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Application of Remote Sensing and GIS in Seismic Surveys in KG Basin

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Summary

Remote Sensing provides digital images of the Earth at specific wavelengths of the electromagnetic spectrum. Various features on the earth either natural or man made give distinguishable signature of the electromagnetic radiation. Classification of the remote sensing data into different features aid in various application of the data. For instance, land cover, vegetation type, terrain conditions aid in agriculture etc. There are many other applications of remote sensing data in forestry, ecology, urban & land use planning, hydrology, water & waste management, environment, transportation, archaeological investigations, military observations and geomorphological surveying etc apart from geological applications.

Geographic information system (GIS) is a computer-based tool for mapping and analyzing things on the earth. A GIS stores information of the earth in a collection of thematic layers which are linked together by geography. This simple concept has proven invaluable for solving many real-world problems in oil and gas exploration also.

Geophysical exploration methods and in particular seismic surveys are commonly used in energy sector for discovering new oil and gas fields. Land seismic surveys depend heavily on the surface terrain. The spatial aspect of the surface features have significant influence at all stages of the seismic surveys.

This paper focuses on the Geographic Information Systems and the use of satellite imagery and for seismic surveys in KG Basin during last field season 2008-09.

Introduction

Geophysical exploration methods and in particular seismic surveys are commonly used for discovering new oil and gas fields. Land seismic surveys require tremendous amount of equipment and workforce. They also depend heavily on the surface terrain, i.e. land use and land cover, relief and presence of man-made features such as build-up areas, roads, bridges etc.

Seismic operations consist of several stages, such as planning, field scouting, survey design and project execution. The spatial aspect of the surface features has significant influence at all stages of the seismic project. Initially, the land cover and elevations have to be assessed in order to estimate severity of the logistics and terrain accessibility. Based on this analysis, areas where focused efforts are required can be identified. All the information

gathered during these stages can build up strategy for data acquisition.

The scale of seismic operations and their dependence on the terrain computer-based systems equipped with spatial data and analytical tools can support decision-making and provide significant improvement in the overall project performance.

Remote Sensing & Satellite Imagery

Remote Sensing image data are digital representations of the Earth. Remote sensors are made up of detectors that record specific wavelengths of the electromagnetic spectrum. The electromagnetic spectrum is the range of electromagnetic radiation extending from cosmic waves to radio waves.(Fig-01)



Application of Remote Sensing and GIS

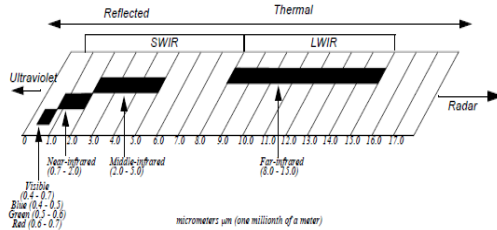


Fig-01: Electromagnetic spectrum

In remotely sensed image data, each pixel represents an area of the Earth at a specific location. The data value assigned to that pixel is the record of reflected radiation or emitted heat from the Earth's surface at that location. The data value is the measured brightness value of the pixel at a specific wavelength.

Image data may include several bands of information. Each band is a set of data values for a specific portion of the electromagnetic spectrum of reflected light or emitted heat (red, green, blue, near infrared, infrared, thermal, etc)

All types of land cover (rock types, water bodies, and so forth) absorb a portion of the electromagnetic spectrum, giving a distinguishable signature of electromagnetic radiation. Knowledge of which wavelengths are absorbed by certain features and the intensity of the reflectance, remotely sensed image can be classified into different features and make fairly accurate assumptions about the scene.

The automatic image classification of the data obtained by satellite imagery can be used to create land cover maps using ERDAS Imagine. Initial, unsupervised classification can lead to defining test / training fields, which can be checked during scouting.

Satellite imagery is generally used for land use / land cover analysis and also used to assess (directly or indirectly) the terrain relief. With high-resolution imagery it is possible to recognize and locate natural features, which is important during the seismic survey. For example, type of vegetation like forest cover, paddy fields, coconut gardens, mangroves, swampy areas, inaccessible water bodies etc can be recognized. These will help in type of equipment to be deployed for each of the various survey activities.

Also, man made features like roads will be used to transport all the equipment and people to the camp and during the project execution in the field. It is also important to locate all objects, which can enforce redesigning seismic profiles (such as inaccessible areas, inhabited places or military areas). All these areas can be located on high-resolution imagery.

