results of this exercise were very interesting and fulfilling the objectives. They are shown in Fig 2 and Fig 3 as well as Tables 3, 4, and 5.

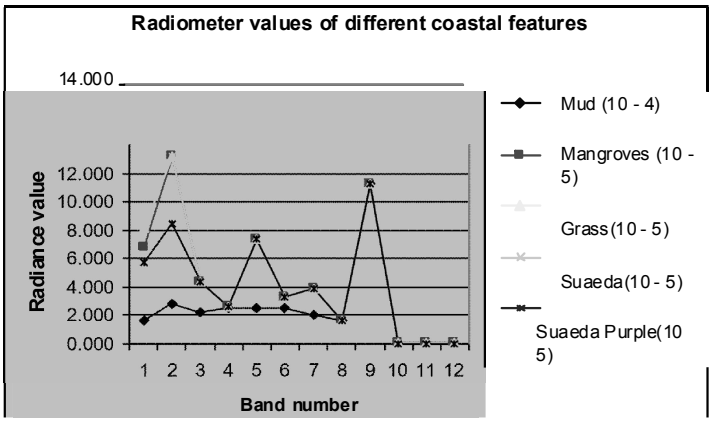

Fig-2 Graph showing radiance values of Radiometer1

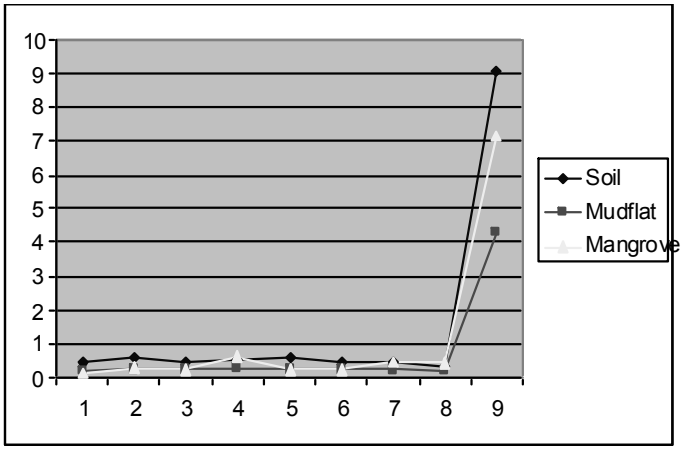

Fig-3 Graph showing radiance values from Radiometer 2

Table-3 ANOVA 1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	12234.809[a]	16	764.676	5.220	.000
landclass	3822.079	4	955.520	6.523	.000
Band no.	4092.524	11	372.048	2.540	.014
Error	6445.267	44	146.483		
Total	18680.076	60			

Table-4 Multiple Comparisons – Dependent Variable : Radiance

	(I) landclass	(J) landclass	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Mangroves (10 - 5)	Grass(10 - 5)	-.1163	4.94104	1.000	-14.1692	13.9365
		Suaeda(10 - 5)	-.1168	4.94104	1.000	-14.1697	13.9360
		Suaeda Purple(10 - 5)	.4971	4.94104	1.000	-13.5558	14.5499
		Mud(10^-5	-19.8792*	4.94104	.002	-33.9321	-5.8264
	Grass (10 - 5)	Mangroves (10 - 5)	.1163	4.94104	1.000	-13.9365	14.1692
		Suaeda(10 - 5)	-.0005	4.94104	1.000	-14.0533	14.0523
		Suaeda Purple(10 - 5)	.6134	4.94104	1.000	-13.4394	14.6663
		Mud(10^-5	-19.7629*	4.94104	.002	-33.8158	-5.7101
	Suaeda (10 - 5)	Mangroves (10 - 5)	.1168	4.94104	1.000	-13.9360	14.1697
		Grass(10 - 5)	.0005	4.94104	1.000	-14.0523	14.0533
		Suaeda Purple(10 - 5)	.6139	4.94104	1.000	-13.4389	14.6668
		Mud(10^-5	-19.7624*	4.94104	.002	-33.8153	-5.7096
	Suaeda Purple (10 - 5)	Mangroves (10 - 5)	-.4971	4.94104	1.000	-14.5499	13.5558
		Grass(10 - 5)	-.6134	4.94104	1.000	-14.6663	13.4394
		Suaeda(10 - 5)	-.6139	4.94104	1.000	-14.6668	13.4389
		Mud(10^-5	-20.3763*	4.94104	.001	-34.4292	-6.3235
	Mud (10^-5)	Mangroves (10 - 5)	19.8792*	4.94104	.002	5.8264	33.9321
		Grass(10 - 5)	19.7629*	4.94104	.002	5.7101	33.8158
		Suaeda(10 - 5)	19.7624*	4.94104	.002	5.7096	33.8153
		Suaeda Purple(10 - 5)	20.3763*	4.94104	.001	6.3235	34.4292

Table -5 Statistical analysis:

Radiance:

	Land class	N	Subset 1	Subset 2
Tukey HSD[a,b]	Suaeda Purple(10 - 5)	12	4.0653	
	Mangroves (10 - 5)	12	4.5624	
	Grass(10 - 5)	12	4.6788	
	Suaeda(10 - 5)	12	4.6793	
	Mud(10^-5	12		24.4417
	Sig.		1.000	1.000

CONCLUSION

- From present exercise it can be concluded that:
- Mangrove can be separated from mud and Sand in band number 9 (863nm)
- Though, dry Sueada sp. could be separated from mangrove and grass in band 2 (478nm), in IR region band 9 (863nm) it was difficult to separate mangrove, grass and Sueada sp.
- For further separation, different methods like Band ratio or Principal component analysis can be tried.
- Ellipsoidal separability and Hyperspectral data will also be tried.
- To test the significant difference of radiance amongst various land classes and impact of band wavelength on radiance, two way ANOVA techniques were applied and from the results it may be concluded beyond doubt that mud flat has maximum radiance as compared to other land classes studied in this case.
- Out of the various bands studied, the band wavelength 1419nm showed maximum separation of land classes on the basis of radiance.
- It can thus be concluded that there is indeed a positive impact of Statistics on the present study and similar studies, leading to better management solutions for the society.

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