

# Study on Urban Land Suitability Assessment using Remote Sensing and GIS: A Case Study of Khairagarh, in Chhattisgarh

Sandipan Das  
Symbiosis Institute of  
GeoInformatics,  
Pune, India

Anirban Bhattacharya  
Symbiosis Institute of  
GeoInformatics,  
Pune, India

Sagar Mali  
Dept. of Geography,  
Shivaji University,  
Kolhapur, India

## ABSTRACT

Rapid urbanization and consequent slapdash growth of cities is a global phenomenon and India is no exception. This is resulting in deterioration of infrastructure facilities, loss of agricultural lands, water bodies, open spaces, and diminution of ground water aquifer zones, water contamination, air pollution, health hazards and many micro-climatic changes. Urban sprawl may be defined as the scattering of new development on isolated tracts, separated from other areas by vacant land (Ottensmann, 1977). It is also often described as leapfrog development (Gordon and Richardson, 1977) as observed in all the major cities across the world. It is in this regard khairagarh municipal area (KMA) showed its pursuit to use the latest technology of KM Area for the period 2021. First of all the population for the year 2021 was determined as 55,968 on the basis of standard statistical methods viz. Arithmetic, Geometrical, Incremental Increase, Exponential and Forecast. To meet the additional demand of this land, an integrated study has been carried out using a multi-parametric index approach. For taking a suitable decision, the study provided the information not only on the existing urban land use pattern, urban sprawl analysis but also on natural hazards, existing infrastructure facilities, hydro geomorphologic features and urban land use suitability suggesting the areas to be used for construction and the areas to be conserved under green belt. High spatial resolution IRS satellite images helps to prepare urban land use maps depicting urban land uses such as agricultural, residential, industrial, commercial, Public and semi-public uses recreational, transportation etc. Modern technology of remote sensing and GIS which helps us to analyze the data spatially, offering possibilities of generating various options (modeling), thereby optimizes the whole planning process. It is in this context, the suitability analysis attempted in this study must be viewed as a basic "Prioritization of land for urban development."

**KEYWORDS.** Urbanization, Remote sensing, GIS, Urban suitability

## 1. INTRODUCTION

Urbanization has become a common feature in all developing countries. The growing population and constant migration from rural to urban exerts tremendous pressure on natural resources like land, water and environment. As a result of uncontrolled urbanization most cities are facing acute problems of drinking water, traffic congestion, pollution and having serious implication in the quality of life. There is immediate attention required for the perspective physical

planning of towns and cities of india due to higher complexity involved in it (Sokhi and Rashid 1999). Urban planning is a complex phenomenon which keeps on changing with time hence planners need detailed information about the distribution of the land and its surrounding. The conventional methods of obtaining urban land cover data is time consuming, tedious and not economically viable for fast growing cities. The rapid development of remote sensing technology (RS) and geographical information systems (GIS) technologies have facilitated in large-scale studies of urban development (Masser, 2001). The remote sensing and GIS techniques play a vital role in any urban planning activity because remote sensing provides reliable, timely, accurate and periodic spatial data while geographic information system (GIS) provides various methods of integration tools data to arrive at solution for decision making.

## 2. AIMS & OBJECTIVES

- To prepare urban land use maps using high spatial resolution IRS satellite data
- To prepare urban sprawl map using multi-date satellite data To prepare a transportation network map for the entire Khairagarh planning area.
- To prepare natural hazard maps related to flood prone areas.
- To prepare hydro geomorphology, ground water prospect, drainage, surface water bodies, slope and soil information maps for urban suitability analysis.
- To prepare urban suitability map

## 3. STUDY AREA

The area considered for the present work is a part of Rajnandgaon district of Chhattisgarh state, which falls in the western parts of Chhattisgarh. The study area covers 6016.439 hectares area and located between N 21° 40' to N 21° 50' Latitude and E 80° 26' to E 81° 11' Longitude. It has an average elevation of 307 meters. As of 2001 India census, Khairagarh had a population of 15,149. The three nearby railway stations, Rajnandgaon, Dongargarh, and Durg, are 40, 42 and 55 kilometres away from Khairagarh respectively. Raipur and Nagpur airports are at a distance of 100 and 225 kilometres, respectively. The location map of the study area is given below in figure 1.