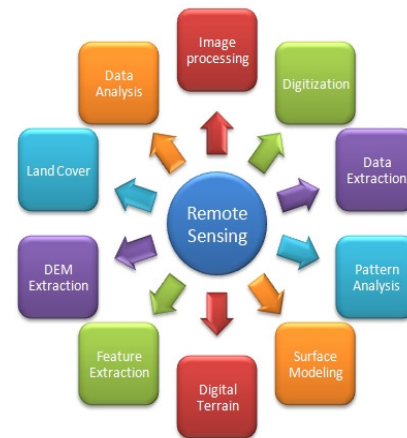


Fig-02: Processing of remote sensing data

The main advantages of the satellite imagery are that it provides an objective description of the whole area of the project. The average size of the 3D seismic survey project identified to be covered in a field season in KG Basin range from 200 to 350 square kilometers. Such large areas cannot be visited and properly assessed during the reconnaissance surveys. (Fig-03)

Geographic Information System

GIS is a tool for spatial data classification, its processing and integrating different types of data. Also it can help to integrate non-geophysical data and data coming from different sources, which have not been widely used before. This includes remote sensing data, such as satellite imagery and digital terrain models and all kinds of general spatial datasets such as DGPS control points, road networks, land use / land cover, water bodies etc. Using such information, it is possible to execute the whole project in terms of various logistics and monitor the progress of seismic data acquisition with more care.



Application of Remote Sensing and GIS

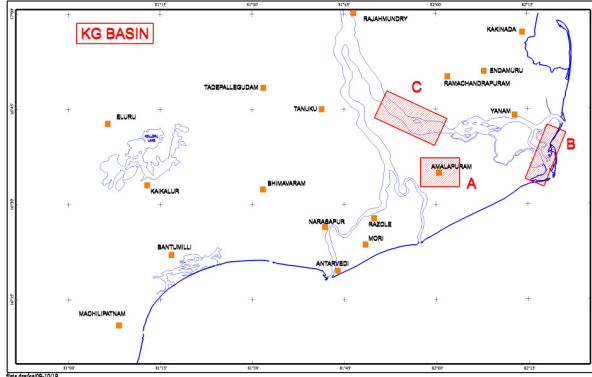


Fig-03 : Location Map KG Basin

Methodology

First, the topographical maps are digitized and georeferenced in ERDAS Imagine Software to the required projection system. Then a mosaic of the topographical maps is generated. Populated towns / villages, roads, drainage, topographic contours and other geographic information are then digitized from this mosaic of topo sheets and populated in the GIS.

The IRS P6 & LISS-IV images are georeferenced to the appropriate projection system in ERDAS Imagine Software.

Combining the Bands 0, 2 and 3 of the LISS-IV images and digitally processing the images using the ERDAS Imagine Software, a land use map is generated from the merged image based on the image classification procedures.

Ground Control Points (GCPs) are selected from the mosaic of georeferenced topographical maps and matched with GPS (GCPs) were done in the field. This also served as a QC of the geodetic survey work.

A typical flow chart is given in Fig-04

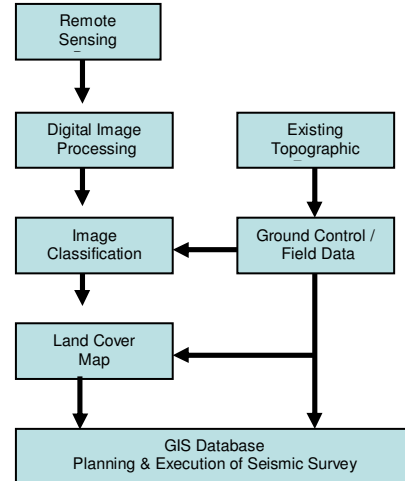


Fig-04: Typical Flowchart

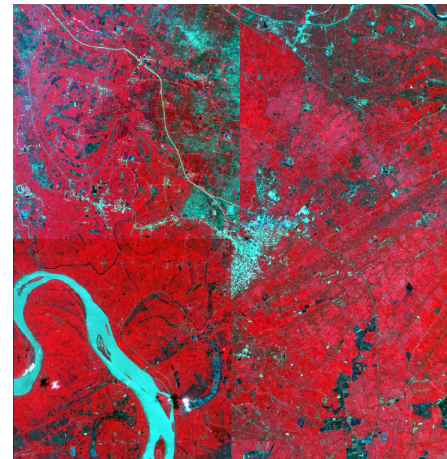


Fig-05: Mosaic of Satellite images

Application

The above methodology was adapted in the following two areas of during the seismic surveys in KG Basin during the last field season 2008-09.



