# Risk Management of Overhead Electric Power Lines

KAMRAN HAFEEZ
Department Of Electrical Engineering
COMSATS Institute of Information Technology
Park Road, Islamabad
PAKISTAN
voltagehigh@hotmail.com

*Abstract:* - A Right-of-Way (ROW) is a land corridor over which power line conductors are stationed irrespective of AC and DC Transmission systems. The High voltage direct current transmission (HVDC) line has less width for the right-of- way compare with HVAC (High Voltage Alternating current) transmission line. Vegetation within the right of way poses the most series risk to power line structures. It is important to review vegetation encroachments within the transmission lines corridor to avoid incidents of power interruptions. Trees overgrown and vegetation unchecked in the ROW width may interfere with electric power lines and leads to dead short circuit and eventually tripping of circuit breakers. Frequent interruptions in power supply can result in economic losses to a utility company. Modern tools such as remotely sensed data and Geographic Information systems can be used for vegetation monitoring around Power line structures in a very efficient way. The Normalized difference vegetation Index (NDVI) is a measured indicator that captures the near infrared and visible bands of Electromagnetic spectrum (EM) to assess the vegetation at the desired target. This paper discusses the technical details of vegetation management for Electric power lines monitoring using NDVI indicator map and GPS Co-ordinates showing the exact location of electric towers on ground.

*Key-Words: - Remote Sensing, Geographic Information System, Risk management, vegetation, Electric line*

## 1 Introduction

Electric power lines are located in a piece of land called Right of Way (ROW). Utility company's owner needs the legal permission for the construction of existing and new transmission lines. Power line structures are most vulnerable to the vegetation encroachment within the ROW width which makes it a serious concern for the utility companies. Normally Vegetation encroachment is curbed by indentifying shrubs and trees that could fall and disconnect supply of electricity to the consumers. The procedure normally followed is to cut trees and branches in a scheduled cycle for providing clearance to power line so that access to the electric power lines is improved, and maintenance cost factor is reduced [1].

Remotely sensed data is used to classify and map vegetation in large spatial scales, replacing conventional classify techniques, which requires more cost and time-consuming field surveys. Since early 1960s, multispectral satellite based remotely sensed tools are applied for the classification and capture of vegetation (Landgrebe, 1999). Multispectral remote sensing technologies, in a single observation, captures data in multi spectral bands between the visible and near-infrared region of the EM spectrum [2].

Since last few decades, remotely sensed data using radar technology have been applied for vegetation characterization, crop surveillance as well as yield prediction, mainly based on medium-resolution C- and L-band synthetic aperture radar (SAR) data. Modern radar satellite sensors captures images with pixel sizes as fine as 1 m on the ground. The TerraSAR-X (TSX) satellite delivers X-band SAR data in different modes, allowing the acquisition of images with different swath widths, resolutions and polarizations [3].

The vegetation index measures the quantity of green vegetation in Earth or land, which is helpful information for land cover assessment. Most of the research so far related to the measurement of vegetation, focuses on the performance of satellite spectral measurements (e.g. Landsat multispectral scanner (MSS), Land sat TM, Advanced Very High Resolution Radiometer (AVHRR), SPOT ,High Resolution Visible Image System (HRV), etc.) [4].

The purpose of this study is to monitor the overhead Electric lines by using the NDVI map and GPS Co-ordinates to assess the live vegetation near power line structures

## 2 Background

The main components of the Electric Power line network are:

1. Towers
   The purpose of transmission tower is to keep the electrical conductors at a safer distance.
2. Lightning Arresters
   These are used for the protection of Over head lines against Lightning discharge.
3. Shield wires:
   Its purpose is to protect the electric conductors against lightning discharge
4. Insulators
   High voltage Insulators are used to insulate the towers from the live electric conductors.
5. Conductors
   The overhead electric line conductors are made of Aluminum, strands and steel material as a reinforcement.

A typical electric power line network is shown in (Figure1) below:

**Figure 1. Overhead Electric Power Line**

The ROW width is related to many design parameters, e.g height of tower, and gap between towers, size of conductors, safety clearance, transmission path security, and the terrain features through which the electric conductors will traverse. The other parameters required in planning an electric line include: magnitude of power transfer, distance, environmental impacts, operating cost of the line, and integrations of electric line to the electricity grid. Electric power can be produced in a large magnitude by using different sources such as coal, hydel power, renewable energy and nuclear power [5].

The Minimum Row Widths is shown in (Table 1).

**Table 1.Minimum Right of Way Widths**

| Voltage(Kilo Volts) | Widths range (ft) |
|---|---|
| <230 | 50 to 120 |
| 230 | 76 to 130 |
| 345 | 76 to 150 |
| 500 | 126 to 175 |

## 3 NDVI Indicator and Global Positioning System (GPS)

Vegetation is conventionally analyzed using data from the wavelengths in red (high absorption) and near-infrared (high reflectance) added into the NDVI indicator (Tucker, 1979). The NDVI, is one of the most widely used vegetation indices in the world.

