Use of GIS Tools and Space Technologies for Optimal Transmission Line Routing and Asset Mapping

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SUMMARY

The paper presents the use of Geographical Information System (GIS) and Space Technology tools for power transmission utilities like POWERGRID. National Remote Sensing Centre (NRSC) provides a very useful web-based tool named Bhuvan, which consists of vector as well as raster data layers that are helpful for Optimal Transmission Line Routing, Asset Mapping and its Vulnerability Assessment. Web based GIS tools Bhuvan and open source desktop GIS tool QGIS have been extensively used for these applications. Bhuvan provides Web Map Service (WMS) layers of its thematic services, which are very helpful in the selection of optimal route of a transmission line, and to eliminate preliminary/ walkover survey. As most of the transmission line projects these days come under Tariff Based Competitive Bidding(TBCB) process, GIS tools can play a vital role in the determination of accurate project cost. This paper explains the process of transmission line routing and then the selection of most optimal route using QGIS and Bhuvan services in detail. Asset mapping and their vulnerability studies have also been discussed in brief.

KEYWORDS

NRSC, Bhuvan GIS, QGIS, OSM, WMS.

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INTRODUCTION

Power Grid Corporation of India Limited (POWERGRID) was incorporated on October 23, 1989 under the Companies Act, 1956 with an authorized share capital of Rs. 10,000 Crore as a public limited company, with 58% shares owned by the Government of India. POWERGRID, a Navratna Public Sector Enterprise, is one of the largest transmission utilities in the world. POWERGRID wheels about 45% of the total power generated in the country on its transmission network. The company has a pan India presence with around 139709 Circuit Kms of Transmission network and 220 nos. of EHVAC & HVDC sub-stations with a total transformation capacity of 292543 MVA.

POWERGRID is a Category-I Telecom Licensee operating telecom links on its overhead transmission lines. For Telecom use it has a network coverage of 36,500 km and Points of Presence (PoPs) at 595 locations. POWERGRID is also actively engaged in Distribution sector wherein, cumulatively, till March, 2016, POWERGRID has created infrastructure for electrification of 74,500 villages and service connection were provided to about 36.7 lakh BPL households. Towards integration of Renewable Energy Resources with Grid, POWERGRID is playing an important role including undertaking the development of Green Energy Corridors as well as transmission schemes for 7200 MW Ultra Mega Solar Parks in various states. It is also setting up Renewable Energy Management Centers (REMC) in seven renewable rich states. This would enable forecasting of renewable resources and efficient management of distributed & intermittent renewable generation ensuring efficient utilization of resources.

OBJECTIVES

The main objectives of use of Space Technology in POWERGRID is to optimize the project costs and increase the operational efficiency of its geographically widespread asset base. This is done through mapping of its distributed asset base and analyzing its vulnerability with respect to natural and man-made factors, also considering different disasters with inputs from Space based Earth Observation Satellites. Besides, optimal transmission Line Routing has become a potential area for using space technology. The detailed objectives are as follows:

i. Line Routing

Optimal transmission line routing using Bhuvan and other open source GIS tools and web services in order to:

a. To increase the accuracy of the survey in areas which are not easily accessible.

b. Reduce the man power and man hour delay in line survey.

ii. Asset Mapping and Vulnerability Assessment

POWERGRID is currently managing more than 150000 circuit kilometers of Transmission Lines across India. Keeping the vast transmission infrastructure healthy requires intense monitoring of transmission infrastructure which is generally done manually. With GIS mapping of each Transmission Tower, many aspects of vulnerability assessment and maintenance task planning can be optimized and improved. This shall greatly enhance operation and maintenance management of transmission assets. Further aided with advanced techniques such as airborne patrolling using Helicopters and UAV, greater insight is achieved regarding incipient faults. High resolution satellite imagery provides information regarding Brick Kilns, whose presence near a transmission facility may cause trippings due to increased pollution levels.