1. Amalapuram Town

The populated town is at the centre of the survey area.(Fig-05) Due to safety distances required to be maintained, the source points were relocated from the pre-plot positions. The seismic coverage under the town was expected to be below the specifications after the planned recovery.

The satellites maps were studied to improve upon the planned recovery. The receivers were planned to be laid out along the roads in a better manner than initially thought. Further, it was seen that some of the shots could be added and few relocated so that the fold coverage can meet the specifications.

The fold map obtained after the actual survey is close to the required specifications.(Fig-06).

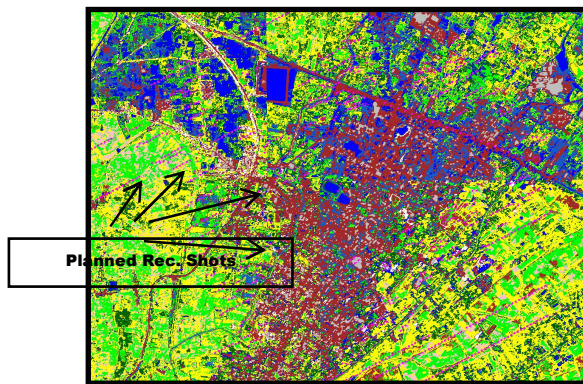


Fig-05 : Classification of the remote sensed image over the Amalapuram town

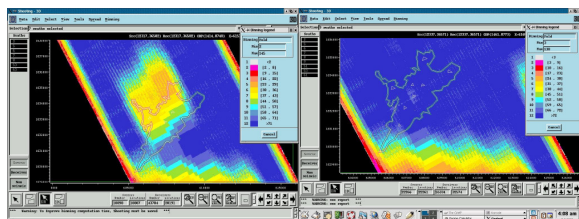


Fig-06 : Actual Fold Coverage after recovery

2. Reserve Forest and Back Waters area

The Kandikuppa Reserve Forest and the back waters covers a large area in the southeastern part of the survey block. (Fig-06) Due to the objective of survey being in the deeper, about 7 Km, and also for merging with the earlier transition zone surveys, it became impossible to leave the area.

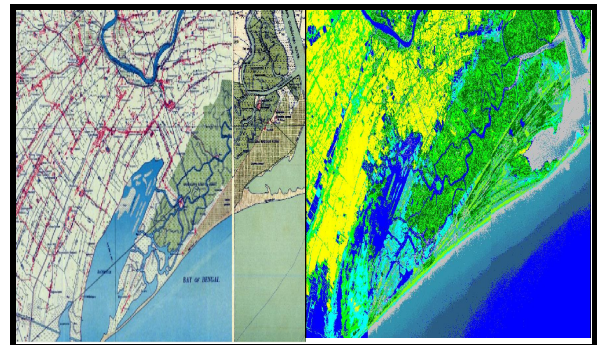


Fig-07 Satellite Image and Topo Sheet comparison over Kandikuppa Reserve Forest.

The land cover map from satellite images have given a birds eye view of the area, which has improved the planning of the surveys in respect of the logistics and risks in the area and to decide the mitigation plans while carrying out the surveys.

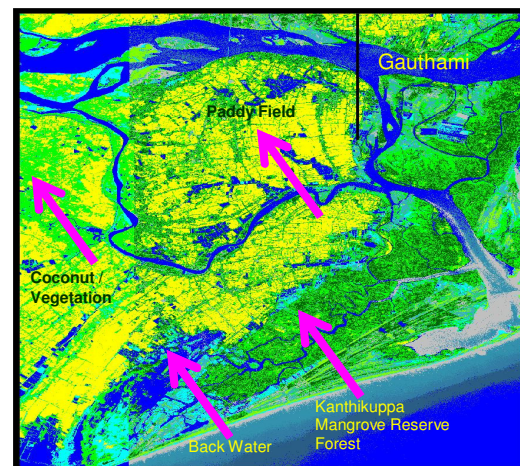


Fig-08 Kandikuppa Mangrove Reserve Forest



The classification of the vegetation of various crops has helped in a better managing the logistics. In areas of coconut vegetation, DGPS signals as well as radio signals were generally poor. Necessary strategies like use of Total Stations, taller antennas for radio communication etc were required to be adopted in such situations. Also, the classification has help in the crop compensations required to be paid depending on the type of vegetation/ crops.

The fold coverage in the back water areas was improved beyond expectation and the coverage was extended very close to the coastline.(Fig-06).