NDVI is presented:

$$NDVI=NIR-RED/NIR+RED \quad (1)$$

Where NIR is the near-infrared wavelengths reflectance and RED is the red wavelengths reflectance. This statistical formula (1) provides a value that has a range from -1 (water) to +1 (stronger vegetation growth). However image band in red is normally used instead of the whole range of Value of Photo synthetically Active Radiation from a pixel (PAR). (Table 2) shows the NDVI values for different land types. NDVI value for water is typically < than 0, bare soils lies between 0 and 0.1 and vegetation > 0.1 [6].

**Table 2. Typical NDVI Values for Different Land Types**

| COVER TYPE | RED | NIR | NDVI |
|---|---|---|---|
| **Densely Vegetation** | 0.1 | 0.5 | 0.7 |

| | | | |
|---|---|---|---|
| **bare soil dry** | 0.269 | 0.283 | 0.025 |
| **Ice and Snow** | 0.375 | 0.342 | -0.046 |
| **Water** | 0.022 | 0.013 | -0.257 |

NDVI indicator shows leaf density, which are main indicators reflecting process of Photosynthesis. SPOT HRVIR and LANDSAT-5 TM are different sensors used for land analysis frequently.

The Global Positioning System (GPS) comprises of 24 satellites moving in earth orbit at an altitude of 20,200 km with an orbital inclination of 55 degree .A GPS receiver at given location determines its location by analysis of signal level received from GPS satellites. Thus, a GPS receiver provides user's three dimensions data i.e longitude, latitude, and altitude. In order to enhance the accuracy of GPS receiver, Differential GPS receiver (DGPS) can be applied [7].

## 4 Methodology

The research methodology of vegetation management for electric power lines monitoring is shown in fig.2.The following is step by step procedure to use NVDVI map and GPS Co-ordinates for electric lines monitoring.

**Step 0**

Selection of study area

**Step 1**

Select multispectral satellite image (geo referenced) of study area

**Step 2**

Collection of GPS Co-ordinates showing exact position of electric towers on ground

**Step 3**

Formation of NDVI map of study area

**Step 4**

Integration of NDVI map and GPS C0-ordinates

**Step 5**

Final layout map

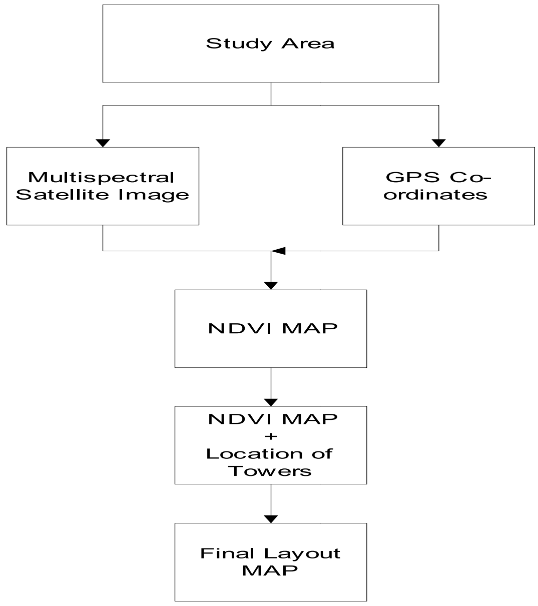


Fig.2. Methodology flow chart

## 5 Case Study

Study area located near Peshawar city [8] is 100 km² (10km × 10km) including land cover types of forest, bare soil, wetland, agricultural land and built-up structures shown in (Figure 3).It has following co-ordinate boundaries

- Min X, Y:(732741.879, 3755994.250)
- Max X, Y:(743244.379, 3766991.75

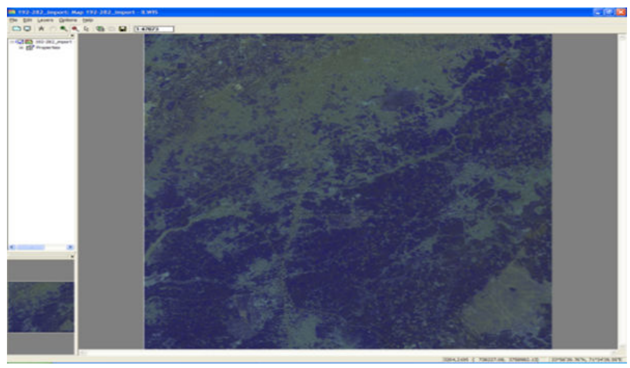

**Figure 3. Study Area**

Multispectral Satellite imagery applied in this paper is from Spot 5. It has 2.5 m Resolution. Satellite data has been processed by using ILWIS image processing software developed by (ITC).The wavelengths of Spot 5 Multispectral image applied in this paper shown in (Table 3).

