IEEE- Fourth International Conference on Advanced Computing, ICoAC 2012
MIT, Anna University, Chennai. December 13-15, 2012

Hyperspectral image processing to detect the soil salinity in coastal watershed

P. Nila Rekha, R. Gangadharan, S.M.Pillai, G.Ramanathan and
A. Panigrahi
Central Institute of Brackishwater Aquaculture,
75, Santhome high road, Chennai- 28
rekha@ciba.res.in /nila_71@yahoo.com

***Abstract*- Hyperspectral images are spectrally over determined, which means that they provide ample spectral information to identify and distinguish spectrally unique materials. With the development and perfection of the hyperspectral remote sensing technologies, it has been the major technique applied for various advance mapping including soil salinity mapping. Brackishwater aquaculture is generally regarded as an environmentally sound practice so far as resource utilization of the marginal land and water of coastal ecosystem goes. However However, impact of shrimp farming on the coastal ecosystem is very often debated. . Amongst the biophysical factors, environmental concerns for the salinization of soil, and water have been raised and this issue needs to be scientifically addressed.With this background for this study hyperspectral analysis was conducted to ascertain the salinity status both near the shrimp farming region(Site A- 4 location) and perennial brackishwater creek(Site B- 2 location) .The electrical resistively survey was also conducted in the same locations to ascertain the results of hyperspectral analysis. The study which integrated both these method, shows that spectral reflectance and wavelength at site A location which is near to shrimp farming area are emitting equivalent type of reflectance and soil properties at all the four locations in the site A are similar. By electrical resistivity survey high resistivity values were observed in those areas indicating there is no salinization. But in site B location, (near to creek)The conspicuous high spectral wavelength and features at 500 nm, 760nm-780nm &1220 nm and the triple feature 1520-1600 nm has been recorded. The resistivity data shows low resistivity which means high conductivity, indicating salinization.This study clearly elucidate different spectral reflectance at both the location.**

***Key words:* Hyperspectral analysis, Shrimp farming, Electrical resistivity , Soil salinity**

I. Introduction

Over the past decade hyperspectral image analysis has matured into one of the most powerful and fastest growing technologies in the field of remote sensing. It is an advanced technique for getting large number of measured wavelength bands in a single pixel. Hyperspectral images are spectrally over determined, which means that they provide ample spectral information to identify and distinguish spectrally unique materials. Thus hyperspectral imagery provides the potential for more accurate and detailed information extraction than possible with any other type of remotely sensed data (Goetz et al. 1985). The hyperspectral sensors are available to provide both high spatial and high spectral resolution with high signal/noise ratio recently.With the development and perfection of the hyperspectral remote sensing technologies, it has been the major technique applied for mineral mapping (Clark 1999) to detect soil properties including moisture, organic content, and salinity (Ben-Dor, 2000) to identify different vegetation species (Clark 1999),to study plant canopy chemistry (Aber and Martin, 1995), and detect vegetation stress (Merton and Harvey 1997). Military personnel have used hyperspectral imagery to detect military vehicles under partial vegetation canopy, and many other military target detection objectives.

Aquaculture is one of the fastest growing food producing sectors and contributes over 45% of world fish supplies for human consumption (FAO 2010). Over 500 million people in developing countries depend directly or indirectly, on fisheries and aquaculture for their livelihoods. Brackishwater aquaculture is prominent in coastal area and its impacting the coastal people economically in a major way utilizing the marginal land and water. But environmentalists elsewhere have raised many issues over the development of brackishwater aquaculture and salinization of soil and water resources is one of then. This has prompted this study to look into the salinization in coastal watershed which is already being influenced by sea water intrusion and the perennial flow of brackishwater creeks. Attempts is made to

978-1-4673-5584-1/12/$31.00©2012 IEEE

ascertain the nature and the extent of salinization. The problem of mapping salt-affected soils is known to be a difficult matter being a dynamic process. Soil salinization is a process in which dissolved salts concentrate on the soil surface and in the upper soil layers. But, using hyperspectral analysis mapping and monitoring degraded lands, especially in salt-affected soils, have shown great promise of enhanced speed, accuracy and cost effectiveness (Mermut and Eswaran, 2001). This approach of delineating soil salinity has been proved in many recent studies to be most efficient (Csillag et al., 1993; Eldeiry et al., 2005; Tamas & Lenart, 2006).