Once a POWERGRID asset has been mapped [1] on Bhuvan [2] platform, it can be analyzed based on vulnerability of our asset towards different types of disasters using the disaster management cycle. As Bhuvan holds current and historical data of various disasters, it facilitates analysis of asset data in a structured manner. Based on the analysis, strategy for standard operating procedures for emergencies can be formed for effective mitigation of the impact of disaster.

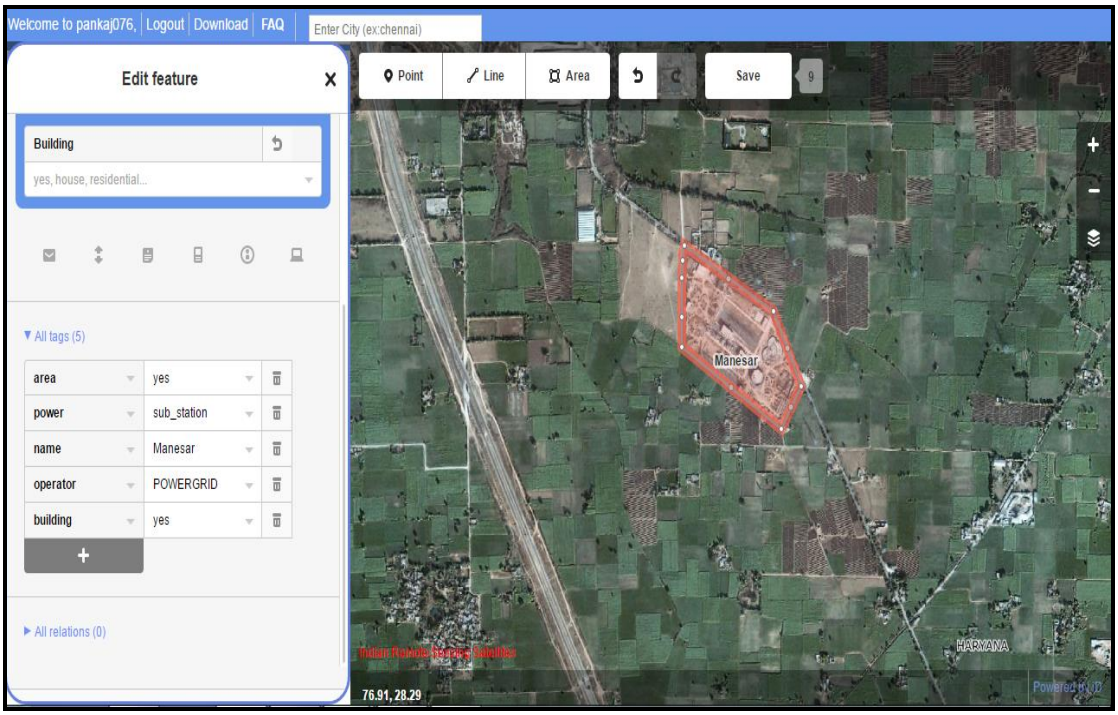

Figure 1: Mapping of Asset (Substation) on GIS Platform

Figure 2: Disaster Management Cycle

From the data provided by NRSC and POWERGRID asset data, the vulnerable asset [3-7] can be identified. Based on the Disaster type and its frequency, engineering structures of the asset can be modified to mitigate the failure and prepare the POWERGRID personnel for upcoming disaster based on historical analysis. Real time or near real time data available in Bhuvan is helpful for authorities to have a prompt response on disaster situation. Post-disaster data can be collected using crowd sourcing technique/remote sensing from ground and uploaded to Bhuvan (ex: Bihar flood, Chennai flood, Nepal earthquake etc.) to assess the extent of damage to POWERGRID asset. This will help POWERGRID to speed up the restoration work.

The river data available on OSM(Open Street Maps) can be used to find the crossing of rivers by transmission lines which can be further utilize to assess the vulnerable towers in case of floods or river meandering.

