FOR OFFICE USE ONLY

Geo-Spatial Lab

With the Infrastructure support from
AMNEX InfoTechnologies, Ahmedabad

LAB PROJECTS REPORT
May 2022

Dhirubhai Ambani Institute of Information and Communication Technology - DAIICT
Gandhinagar 382007
Gujarat (India)

Contents

A. Government agency sponsored projects:

1. Desertification and Land Degradation: Monitoring, Vulnerability Assessment and Combating Plans

Project Details:

1. Title of the project	:	Desertification and Land Degradation: Monitoring, Vulnerability Assessment and Combating Plans
2. Funding Agency	:	Space Applications Centre, Indian Space Research organization(SAC-ISRO) Ahmedabad.
3. Name of the Institute	:	Dhirubhai Ambani Institute of Information and Communication Technology - DAIICT, Gandhinagar-382007
4. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT
5. Name of the co-project in charge	:	Dr. Suman Mitra Professor, DAIICT
6. Date of start of project	:	4th July 2017
7. Date of end of project	:	30th September 2021
8. Contact Details	:	Phone: (Office) +91-79-30510649 Phone: (Lab) +91-79-30510697

Project Objectives:

Abstract 1: Desertification and Land Degradation Vulnerability assessment

Desertification and Land Degradation risk is one of the major environmental and socio-economic problem which constantly affects the global environment. Reduction or loss of land productivity caused by natural processes and human activities is land degradation which leads to desertification. The flaw in any system can be measured by basic concept of vulnerability. In the present study, desertification vulnerability assessment was carried out using geographic information system (GIS) for mapping sensitive areas using Mediterranean Desertification and Land Use (MEDALUS) approach, which identifies such sensitive areas on the basis of an index in which environmental quality as well as anthropogenic factors are included as layers for four districts(eg. Surendranagar, Panchahal, Sabarkantha, Bhavnagar) of Gujarat state in India. Many aspects of vulnerability arising from natural and human factors were considered in this study. Soil, climate, land utilization, geography and vegetation contribute in the land degradation of any area. Indices related to these factors have been generated. Socio-economic factor is a one of the major input to assess desertification vulnerability as anthropogenic

activities. As a result in this study MEDALUS model has been used for both natural and socioeconomic factors for finding the severity level of the desertification vulnerability in four districts of Gujarat.

Abstract 2: Action plans for Combating Desertification and Land Degradation

"Desertification" is land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities, said by UNCCD. 30% of India's total geographical area being affected by land degradation and to prevent it combating plan for land degradation is necessary. From multi-date satellite data and ancillary information with other thematic maps, e.g. Land use/ land cover, vegetation cover, land capability and slope are prepared. Realizing the importance of adopting an integrated approach, and recognizing the mutual interdependence of natural resources, thematic information is integrated using python programming platform. In order to integrate various themes, firstly, land use/ land cover layer is integrated with vegetation cover layer. The resultant of these two themes is unionized with slope and finally with land capability. The resultant coverage has the basic information of all the four themes- land use/ land cover, vegetation cover, land capability and slope and referred in resource data base. Various map units known as composite land development units (CLDU) are created in this composite layer. Overall methodology for combating desertification is given in figure 2 below. Based on the CLDU characteristics various measures are suggested for conservation and protection of natural resources.

Abstract 3: Predictive Soil Mapping using machine learning algorithms.

Soil properties play an important role in desertification process. Desertification causes soil degradation and severely reduces potential land productivity. Due to this process degradation of the ecosystem and its associated ecosystem services. There are several soil properties through which one can get an idea about the soil condition. Soil properties information can indicate the status of the soil desertification of the particular region. Different Soil properties play different roles in the soil system.

Soil Electrical Conductivity (SEC) is a measure of the amount of soluble salts in soil (salinity of soil). It is an important indicator of soil health. It is a measurement that correlates with soil properties that affect crop productivity, including soil texture, drainage conditions, and organic matter level, salinity, and subsoil characteristics. The electrical conductivity of soils varies depending on the amount of moisture held by soil particles. Sand has low conductivity, silt has medium conductivity, and clay has high conductivity. Consequently, SEC correlates strongly to soil particle size and texture. In addition to SEC values separating variations in soil texture, SEC has been shown to relate closely to other soil properties used to determine a field's productivity. So, for different uses mapping of SEC in soil is important. Same way

Soil pH is also correlates with the soil salinity. So, in this study Soil pH and SEC both prediction algorithm has been developed based on Prediction Soil Mapping or Digital Soil mapping model.

