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Analysis of vegetation shadow effect on mobile telecommunication towers' radiation distribution intensity in an urban area using satellite data derived information: A case study within Ranchi municipality

Nikita Sharma[a], Richa N K Sharma*[a] and V. S. Rathore[a]

*[a]*Assistant Professor, Department of Remote Sensing, Birla Institute of Technology, Mesra*

Abstract

Density of mobile telecommunication towers is constantly increasing with the exponential growth of mobile users. High density is seen particularly in urban areas. The radiation from mobile towers beyond certain limit is hazardous for life. Different countries have made regulations for mobile tower radiations. these regulations vary from country to country. The present study attempts to measure the mobile tower radiation in vegetated and non-vegetated areas of Ranchi city, the capital of Jharkhand State of India, with the aim to understand the radiation intensity variation. Further to know the vegetation cover in the city area Normalised Difference Vegetation Index (NDVI) from Landsat 8' Operational Land Imager (OLI) sensor data for October 2016 was generated. The mobile towers signal strength was measured with the help of a mobile app, 'Network Cell Info Lite' at 100 m distance from the towers of almost the same specification of various service providers. These signals were converted into radiation values. Two radiation spread layers for the study area were generated by calculating the radiation values for unknown points using Inverse Distance Weightage (IDW) technique. One, with the actual observed data and the other, with radiation data from towers devoid of vegetation around them. The radiations were classified into five classes: very high, high, moderate, low and very low. Comparison of the radiation values indicated a significant drop in the south west region of the study area coinciding with high NDVI values. No significant changes were observed for areas under very high radiations, very low radiations and medium radiations. However, areas under low radiations showed an increase and high radiations a decrease when compared with the NDVI values.

Keywords: Remote sensing data; Mobile tower radiation; Inverse Distance Weighted interpolation (IDW); Normalised Difference Vegetation Index (NDVI)

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1 INTRODUCTION

Wireless communication industry in the recent past has witnessed tremendous expansion (Tambe, 2015, Choi et al. 2016). India too, is at par with other countries with the launch of mobile services in1995 (Sangeetha et al. 2014). The industry for wireless telecommunication requires supporting infrastructure. Thus, a huge network of transmission towers has been installed for multiple uses of mobile phone applications and broadcasting services (Nyakyi et al. 2013). These mobile towers emit radiations which beyond a certain limit are hazardous to the life. There are efforts, world over, to keep these radiations within safe limits. Radiation norms and guidelines (Table 1) are laid down by an international body, International Commission on Non-Ionizing Radiation Protection (ICNIRP), to protect people from 'detrimental Near Infrared (NIR) exposure' (ICNIRP, 1998, Annon, 2014). Studies have been carried to analyse the effect of vegetation on signal strength emanating from the mobile towers by generating Normalized Difference Vegetation Index (NDVI) from satellite data (Naveenchandra et al. 2011, Sangeetha et al., 2014). The present study aimes to compare the theoretical signal strength (not affected by any local terrain features) with the observed signal strength (affected by the presence of vegetation). The presence of vegetation is derived from NDVI generated from satellite data. NDVI values range from -1 to 1 and positive NDVI values indicate presence of vegetation. NDVI above 0.4 indicates good vegetation.

2 STUDY AREA

The study was carried out within the municipal limits of Ranchi city having an area of 175.12 km^2. Though the city has a population of 1,073,427 (Census of India 2011), the population density is about 613 persons per km^2. The population is mostly concentrated in pockets as a substantial area has a green cover, water bodies and agricultural fields. It is bounded by 23.12° N to 23.25° N and 85.14° E to 85.16° E.

3 METHODOLOGY

3.1 NDVI Generation.

NDVI is an index of vegetation health and its density. It is given by the equation:

NDVI = (NIR– R) / (NIR + R) (1),

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where, NIR and R are the reflectance values from the Near Infrared and Red bands of the satellite datae (Jensen, 2003). Index value above 0.4 indicates presence of healthy vegetation. The satellite data (Landsat 8, Operational Land Imager (OLI) sensor of October 2016) pertaining to the study area was downloaded from the Earth Explorer site of United States Geological Survey (USGS) site and was a freeware . The data was then processed in the ERDAS imagine software for generating NDVI. The area under the standing crops was also considered as green cover.