WEB BASED AND DESKTOP GIS TOOLS

A. Web based GIS tool: Bhuvan

Bhuvan is a web-based GIS application by NRSC (ISRO) which allows users to explore a 2D/3D representation of the surface of the Indian Landscape using its vector map and satellite images. It provides many GIS features such as viewing and analyzing vector data (.shp, .kml file) online. It also provides different disaster services data like flood, earthquake, landslide, cyclone, forest fire etc. online as well as in the form of web map services.

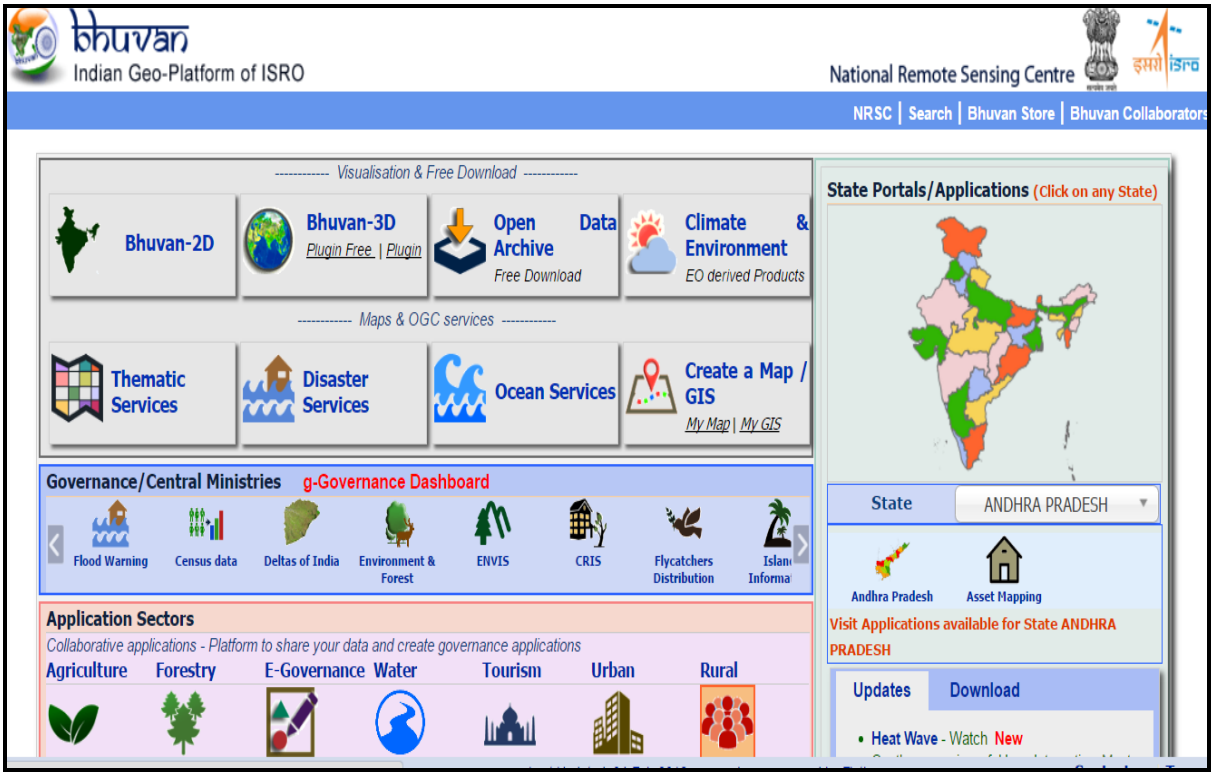

Figure 3: Home page of NRSC-Bhuvan

Above figure 3 shows the various services of Bhuvan platform for different applications. Bhuvan layers along with other GIS tools like QGIS can be used for mapping, viewing and analyzing the POWERGRID asset viz. Substation boundaries, Tower data, Transmission line data etc.

These web map services in BHUVAN are helpful to visualize our assets prone to disaster and classify the assets as per vulnerability level. It can also act as a single platform where POWERGRID asset can be visualized and information such as substation land data, line length, vulnerable asset can be extracted.