Abstract 4: Desertification and land degradation status mapping for Gujarat State

Desertification and Land Degradation Status Mapping at 1:50,000 scale is carried out in 4 district of Gujarat State. These districts/sub-basins have been selected based on list of districts identified as drought prone under Drought Prone Areas Programme (DPAP) of Department of Land Resources, Ministry of Rural Development, Government of India and/or chosen by the concerned state department/academic institute based on their priority. Below is the districts where the desertification status mapping has carried out at 1:50,000 scale.

Table1: Lists of Districts for 1:50,000 scale mapping

S.No.	State	District
1	Gujarat	Bhavnagar
2		Panchmahal
3		Sabarkantha
4		Surendranagar

2. Detection of Heavy Metal Pollution in Vegetation and Characterization of Soil Clay Minerals using AVIRIS-NG Data

Project Details:

1. Title of the project	:	Detection of Heavy Metal Pollution in Vegetation and Characterization of Soil Clay Minerals using AVIRIS-NG Data
2. Funding Agency	:	Space Applications Centre, Indian Space Research organization(SAC-ISRO) Ahmedabad.
3. Name of the Institute	:	Dhirubhai Ambani Institute of Information and Communication Technology - DAIICT, Gandhinagar-382007
4. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT
5. Name of the co-project in charge	:	Dr. P.S. Kalyan Shashidhar Associate Professor, DAIICT
6. Date of start of project	:	:19 December 2017
7. Date of end of project	:	31 December 2020
8. Contact Details	:	Phone: (Office) +91-79-30510649 Phone: (Lab) +91-79-30510697

Project Objectives:

Abstract 1: To study heavy metal contamination using combination of biochemical and hyperspectral data.

Hyperspectral images provide rich spectral information that can be used for determining more detailed spectral properties due to continuous narrow bands and timely availability. The concentration of heavy metal in plant is an important indicator of pollution stress in surrounding environment. Detection of heavy metal concentration in plants is a challenge for realizing the full potential of hyperspectral technology due to their low concentration in plant leaves and absence of evident physical absorption feature. To establish the presence of heavy metal in plants from satellite data and for validation purpose reference contaminated spectra at various levels of heavy metals is required for particular crop. To achieve this, study was carried out in four major steps:

• Spectral signature studies for Lead and Cadmium for tobacco and cotton in controlled pot experiment using hand held Spectroradiometer ASD (Analytical Spectral Devices, Inc., Boulder, CO, USA) at different heavy metal concentrations and growth stages of plants. Spectral decomposition of Spectroradiometer reflectance data using Wavelet method and its

correlation with actual heavy metal content to find the most affected wavelength region due to heavy metal stress.

• Classification of Cotton and Tobacco from AVIRIS-NG data of Surendranagar and Anand study area.

• Reference spectral profile with Pb contamination in cotton and Cd contamination in tobacco is generated showing various level of contamination.

• Implementation of spectral matching technique, Dynamic Spectral Warping (DSW) for detection of heavy metals pollution in the particular crop using AVIRIS-NG data.

• Based on the spectral analysis detailed wavelet coefficients were selected for pure profile generation of cotton and tobacco with lead and cadmium contamination. Three classes were selected for classification based upon their availability in plants.

• Heavy metal pollution maps of cotton and tobacco were prepared with various level of pollution for both the study area.

Study Area description & Data used

The level-2 surface reflectance AVIRIS New Generation (NG) data was used for research.

Study area	**Target**	**Heavy Metals and Clay minerals**	**Data**
Anand	Heavy metal contamination in Tobacco plants	Lead and Cadmium	Spectroradiometer (ASD) and AVIRIS-NG Data
Surendranagar	Heavy metal contamination in cotton plants	Lead and Cadmium	Spectroradiometer (ASD) and AVIRIS-NG Data

Abstract 2: To characterize clay minerals using chemical analysis and hyperspectral data

One of the vital constituents of soil is clay minerals such as kaolinite, montmorillonite. The chemical and physical composition of clay minerals has specific absorption of reflection at different wavelengths related to clay minerals present in the soil. The soil clay mineral analysis was carried out in different stages:

• Ground truth points with dominance of different clay minerals like Kaolinite, Montmorillonite and Illite were selected following SFF analysis of AVIRIS – NG data. The standard spectral feature fitting algorithm using the spectra from USGS Spectral library for different minerals was carried out on AVIRIS-NG dataset. Points for ground truth were selected of both Udaipur and Ambaji.