The main objective of this research paper is to establish the best hyperspectral wavelength for soil salinity assessments. The selection of suitable wavelength for assessing the soil salinity not only improves classification accuracy but also aid dimensionality reduction that substantially reduces computational time. The information obtained will be helpful in planning strategy for reclamation and optimal utilization for sustainable development in and around shrimp farming region.

II. METHOD AND MATERIALS

A. Study site

The study area selected lies between 11.47 and 11.45 North latitude and 79.72and 79.73 East longitudes of Chidambaram Taluk, Cuddalore district, Tamil nadu (Fig: 1). Based on reconnaissance survey two sites were selected. The first site being shrimp farming area (Site A). The shrimp farming activity in the selected area extends to more than 70 ha and it is the major cluster of farming in the watershed. The second site is near to perennial brackishwater creek where there is no shrimp farming(Site B). Geographical position of the sampling points was recorded by using a Garmin E-Trex GPS. Totally six points have been analysed hyperspectrally. The area frequently presents a shallow water table due to the rise of the Vellar river and the area corresponds to a flood plain. Loamy soil is the predominant soil type in study area. Both the sites selected were spatially homogeneous over sizeable areas and therefore potentially the most suited to image-based mapping. Moreover similar geology and soil type exists at both these sites. Hyperspectral analysis, Geophysical survey and detailed landscape descriptions were obtained at both these sites, Site A and Site B (Fig: 1).

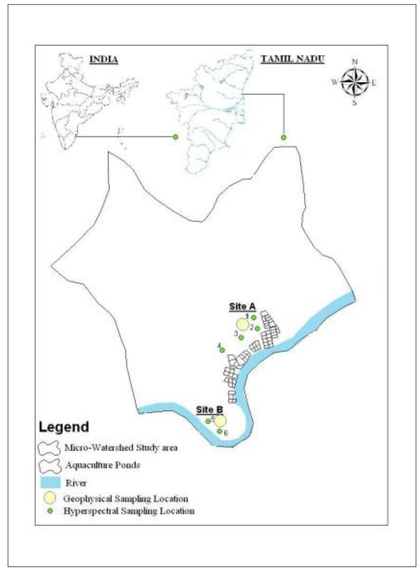

Fig: 1. Micro-Watershed study area.

B. Data used.

The hyperspectral image data used in this work is collected from EO1 Hyperion sensor on 14 February 2009 in path and row of 142 & 52. Hyperion is a push-broom imager with 242 bands covering the spectrum from 400nm - 2400nm with 10nm width. On the ground, the Hyperion sensor's pixels are approximately 30 meters by 30 meters and its imaged lines are close to 7.7 km wide. (Folkman et al. 2001, Ungar et al. 2003). The Hyperion sensor covers the visible and near infra-red (VNIR, or 400 nm to 1000 nm) and shortwave infra-red (SWIR, 900 nm to 2500 nm) ranges. The reference spectra from each hyperspectral pixel contain detailed structure; such as narrow absorption features. The Spectral wavelength analysis was done using ERDAS 9.1 software.

C. Insitu salinity using Electrical resistivity.

The *insitu* salinity was measured using electrical resistivity survey. The method used was the Vertical Electrical Sounding (VES). VES introduce an electrical current into the soil through current electrodes at the soil surface and the difference in current flow potential is measured at potential electrodes that are placed in the vicinity of the current flow. The VES survey is widely used in the identification of salinaitization study (Nouri et al., 2008; Martinez et al., 2009; Calvache, et al., 2011). Vertical electric resistivity soundings were performed on a N-S & W-E trending profile situated at site A &

site B, VES points were situated at 50 m interval and a maximum AB/2 = 100 m was deployed (Georgescu et al., 1993). Since only qualitative interpretation was intended for resistivity changes in the aquifer the electrical resistivity results obtained using VES were displayed as resistivity pseudosections aiming to avoid any distortions determined by inversion techniques (Georgescu et al., 2010). Soil salinity can be measured upto a depth ranging from surface to 3m depth (McNeill, 1997; Rhoades and Corwin, 1981). The data was analyzed using IPI2WIN software.