### 3. MATERIALS AND DATA

#### 3.1 Satellite data

Details of the data acquired for the study area is given in table 1. Various combinations of this data has been primarily used for the preparations of existing of land use/cover, surface water bodies, hydrogeomorphology, transportation network, flood hazard and, erosion hazard thematic maps. Multi-data satellite data has been used for the preparation of urban sprawl map.

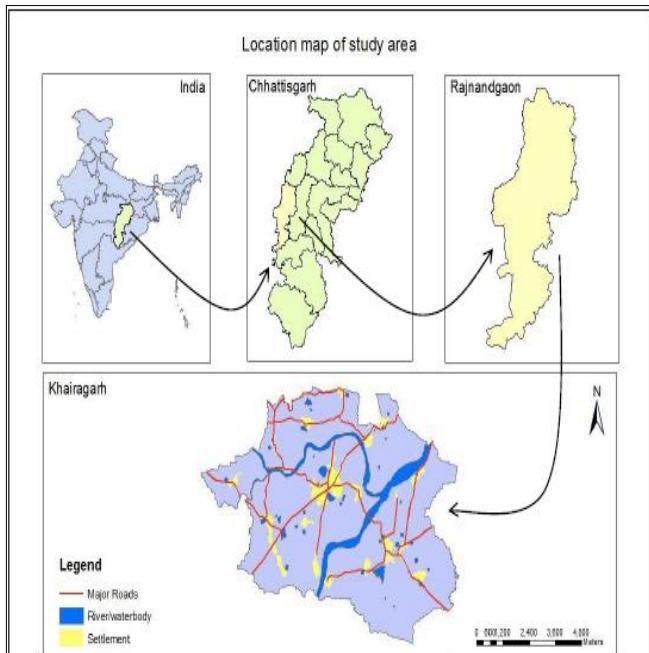


Figure 1: Location map of study area

#### 3.2 Collateral data

##### 3.2.1 Survey of India (SOI) topographic maps

Survey of India topographic map on 1:50,000 scale (64D/13) cover entire Dongargaon Planning area. This map is used for preparing base maps taking base information such as settlements, their connectivity, surface water bodies drainage etc. for the entire study areas.

##### 3.2.3 Cadastral maps

The Cadastral maps covering all villages of Dongargaon planning area (20villages). Showing plot boundaries with survey numbers were also used in the study.

#### 3.2.4 Census abstracts

Sr. No.	Satellite	Acquisition date
1	Cartosat-1 (PAN)	4 <sup>th</sup> January 2007
2	IRS-P6 (LISS-IV)	1 <sup>st</sup> January 2006
3	IRS-P6 LISS-IV+ Cartosat-1 PAN (Merged data)	January 2007

Table 1: Details of satellite data used

Population data of 2001 (provisional) census have been utilized for the purpose of population projection analysis.

#### 3.2.5 Soil map

District soil map prepared on 1:250,000 scale and printed on 1:5,00,000 scale was obtained from NBSS & LUP, Nagpur and data related to soil depth, soil texture, soil series etc. has been taken from this map for integrated analysis.

## 1. METHODOLOGY

The overall methodology adopted to prepare a sustainable urban suitable site is given in figure-2. As per this methodology, it is prerequisite to project the population. Therefore, various statistical techniques have been employed to project the population of Khairagarh planning area for the year 2021. The important physical parameters which are considered for the suitability analysis are as follows land use/cover, groundwater prospects, soil depth, soil texture, erosion hazard, slope, surface water bodies, flood hazard and road network. The inventory of these parameters has been carried out using RS and GIS techniques. These parameters are then given weightage as per the Saaty's AHP method by creating a separate field in each layer in arcgis 9.1 software. Each class associated with each layer are given a rank and stored as separate field in geodatabase. The product of weightage and rank are computed and stored in another field. These vector layers are then integrated in a GIS environment application of weighted index model to find the site suitability for urban development.