• Soil samples were collected from the selected ground points for X- Ray diffraction analysis. Purposive sampling was carried out based on the requirement for clay abundance mapping as well as ease of collection. Mostly barren fields adjacent to roads were selected for sampling.

• The clay fraction was extracted from the soil samples for XRD analysis as per the procedure mentioned in "A laboratory manual for X-ray diffraction" by U. S.Geological Survey. X- Ray diffraction was carried out on the clay fraction of the soil to identify the dominant minerals.
• Mineral abundance mapping was done using linear regression analysis of Absorption Peak Depth (APD) obtained from AVIRIS-NG data for the samples with known mineral content.

Study Area description & Data used

The level-2 surface reflectance AVIRIS New Generation (NG) data was used for research.

Study area	**Target**	**Heavy Metals and Clay minerals**	**Data**
Ambaji	Clay mineralogy	Montmorillonite, Kaolinite, Illite	XRD and AVIRIS-NG Data
Udaipur	Clay mineralogy	Montmorillonite, Kaolinite, Illite	XRD and AVIRIS-NG Data

B. Consultancy Project:

1. Title of the project	:	Pre Harvest Cotton Yield Prediction – A Machine Learning Based Approach
2. Funding Agency	:	Amnex Infotechnologies Limited, Ahmedabad
3. Name of the Institute	:	Dhirubhai Ambani Institute of Information and Communication Technology - DAIICT, Gandhinagar-382007
4. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT
5. Name of the co-project in charge at funding agency	:	Thamizh Vendhan
6. Date of start of project	:	1th December 2019
7. Date of end of project	:	31th March 2020

Abstract:

Crop Cutting Experiment (CCE) is one practice followed in our country for estimating pre harvest crop yield across all crops and states. However CCE is labour intensive task and the quality of data cannot be guaranteed in large countries like ours. Thus, automated mechanisms using survey data and other variables related to crop-growth , weather and soil properties are used to model crop yield. These approaches work well when plentiful data of high quality is available. But, such data are typically not available in our country. Thus an automated mechanism where hand-crafted features are not needed is most sought. This inspired the use of remote sensing data which is available globally and relatively inexpensive for prediction of pre harvest crop yield. The project is aimed to develop a machine learning based model to predict yield of cotton crop in Botad and Bhavanagar District of Gujarat, using remote sensing data and CCE data from approximately 700 CCE sites of both the districts during 2017 to 2019.

Students projects 1:

1. Title of the project	:	Predictive Mapping of Soil Organic and Inorganic Carbon Stocks over DA-IICT Campus
2. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT
3. Name of the student	:	Srikumar Sastry (B.Tech)

Abstract:

DA-IICT campus has varied species of trees, bushes and exotic flowering plants. A vital factor to keep the campus carbon neutral is to evaluate carbon sequestration by reporting the soil carbon stocks and examining its spatial and temporal distribution. In this study, a methodological approach was used to build a predictive model for topsoil Soil Organic Carbon (SOC) and Soil Inorganic Carbon (SIC) and to determine the dependence of environmental covariates on these. Total 58 soil samples were collected across the campus based on Latin Hypercube Sampling and ecosystem division strategy. SOC varied between 1.76-23.89 tC/ha while SIC varied between 0.75-3.36 tC/ha. Monthly data of 11 environmental covariates were compiled including vegetation indexes, DEM and climatic variables at a minimum spatial resolution of 10m between 2018-2020. Three different data preprocessing methods, for dimensionality reduction were separately used viz PCA, RFE and wavelet transform. Three different prediction methods have been compared viz. Ordinary Kriging, Regression Kriging and Stacked Regression model. The Stacked Regression model using Kernel Ridge Regressor, Random Forest and XGBoost Regressor gave the best performance with R 2 value of 0.81 and an MSE of 0.015. Using this model, the total SOC and SIC stock of DA-IICT was computed to be 0.418 TgC and 62.83 GgC upto 15cm depth in the whole campus of 50 acre respectively.