D. Spectral Analysis

There are many unique image analysis algorithms that have been developed to exploit the extensive information contained in hyperspectral imagery. Most of these algorithms also provide accurate, although more limited, analyses of multispectral data. Spectral analysis methods which has been used in the present study. In this method the pixel spectra at two locations Viz., near shrimp farming region and near the brackishwater creek has been compared with ground truth information using electrical resistivity method. GM methods have proven to be very effective in locating salinity areas, mapping the extent and intensity of salinization, and locating potential salinity. Measuring ground conductivity noninvasively and estimate soil and water salinity at depths ranging from less than 1 to more than 50 m (less than 1 to 3m depth nearly close to soil salinity) [De Jong et al., 1979; Williams and Fidler, 1985].Thus two methods have been developed for determining soil salinity at field scales: (i) Spectral wavelength analysis (ii) in situ measurement of electrical resistivity (ER).

In this study, due to atmospheric radiation absorption, some bands in the spectral ranges 850-1,065 nm; 1,400-1,450 nm and 1,800-1960 nm are not considered. Also, data in 400-430nm are not considered due to spectral inconsistencies. The removal of bad bands and noise are carried out manually (Pearlman et al. 2003). In site A, four locations (profile 1, 2, 3 & 4) and site B, two locations (profile 5 & 6) were selected for spectra wavelength.

III. RESULTS AND DISCUSSIONS

A. Spectral reflection

In site A, spectral wavelength from 430 – 850nm as shown in the Fig: 2a it is evident that all the four profiles near to aquaculture are traveling in close proximity at same wavelength and reflectance. Similarly in range of 1065-1800nm also all the four profiles of site A travels in the same wavelength and reflectance till 1400nm and then it splits in little different wavelength as clearly depicted in Fig: 2b. In the spectral wavelength of 1960 – 2400nm the Fig 2c shows that again all the four profiles of shrimp farming regions are traveling together in nearby reflectance and wavelength. It clearly shows the reflectance of all the profiles from shrimp farming regions are imitating same manner.

From the Fig 2a, it is very evident that the spectral reflectance from the site B (locations near to the perennial brackishwater creek) is higher than those from the shrimp farming area. Moreover it also contains distinct doublet absorption feature with peaks centered near 500 nm in profile 5 & 6 and 760nm, 780nm. In the Fig 2b, it could be seen that the profile 6 which is from the site B is significantly having higher reflectance than the other five profiles. Also it is at peak at 1220 nm feature and also has a sinusoidal feature t near 1520-1600 nm. Similarly in the wavelength of 1960 – 2400nm as in fig 2c the profiles 5 and 6 both from the site B have higher reflectance than the other four profile.

This hyperspectral analysis clearly shows that both sites have different wavelength and reflectance. Site B is showing high reflectance.