**Table 3. Wavelengths of Multispectral image**

| SATELLITE | BAND | WAVELENGTHS |
|---|---|---|
| SPOT 5 | Red, NIR | 0.63-0.69, 0.76-0.90 |

The results can be obtained using NDVI Indicator Map and a specific addition of bands used to form color composite image called False Color Composite (FCC as shown in (Figure 3) and (Figure 4) (Minimum value of NDVI 0.08 and Maximum value 0.11). The land in the study area can be classify in different themes or classes as ever green forest, dry evergreen forest, mixed forest, agriculture land, urban area , water region and other areas [9-10].

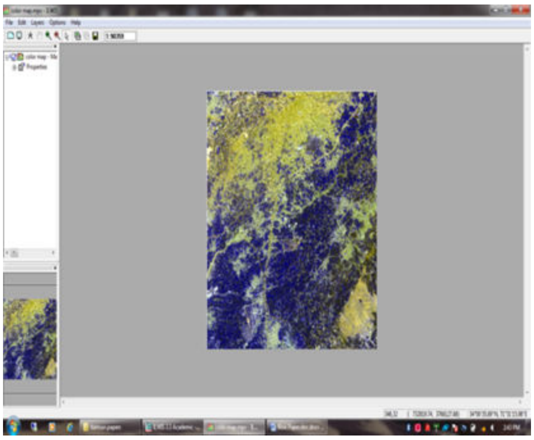

**Figure 3. False color composite**

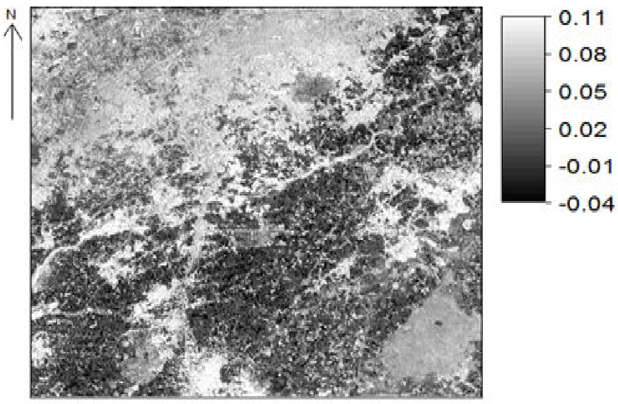


**Figure 4. NDVI Indicator Map( NDVI values) of Study Area**

The GPS Co-ordinates of electric power line is given in table 4.

**Table. 4.**

**GPS location of Electric Power Line towers**

| Towers | GPS Co-ordinates |
|---|---|
| **A** | N 33.932, E 71.546 |
| **B** | N 33.9326 ,E71.547 |
| **C** | N 33.934, E 71.550 |
| **D** | N 33.9353, E 71.554 |
| **E** | N 33.95926 , E 71.585816 |
| **F** | N 33.97143, E 71.600466 |
| **G** | N 33.978583, E 71.606 |
| **H** | N 34.002083, E 71.6113 |
| **I** | N 34.01338, E 71.6102 |

The latitude and longitude graph (geo referenced) is given in Fig.5 where each tower (circle) is shown as a small circle using GPS Co-ordinates.

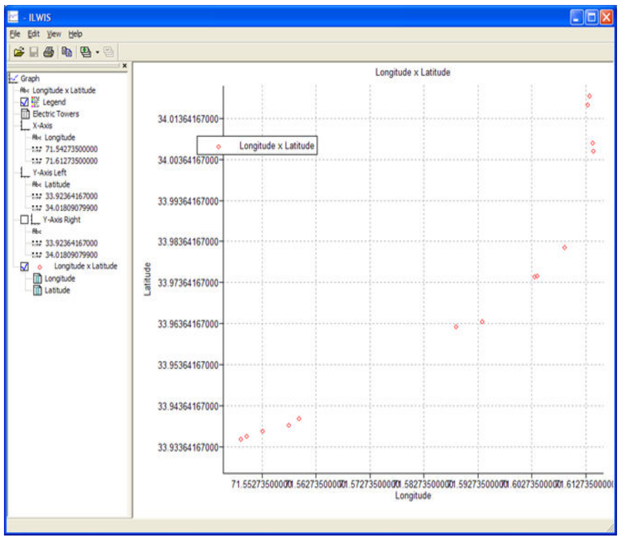


**Fig.5 Location of Towers (Latitude VS Longitude)**

After examining the NDVI map and latitude VS longitude graph a table can be drawn ( Table.5) to monitor the level of vegetation neat electric line towers

**Table. 5. Vegetation Level**

| Towers | NDVI Values | Vegetation Level |
|---|---|---|
| A | 0.01 | low |
| B | 0.01 | low |
| C | 0.03 | low |
| D | 0.02 | low |
| E | 0.04 | low |
| F | 0.10 | medium |
| G | 0.11 | medium |
| H | 0.05 | low |
| I | 0.08 | low |

## 6 Conclusion

This paper presents that monitoring of overhead electric line can be performed using GIS and Remote sensing techniques in an efficient way. The NDVI indicator and GPS location of towers gives details of vegetation level near power line structures and thus maintenance and monitoring is much easier.

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