B. Desktop GIS Tools: QGIS

It is a cross-platform, free and open-source desktop geographic information system application that supports viewing, editing, and analysis of geospatial data. QGIS functions as geographic information system software, allowing users to analyze and edit spatial information, in addition to composing and exporting graphical maps. It supports both raster and vector layers; vector data is stored as point, line, or polygon features. Multiple formats of raster images are supported and the software can georeference images. QGIS supports shapefiles, coverages, personal geodatabases, dxf, PostGIS, and other formats. Web services, including Web Map Service and Web Feature Service, are also supported to allow use of data from external sources.

OPTIMAL TRANSMISSION LINE ROUTING USING GIS TOOLS

Traditionally the line routing is done manually. Manual process of line routing consumes lot of man power and man hours. Line routing using GIS tools not only saves time and man power but also improves accuracy. Thiruvalam-Pugalur 400kV transmission line is taken up as a pilot project and details are explained in next sections.

PROCEDURE/METHODOLOGY ADOPTED FOR THIS ASSIGNMENT

1. Pick up a base map: first of all, choose a base map having Geo-tagged information of state boundaries.
2. Mark the proposed Substations
3. Draw a bee line (a straight line virtually connecting two points/Substations).

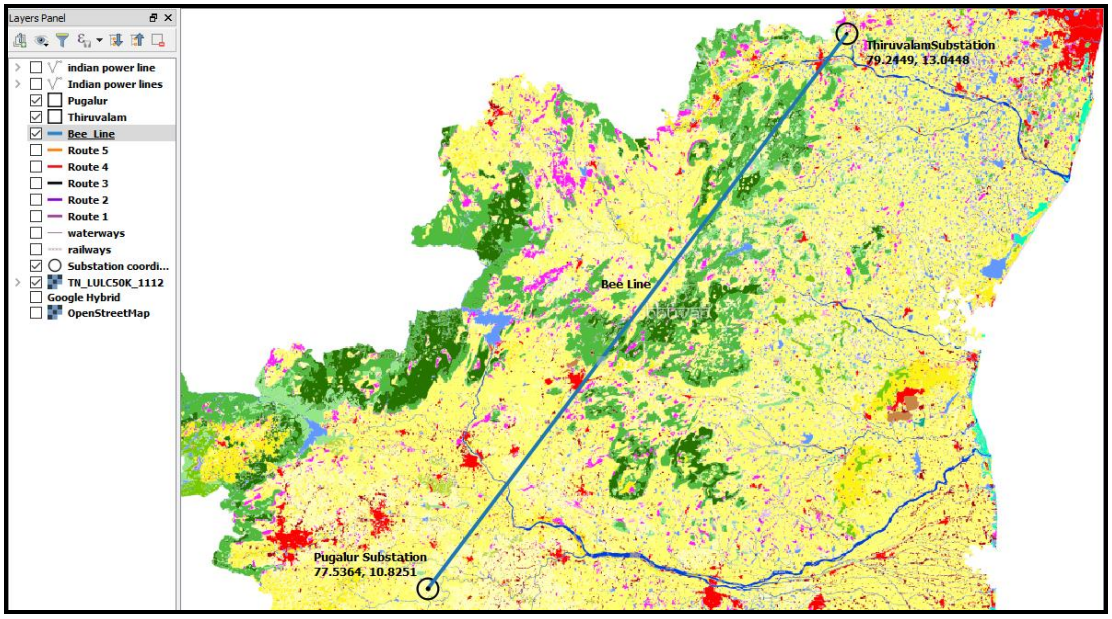

Figure 4: Bee Line drawn on base map Bhuvan LULC layer

4. Modify the bee line based on the following layers which contains various Geographic information:
   i. Bhuvan Land Use Land Cover (LULC) layers(WMS)
   ii. Google, Bing, Open Street Map(WMS)
   iii. Bhuvan disaster service layers (Ex: Cyclone, earthquake, flood, forest fire, land slide).
5. Add the layers one by one on the base map and study various routes with reference to involvement of Railway crossings, Power line crossings, Forest & Wildlife, Hilly area, Flood Zones, Earthquake, Land Slide and Snow & Avalanche, Cyclone etc., River crossings and River Meandering, Pollution sources, Fog & Adverse Weather etc.