3.2 Signal Strength Measurement

The signal strength was recorded for 52 towers distributed in the city area at a distance of 100 m from the towers, using an app, 'Network Cell Info Lite' in a mobile phone handset (Figure 1) in dBm. . These values were then converted into mW, for the ease of calculation. Using the following equation, the final values were obtained in W/m^2.

$$P_d = PG/\pi D^2 \text{P} \quad (2)$$

where, P_d is power density at a distance D; P is power; G is absolute antenna gain (Kraus, 1988).

3.3 Radiation Zone Creation.

Radiation zones maps was prepared in a GIS environment (ArcGIS software version 10.3) from mobile tower radiation data collected by applying Inverse Distance Weighted (IDW) interpolation techniques. These zones were then reclassified into five classes: very high, high, moderate, low and very low. A radiation zone was prepared for mobile towers without vegetation around them (Figure 2). This radiation zone map was considered theoretical as it did not take into account any local terrain feature effect. Another radiation zone map was prepared with the actual observed values of radiations as recorded (Figure3).

4 RESULTS AND CONCLUSIONS

Both the maps were compared with respect to the area under each class (Table 3). The overall area under very high radiations, very low radiations and medium radiations did not show any remarkable change in the observed values (.0.35% to 3.65%) The area under low radiations increased by 10.91% and high radiations decreased by 12.43%. The maximum change was seen in the south west and the north east within the municipal boundary. In the south-west, the observed area was under low to very low radiations. The case was somewhat reversed in the north east. The theoretical area under very low radiations was observed as medium radiations. This could be accorded to the fact that the urban expansion is oriented towards the north east of the municipal limits. In this region, a ring road and a new railway stations are also upcoming. This region has undergone tremendous green cover loss.

It may not be directly concluded that healthy vegetation is the only reason for the reduction of radiation levels in the south west of the study area. The study can be extended by including more parameters like view shed analysis, local terrain effect and presence of water bodies to know the radiation behaviour in such areas.

Studies have been conducted on effects of increased levels of radiations from mobile towers on man, birds and animals in heavily inhabited areas (Raghu et al., 2017). Any parameter which may ease out the radiation density will definitely make the planet Earth inhabitable in the long term.

5 ACKNOWLEDGEMENT

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Figure 1. Mobile app.'Network Cell Info Lite' used to measure signal strength at 100 m from the tower in dBm. Value close to zero indicates stronger signal

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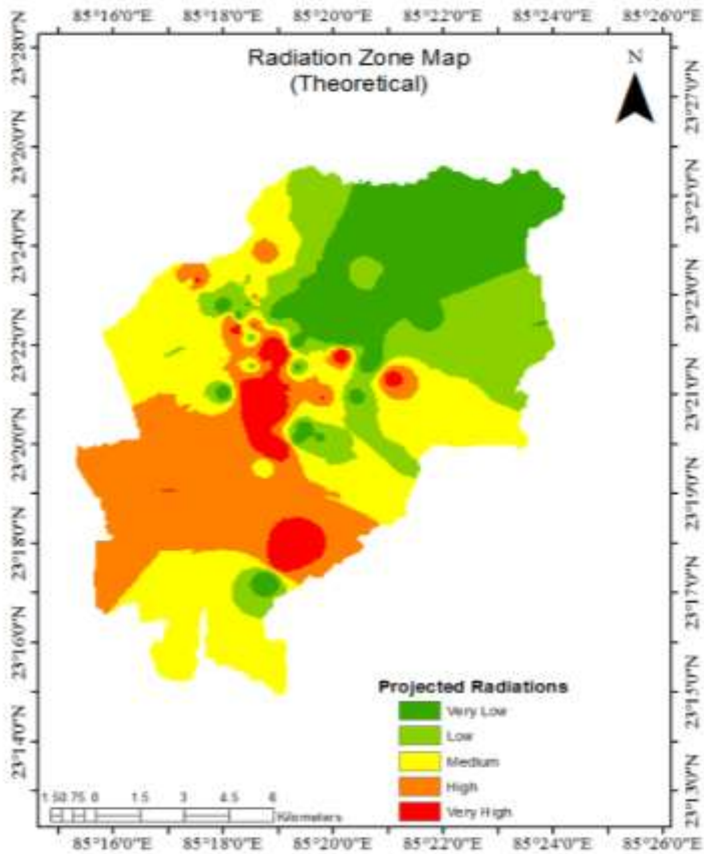

Figure 2. Mobile Tower Radiation at 100m distance from towers using IDW. Radiation zones are considered theoretical as local terrain feature effects are not taken into account.