Students projects 2:

1. Title of the project	:	Evaluation of tree species classification methods using multi-temporal satellite images
2. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT
3. Name of the student	:	Srikumar Sastry Arnav Saha (B.Tech)

Abstract:

Tree species classification is an important step towards forest monitoring and biodiversity conservation. This research study evaluates several multispectral image classification techniques for tree species over Ahwa village in Dang district, South Gujarat, India. Multispectral images consisting of 4 bands-R, G, B and NIR collected over 4 months was used. Object-based segmentation using mean shift, cluster-based using K-Means and Gaussian Mixture Model (GMM) and pixel-based methods have been analyzed. Additionally, a new method of classification has been described using the Dynamic Time Warping (DTW) algorithm. It outperformed supervised classification techniques with accuracy over 95%. The GMM+DTW model accurately reflected the actual species distribution found in the ground truth.

Students projects 3:

1. Title of the project	:	Comparison of supervised and unsupervised algorithm for multispectral and hyperspectral data classification
2. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT
3. Name of the student	:	Abhijeet Ghodgaonkar (M.Tech)

Abstract:

Study of two different classification techniques using two types of datasets, Multispectral (MS) and Hyperspectral (HyS), for crop classification. Supervised and unsupervised method of classification Support Vector Machine (SVM) and Autoencoder respectively, were compared using Multispectral (Landsat) and Hyperspectral (AVIRIS) data sets over the same region , Indian Pines.

Students projects 4:

1. Title of the project	:	Rainfall prediction for the state of Gujarat using deep learning technique
2. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT
3. Name of the student	:	Rushikesh Nalla Urmil Kadakia (B.Tech)

Abstract:

Rainfall prediction has been done in the past using infrared and visible spectral data from satellites. In this study, two deep learning methods MLP and LSTM are discussed at length for predicting precipitation at finer spatial (10km x 10km) and temporal (hourly) resolution. These methods are applied by using the multispectral (VIS, SWIR, MIR, WV, TIR1, TIR2) channel data such as cloud top temperature and radiance values of the INSAT-3D satellite (ISRO) as features for the model. We have incorporated texture features of satellite images by considering mean and standard deviation of its neighborhoods. Rainfall depends on the elevation and vegetation on earth's surface so we have used SRTM DEM and AWIFS NDVI respectively. Actual rainfall is obtained from two sources: AWS (point source) and TRMM (10km x10km) resolution. We have created two datasets based on different features and actual rainfall sources. This papers does a comparison between MLP and LSTM models trained using different data-sets. Our results show that LSTM performs better than MLP for balanced class data-sets.

Students projects 5:

1. Title of the project	:	Geometric and Radiometric Assessment of Sentinel-2A and Sentinel-2B sensors
2. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT
3. Name of the student	:	Nishi Doshi (B.Tech)

Abstract:

Landscape monitoring through remote sensing benefits from a time series of observations. Data obtained from multiple satellite systems is integrated in order to enhance the monitoring approaches. Before merging the data, statistical corrections need to be applied to them. In this paper, we perform geometric and radiometric assessment of data obtained from two sensors of Sentinel-2 satellite mission. We perform mathematical and trend analysis to perform assessments on areas near Bhavnagar and Botad district of Gujarat. On the basis of results from experiments, we conclude that the data obtained from both satellites of Sentinel-2 mission can be used interchangeably.

Students projects 6:

1. Title of the project	:	Hierarchical Land Use and Land Degradation Process Mapping - Assessment of Various Digital Techniques
2. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT

3. Name of the student	:	Tanya Garg (B.Tech)

Abstract:

Remote sensing images are essential for various applications be it social or environmental. This study aims at providing methodological options for land use land cover classification, degradation process identification and mapping using multispectral Landsat-8 and LISS-3 imagery. In this project, I propose patch-based CNN architecture, a deep learning architecture to achieve high accuracy on LULC level 1 classification. The results of the CNN model are compared with machine learning algorithms like SVM in different terrain and using different datasets with varying resolutions. The study demonstrates that CNN outperforms SVM with an accuracy of 95% for level 1 land use classification. The study also shows that the choice of resolution matters and pixel-based classification is more suited to low-medium resolution images as opposed to high-resolution images. Further, vegetation degradation in forest areas is assessed in central parts of Gujarat, having deciduous tropical forest cover. Clustering algorithms like KMeans and GMM were applied to NDVI values obtained from satellite reflectance values. The results show that KMeans performs better than GMM. Lastly, land degradation in agricultural areas due to soil salinity is studied, particularly in southeastern parts of Gujarat. Degradation due to high saline nature of soil is very common in arid and semi-arid regions. ML algorithms like SVM are applied to six soil salinity indices. It is demonstrated that these have a high correlation among them and applying dimensionality reduction techniques not only reduces computation time but also improves the performance of the model by increasing the accuracy by about 12%.