## 2. RESULT AND DISCUSSION

The identification of suitable land for urban development is an important fundamental work in urban planning. The physical parameters affecting the suitability of land are discussed below. The cumulative effect of these factors determines the degree of suitability and also helps in identification of the limitations of the land for urban development.

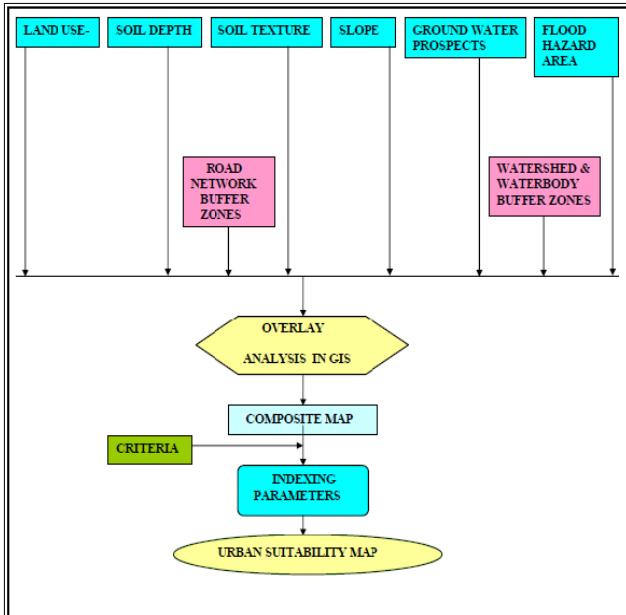


Figure 2 : Methodology Chart

## 5.1 Population Projections

The study of demographic pattern plays a major role in the preparation of development plan. This type of study helps to access the past and present growth trends and to estimate the future growth. The knowledge of basic demographic trend, in the area to be planned, is very essential to perceive the problems and exact needs of the area. It gives the idea about the living conditions of the people and their immediate needs of basic amenities. Hence, the population projection has been carried out using census data pertaining to the study area. The population projection for the year 2011, 2021 has been estimated by geometric method, arithmetic method and incremental increase method. The projected figures for these years are shown in table 2. It is estimated that in the year 2021, the population of the Municipal area is likely to be more than **55,968**. It can be seen that increase in population of successive decades is tremendous. This very high rate of growth of population is mainly attributable to the rapid development.

Table 2:Population projections

POPULATION				
Year	Incremental Increase method	Geometric Increase Method	Arithmetical Increase method	Average population
1991	9317	9317	9317	9317
2001	11517	11517	11517	11517
2011	38951	18717	18717	25461.6
2021	55968	26776	20917	34553.6

## 5.2 Land Use / Land Cover Map

Land Use / Land Cover map has been prepared by using satellite image and cadastral map in field. The land use/cover information help in formulation of policies and programmes for urban development. It has been observed that 79.31% area is under agriculture land. The prime surface water body in the area is Shivnath river. The landuse/landcover map and area of existing landuse type is shown in figure 3.

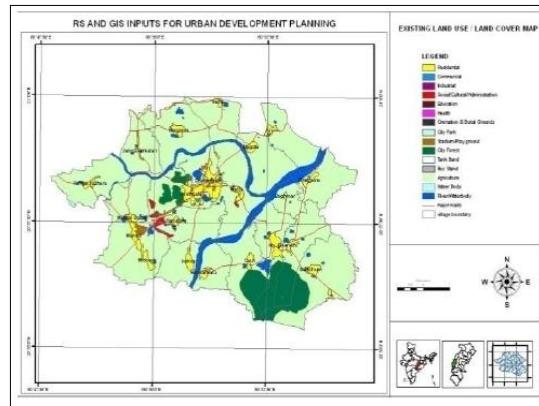


Figure 2: Existing landuse/landcover map

### 5.3 Urban Sprawl Map

Urban sprawl map of khairagarh municipal area was prepared using SOI topographical maps and multi-date remote sensing data. The average yearly percentage increase in population KM area is 1.2%. Khairagarh and Sewatatola shows more growth because of merging of two villages, industrial and having commercial activities. The urban sprawl map and area of area of urban sprawl is shown in figure 4.