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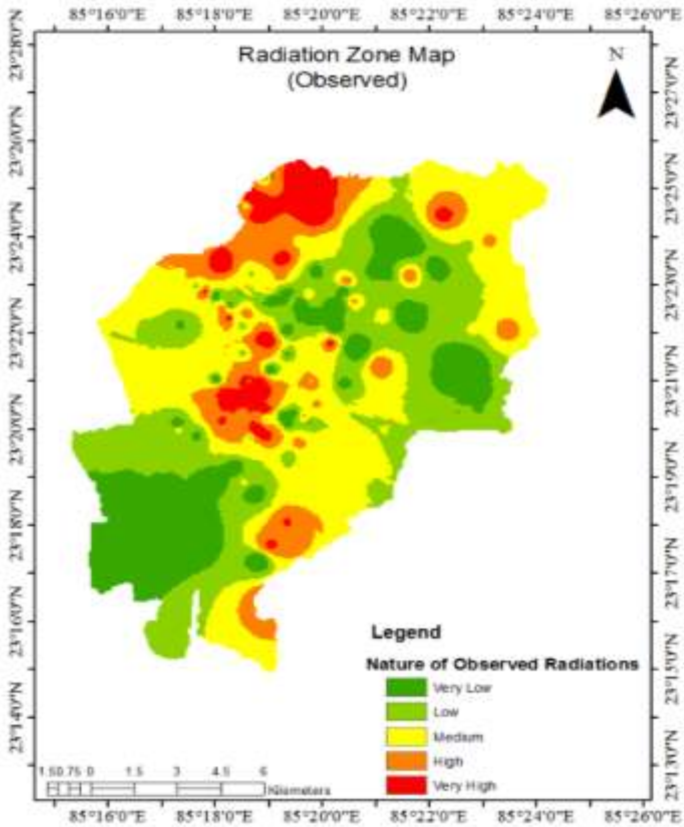

Figure 3. Mobile Tower Radiation at 100m distance from towers using IDW. Radiation zones are as observed

Table 1: Mobile towers radiation guidelines (after ICNIRP)

Country	Milliwatt / m²	Watts / m²
INDIA (adopted ICNIRP)	**4500**	**4.5 (f/200)**
INDIA (Adopted 1/10th of ICNIRP on Sep. 1, 2012)	450	0.45 (f/2000)
AUSTRALIA (New South Wales proposed)	0.01	0.00001
AUSTRIA (Salzburg city)	1	0.001
BELGIUM	45 to 1125	0.045 to 1.125
BELGIUM (Luxembourg)	24	0.024
BIO-INITIATIVE REPORT (Outdoor)	1	0.001
BIO-INITIATIVE REPORT (Indoor)	0.1	0.0001
CANADA (Toronto Board of Health - proposed)	100	0.1
CHINA	400	0.4
FRANCE (Paris)	100	0.1
GERMANY (ECOLOG 1998 - Precautionary Recommendation)	90	0.09
GERMANY (BUND 2007 - Precautionary Recommendation)	0.1	0.0001
ITALY	100	0.1
NEW ZELAND (Aukland)	500	0.5
POLAND	100	0.1
RUSSIA	100	0.1
SWITZERLAND (Apartments, Schools, Hospitals, Offices & Playgrounds)	42	0.042
USA (Implementation is strict)*	3000	3 (f/300)
Final Recommendations		
Indoor - include apartments, schools, hospitals, offices & playgrounds.	**0.1**	**0.0001**
Outdoor - where people spend few minutes a day.	**10**	**0.01**