Students projects 7:

1. Title of the project	:	Geometric and Radiometric Assessment of Sentinel-2A and Sentinel-2B sensors
2. Name of the project in charge	:	Dr. Ranendu Ghosh Professor, DAIICT
3. Name of the student	:	Abhijeet Ghodgaonkar (M.Tech)

Abstract:

Hyperspectral remote sensing is one of the most exciting fields of remote sensing with enormous amounts of data it produced due to its high spectral resolution. Hyperspectral data has both spatial and spectral components making a data cube which is very large to process. Classification of crops using hyperspectral data is challenging because of small-sized classes and spectral similarity. Multi-crop classification is a big challenge due to the spectrally similar curves between classes. Up till now spectral angle mapper and various GIS techniques

had been used to perform classification. Classification using the machine learning algorithms like Support Vector Machine, Random Forest, k-Nearest Neighbors and Multinomial Logistic Regression are also used for classification. With the advent of Neural Networks and increased computing power, Convolutional Neural Networks have been becoming more important in Image Classification. Agricultural land cover is an important category in Remote Sensing Data and multi-crop classification is a major challenge in it. The collection of the ground truth for all the points are time-taking, so various pattern recognition techniques have to be developed in order to classify the data accurately. Various classical and deep learning models will be addressed in this thesis.

Paper Published:

- “Desertification and Land Degradation Atlas of India (Assessment and analysis of changes over 15 years based on remote sensing)”, Space Applications Centre, ISRO, Ahmedabad, India, Ahmedabad, 2021.

- M. Pandya, V. Dave and R. Ghosh, "Artificial Neural Network (ANN) based Soil Electrical Conductivity (SEC) prediction," 2020 7th International Conference on Signal Processing and Integrated Networks (SPIN), Noida, India, 2020, pp. 581-586.

- Kotta H., Pardasani K., Pandya M., Ghosh R. (2021) Optimization of Loss Functions for Predictive Soil Mapping. In: Hassanien A., Bhatnagar R., Darwish A. (eds) Advanced Machine Learning Technologies and Applications. AMLTA 2020. Advances in Intelligent Systems and Computing, vol 1141. Springer, Singapore.

- Doshi, Nishi, Purvi A. Koringa, and Ranendu Ghosh. "Geometric and Radiometric Assessment of Sentinel-2A and Sentinel-2B sensors." In 2020 7th International Conference on Signal Processing and Integrated Networks (SPIN), pp. 975-980. IEEE, 2020.

- Sastry, Srikumar. "Predictive Mapping of Soil Organic and Inorganic Carbon Stocks over DA-IICT Campus."

- Saha, Arnav, Srikumar Sastry, Viral A. Dave, and Ranendu Ghosh. "Evaluation of Tree Species Classification Methods using Multi-Temporal Satellite Images." In 2020 IEEE Latin American GRSS & ISPRS Remote Sensing Conference (LAGIRS), pp. 40-43. IEEE, 2020.

- Dave, Viral, Megha Pandya, and Ranendu Ghosh. "Identification of desertification hot spot using aridity index." Ann. Arid Zone 58, no. 1–2 (2019): 39-44.

- Dave, Viral A., Megha Pandya, and Ranendu Ghosh. "An Assessment of the Desertification Vulnerability based on MEDALUS model." In 2019 International Conference on Intelligent Computing and Remote Sensing (ICICRS), pp. 1-6. IEEE, 2019.

- Dave, Viral A., and Koyel Sur. "Fuzzy integrated desertification vulnerability model." The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences 42 (2018): 395-401.

- Saha, Arnav, Srikumar Sastry, Viral A. Dave, and Ranendu Ghosh. "Evaluation of Tree Species Classification Methods using Multi-Temporal Satellite Images." In 2020 IEEE Latin American GRSS & ISPRS Remote Sensing Conference (LAGIRS), pp. 40-43. IEEE, 2020.