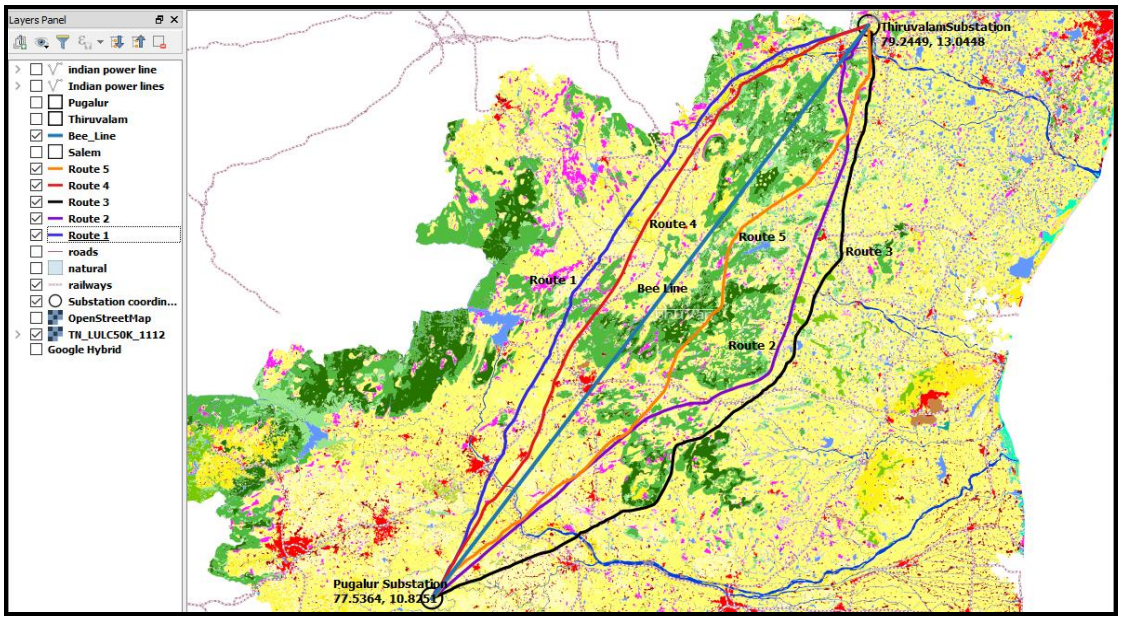

Figure 5: Proposed routes with Railway line layer on Bhuvan LULC layer

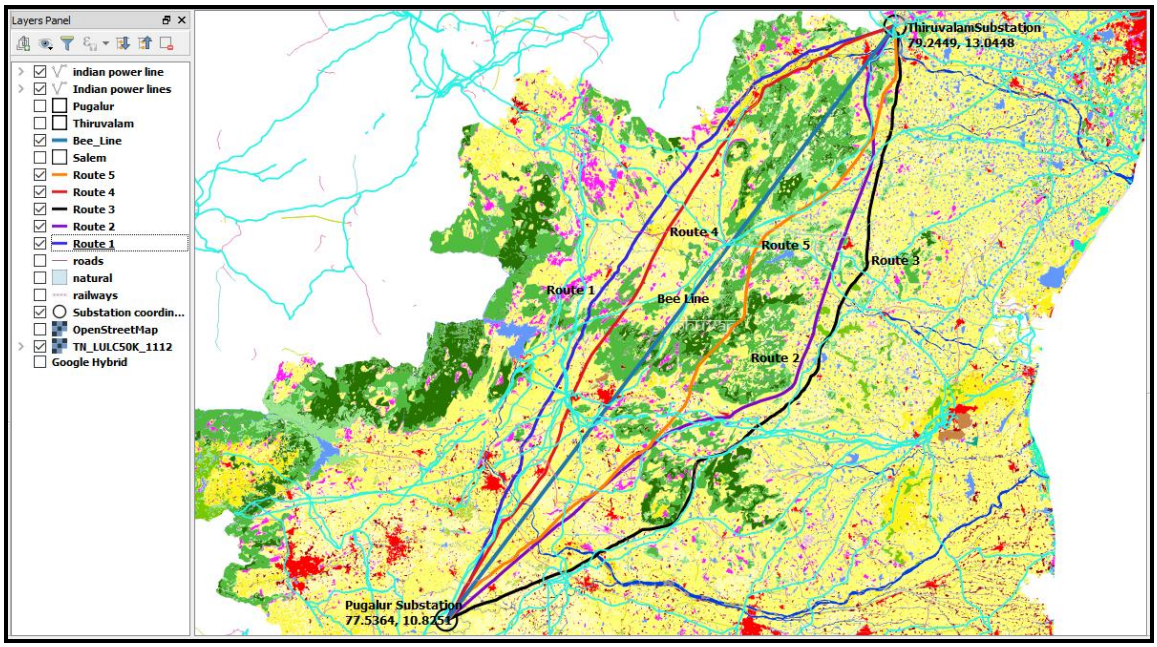

Figure 6: Proposed routes with Power Lines (132 kV and above) layer on Bhuvan LULC Layer

6. Find out the line profile using QGIS, Bhuvan and Google Earth.
7. Fly through alternative routes using Bhuvan 3D/Google earth to get an aerial overview.
8. Compare the alternative routes with reference to various attributes mentioned in step no. 5 above.
9. Select the most economical route from the point of view of construction and maintenance.

COMPARISON OF DIFFERENT ROUTES

Sr. No.	Description	Bee Line	Route-1	Route-2	Route-3	Route-4	Route-5
1.	**Line Length (in Km)**	311.76	328.74	340.57	352.81	323.83	329.59
2.	**Sanctuary**	--	Nil	Nil	Nil	Nil	Nil
3.	**Reserve Forest**	--	Nil	Nil	Nil	Nil	Nil
4.	**Social/Other Forest (in Km)**	--	5	8	2.8	11	15.60
5.	**Railway crossing**	--	10	9	6	12	5
6.	**River Crossing** (Major Rivers)	--	5	4	3	2	2
7.	**Power Line Crossing (132V & above)**	--	13	15	16	14	15
8.	**Highway Crossing** (NH)	--	7	9	7	6	7
9.	**No of angle points**	--	128	95	115	213	108

OBSERVATION AND FINDINGS

The optimal route amongst the proposed routes can be chosen by taking into consideration the factors mentioned in the above comparison table. Looking solely at the lengths of proposed routes, it can be seen that route-4 is the shortest route. It is important to note here that there is only a difference of 3km

length in route-1 and route-4. However, comparing route-4 and route-1 it is clear that route -1 would the most economical route as the reserve forest (in km), railway crossings, power line crossings (132V & above) and no. of angle points are lesser in the case of route-1 than route-4. Therefore, it can be inferred that route-1 can be taken as the optimal route.
The above assignment was a pilot project. The preliminary survey for same line was also carried out at site by traditional method and result were compared.

CONCLUSION

The paper explains the need of asset mapping and optimal transmission line routing on a GIS platform in POWERGRID. Since long, the preliminary line routing survey has been done manually, but by using the Bhuvan services, various open source map services and QGIS, this process of preliminary line survey can be eliminated to a great extent thus resulting in reduction in man power and man hour delay. The manual survey can now be limited to a few critical areas where the manual survey is unavoidable.
Currently the line routing methodology using GIS tools is being exercised only for optimal transmission line routing but it can also be extended to devise a tower spotting methodology to further reduce the manual survey and man hour delay.

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