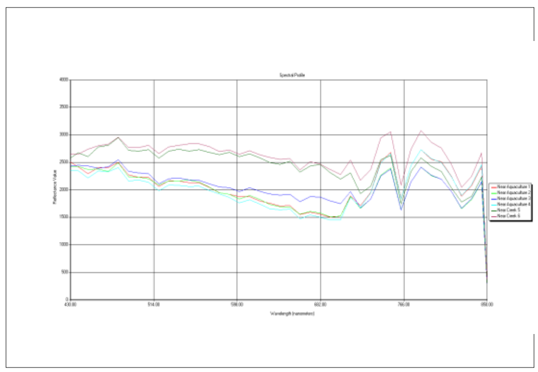

Fig: 2a. Spectral wavelength between 430nm-850nm

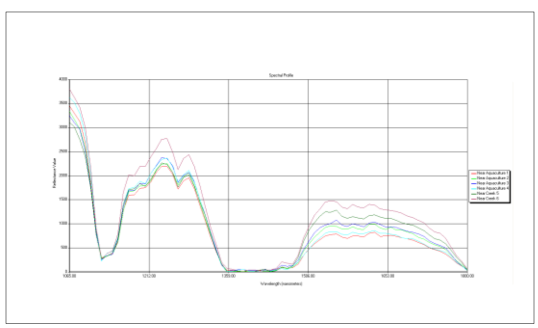

Fig: 2b. Spectral wavelength between 1065nm-1800nm

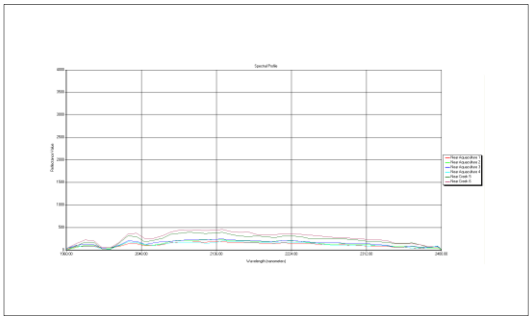

Fig: 2c. Spectral wavelength between 1960nm-2400nm

B. Electrical resistivity

The result of geophysics analysis (Fig:3) revealed that in site A, the value ranges from 860 to 1500 Ωm from surface to 6m depth. This obviously shows there is no salinization at the surface level. But in site B, the resistance exists in the range of only 71 to 80 Ωm which indicate the low resistivity exists. This implies salinity occurs at top of surface.

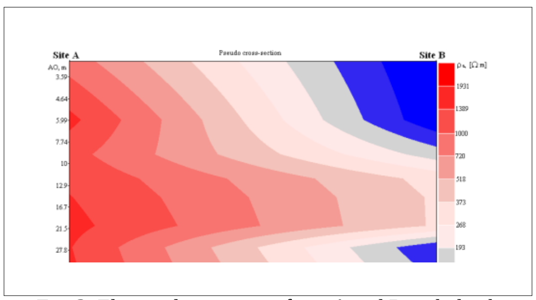

Fig: 3. Electrical resistivity of site A and B with depth

IV. Summary and Conclusion

Integrating both these method, the analysis visibly shows that spectral reflectance and wavelength at site A location which is near to shrimp farming area are emitting equivalent type of reflectance and soil properties at all the four locations in the site A are similar. By electrical resistivity survey high resistivity values were observed indicating there is no salinization. But in site B location, The conspicuous high spectral wavelength and features at 500 nm, 760nm-780nm &1220 nm and the triple feature 1520-1600 nm has been recorded. The resistivity data shows low resistivity which means high conductivity, indicating salinization. NEERI (1995) and others indicated that the problem of salinization due to shrimp farming were site specific and the magnitude of problem are very low. This study indicates similar observation and counteract the risk of salinisation by the shrimp farming activity. However, detailed study at different locations needs to be done further to conclude this findings firmly.

Reference

[1] Aber, J. D., Martin, M. E. (1995). High Spectral Remote Sensing of Canopy Chemistry, In: Summaries of the Fifth Annual JPL Airborne Earth Science Workshop, Vol. 1, AVIRIS Workshop (Ed: R.O. Green), January 23-26, 1995. NASA Jet Propulsion Laboratory publication 95-1, Vol.1, p1-4.

[2] Ben-Dor, E.; Inbar, Y. & Chen, Y. (1997). The reflectance spectra of organic matter in the visible near-infrared and short wave infrared region (400–2500 nm) during a controlled decomposition process. Remote Sensing of Environment, Vol. 61, No. 1 (July 1997), pp. 1-15, ISSN 0034-4257.

[3] Calvache, M. L.; Duque, C.; Gomez Fontalva, J. M.; Crespo, F. (2011). Processes affecting groundwater temperature patterns in a coastal aquifer. Int. J. Environ. Sci. Tech., 8 (2), 223-236.

[4] Clark, R., 1999. Spectroscopy of Rocks and Minerals and Principles of Spectroscopy', in Rencz.A (ed), Remote Sensing for the Earth Sciences, Manual of Remote Sensingedn, 3, John Wiley and Sons, New York pp. 3-58.

[5] Csillag, F.; Pasztor, L. & Biehl, L.L. (1993). Spectral band selection for the characterization of salinity status of soils. Remote Sensing of Environment, Vol. 43, No. 3 (March 1993), pp. 231-242, ISSN 0034-4257.

[6] De Jong, E., A.K. Ballantyne, D.R. Cameron, and D.W.L. Read. 1979. Measurement of aparent electrical conductivity of soils by an electromagnetic induction probe to aid salinity surveys. Soil Sci. Soc. Am. J. 43: 810-812.