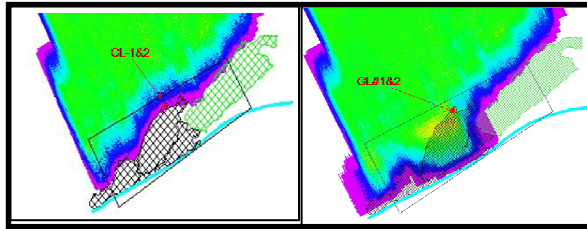


Fig-09: Improvement in actual seismic Coverage

Future Plans

A 3D seismic survey is planned during the current field season 2009-10 across the Godavari River near Mandapeta town in KG Basin.

It is seen from Fig- 08, the changes in the features of the topo sheets and the satellite images. The existing land cover has changed considerably since the preparation of the topo sheets, necessitating the use of the latest satellite imagery.

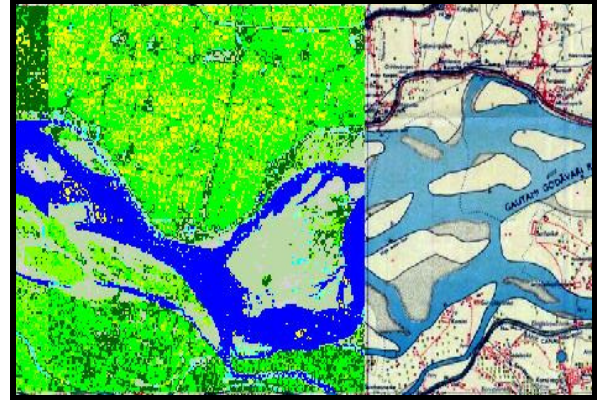


Fig-10: Comparison of Satellite image and corresponding Topo sheet across the Godavari river

Based on the satellite images and Google Maps, the surface land cover and the logistics involved have been analysed prior to scouting of the area. The likely seismic coverage of the area has been mapped. The areas of seismic fold drop are identified which would require suitable recovery programme to fulfill the objectives of the survey.

The total area falling in the river and the sandy patch is about 30% of the total survey area. Such area would require specialized equipment & methods such as hydrophones to be deployed in the river part, which need to be sourced and also for shot hole drilling additional resources like bentonite to avoid collapsing in the sandy patches.

Thereafter, planning need to be done for proper placement of source-receiver layout to obtain the optimum fold coverage along the river patch apart from safety and environmental issues.

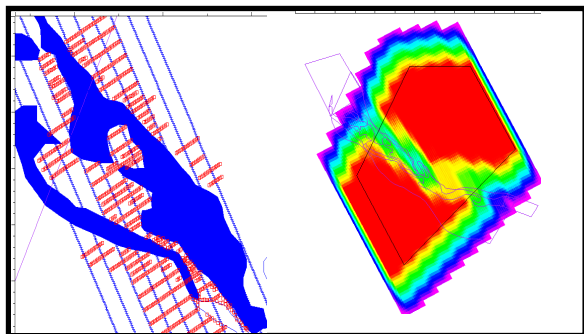


Fig-11: Planned field layout and likely seismic coverage

Based on the use of GIS & Satellite images including Google Maps, the survey work in the area would be carried out in the ensuing field season 2009-10.

Terrain analysis

Digital terrain models (DTM) provide detailed information about the terrain. DTMs can be used to generate elevation profiles for each seismic line and to calculate slopes and relative elevation differences.

The digital terrain model can be generated, based on the field measurements during the survey. An average 3D seismic project consists of several hundreds of measured locations. Measurements are frequently made using GPS, which provides reliable coordinates including elevation. The topographic contours and elevation points can be interpolated using the Triangulated Irregular Network (TIN) method to generate the Digital Elevation Model (DEM).

Safety & Environment

GIS systems integrate seismic data (e.g. location and characteristics of source and receiver points and up-holes) with topographic data (e.g. roads, rivers, water bodies, buildings). This integration of spatial analysis tools results in a powerful solutions. For example, at each of the seismic project so called "safe distances" are used, which are the minimum distances from source points to other objects such as houses or environmental concerns. The idea is to ensure minimum impact on these when generating seismic waves. A typical GIS system provides tools to check

whether all source points fulfill the required safe distances while execution of the seismic surveys..

Conclusions

Seismic surveys are spatial in nature as they depend heavily on the terrain such as land cover and elevation which have a significant impact on the overall performance of the project in terms of quality, time as well as costs.

GIS technologies are valuable tools for creating and developing a robust database integrating the topographic information, satellite imagery and other surface & sub-surface information which can be collated and used for seismic surveys and also geophysical & geological interpretation.

The database can further be useful in the entire E & P activities of the oil companies apart from the environmental impact assessment of these activities.

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