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Table 2: Methodology

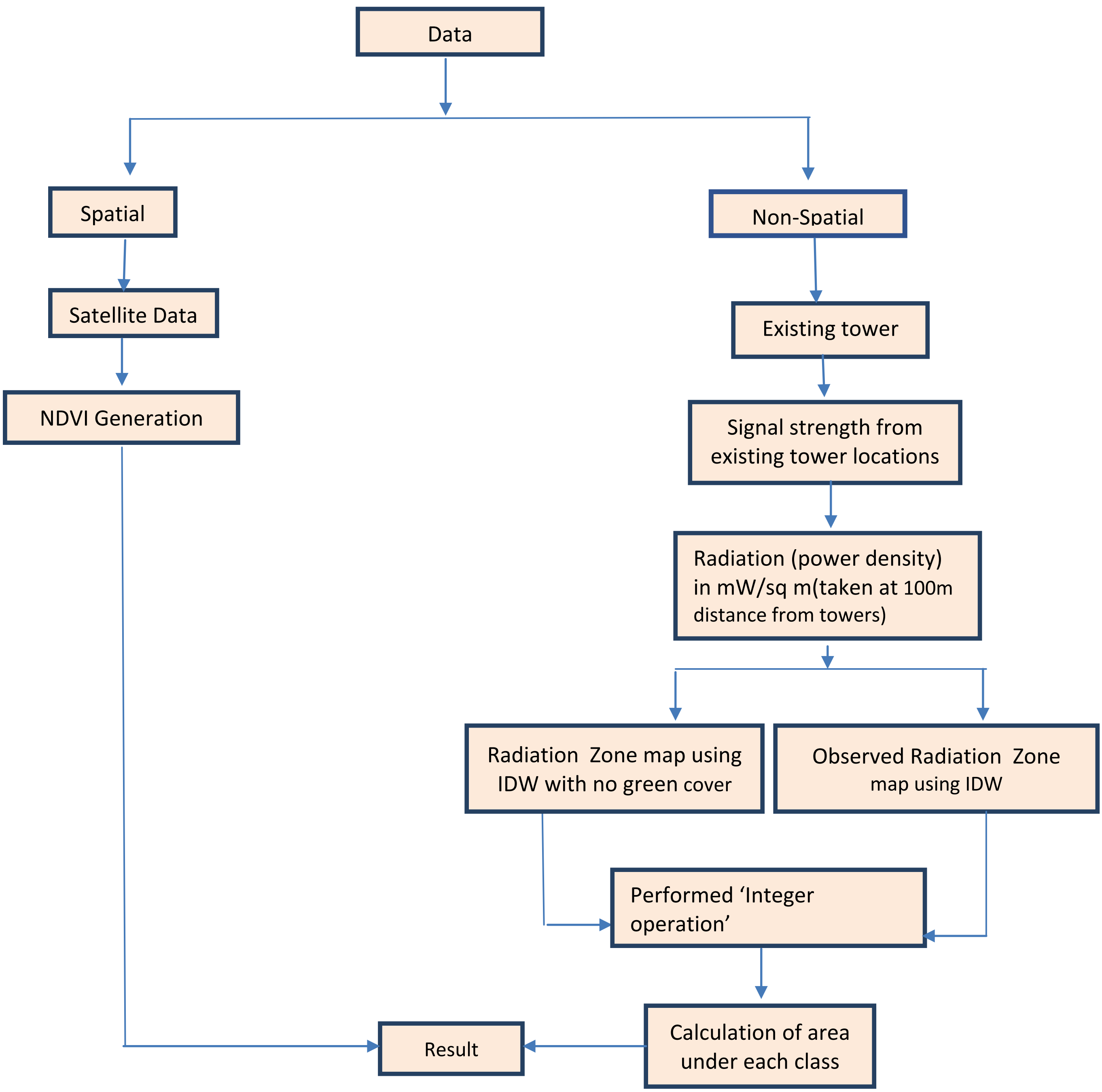

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Table 3: Comparison of areas under two classes (a) without taking into account terrain features and (b) as per the observed values

Radiation	Area (km^2). Without taking into account local terrain feature effect (a)	Area(km^2) as observed (in –situ) (b)
Very Low	20.76	18.27
Low	18.59	29.5
Medium	31.73	35.38
High	24.35	11.92
Very High	4.56	4.93
	99.99	100

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