[7] Eldeiry, A. A., and L. A. Garcia. 2008. Detecting soil salinity in alfalfa fields using spatial modeling and remote sensing. Soil Science Society of America Journal 72:201–211.

[8] FAO, (2010) The state of world fisheries and aquaculture. Food and Agricultural. Organization. Rome. 197 pp.

[9] Folkman, M., Pearlman, J., Liao, L. & Jarecke, P., 2001. EO-1/Hyperion hyperspectral imager design, development, characterization, and calibration. Hyperspectral Remote Sensing of the Land and Atmosphere, Proceedings of SPIE, 4151, pp. 40-51.

[10] Georgescu P., Dinu C., Niculescu V., Ion D., 1993. Some applications of VES to groundwater exploration in the vicinity of Romanian coast of the Black Sea. Revue Roumaine de Geophysique, vol. 37, p.113-121.

[11] Georgescu P., Ioane D., Niculescu B.M., Chitea F., 2010. Geoelectrical investigations of marine intrusions on the Romanian Black Sea shore. Geo-Eco-Marina 16, p.85-92, Bucharest.

[12] Goetz, A. F. H., Vane, G., Solomon, J. E., and Rock, B. N., 1985, Imaging spectroscopy for Earth remote sensing. Science, 228, 1147–1153.

[13] Martinez, J.; Benavente, J.; Garcia-Arostegui. J. L.; Hidalgo, M. C.; Rey, J., (2009). Contribution of electrical resistivity tomography to the study of detrital aquifers affected by seawater intrusion-extrusion effects: The rivel Velez delta (Velez-Malaga, southern Spain). Engin. Geol., 108 (3-4), 161-168 .

[14] McNeill, J. D. (1997). The application of electromagnetic techniques to environmental geophysical surveys, Geological Society (Editor), London, Engin. Geol. Spec. Pub., 12, 103-112.

[15] Merton, R. N., Harvey, L. E. (1997). Analysis of Seasonal Changes in Jasper Ridge Vegetation Biochemistry and Biophysiology Using Multi-Temporal Hyperspectral Data. ASPRS Conference, Seattle, WA. 6-10 Apr 1997.

[16] Mermut, A.R., & Eswaran, H. (2001). Some major developments in soil science since the mid-1960s. Geoderma, Vol. 100, No. 3-4 (May 2001), pp. 403 -426, ISSN 0016-7061.

[17] NEERI., 1995. Investigation report on impacts of aquaculture farming, and remedial measures in ecologically fragile coastal areas in the states of Andhra Pradesh and Tamil Nadu. Submitted to Hon'ble Supreme Court. National Environmental Engineering Research Institute, Nagpur, India, 143 p.

[18] Nouri, J.; Danehkar, A.; Sharifipour, R. (2008). Evaluation of ecotourism potential in the northern coastline of the Persian Gulf . Environ. Geo., 55 (3), 681-686.

[19] Pearlman, J.S., Barry, P.S., Segal, C.C., Shepanski, J., Beiso, D. & Carman, S.L., 2003. Hyperion, a Space-Based Imaging Spectrometer. IEEE Transactions on Geoscience and Remote Sensing, 41(6), pp. 1160-1173.

[20] Rhoades, J. D., D.L. Corwin, and G.J. Hoffman. 1981. Scheduling and controlling irrigations from measurements of soil electrical conductivity. Proc. ASAE Irrigation Scheduling Conference, Chicago, IL., Dec. 14, 1981. pp. 106-115.

[21] Tamas, J., and C. Lenart. 2006. Analysis of a small agricultural watershed using remote sensing techniques. International Journal of Remote Sensing 27:3727–3738.

[22] Ungar, S.G., Pearlman, J.S., Mendenhall, J.A. & Reuter, D., 2003. Overview of the Earth Observing One (EO-1) Mission. IEEE Transactions on Geoscience and Remote Sensing, 41(6), pp. 1149-1159.

[23] Williams, B. G., and F.-T. Fidler, 1985, The use of electromagnetic induction for locating subsurface saline material, in F. X. Dunin, ed., Relation of groundwater quantity and quality: Wallingford, Oxfordshire, United Kingdom, IAHS Press, IAHS Publication 146, p. 189–196.