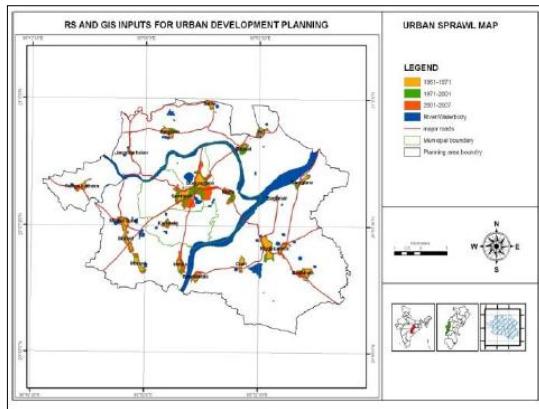


Figure 3: Urban Sprawl map

### 5.4 Hydrogeomorphological Map

Hydrogeomorphological map is prepared on the basis of geology, geomorphology and structure. It is used to access the groundwater prospects. It has been observed that most of the area is under pediplain. Pediplain region is characterized by little slopy area having good moisture content. The hydrogeomorphology map and area of hydrogeomorphological units is shown in figure 5.

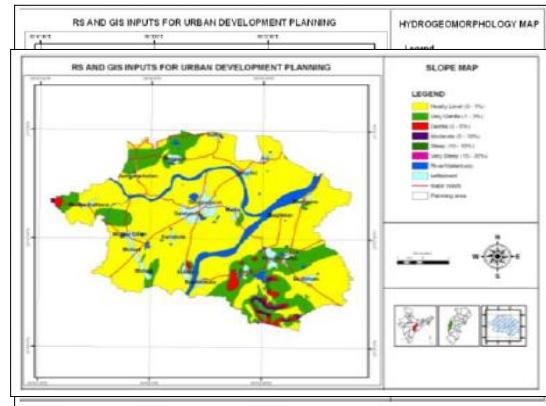


Figure 5: Hydrogeomorphology map

### 5.5 Ground Water Prospect Map

The groundwater potential is dependent on hydrogeomorphological units. Alluvial plain and flood plain are considered as very good potential zones. Pediment and pediplain are considered as moderate ground water potential zones. Structural hills, denudational hills are considered as poor potential zones. It has been observed that most of the area is under moderate zone. The ground water prospect map and area of ground water prospect zone is shown in figure 6.

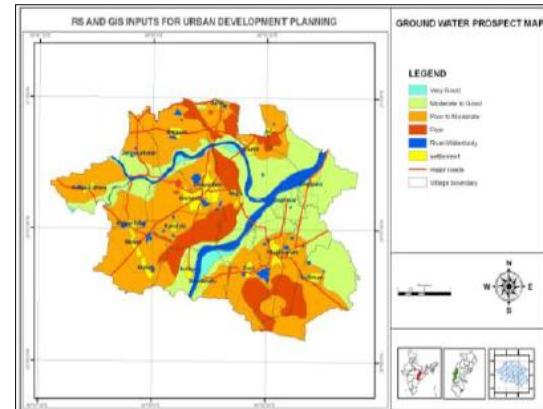


Figure 6: Groundwater prospect map

### 5.6 Soil Depth Map

The soil information collected from NBSS & LUP, Nagpur has been studied and soil coverage has been created. From these soil types, soil depth have been separated out and the map has been prepared separately. It has been observed that most of the area is under deep (9 -10 m) category. The soil depth map and area of soil depth zone is shown in figure 7.

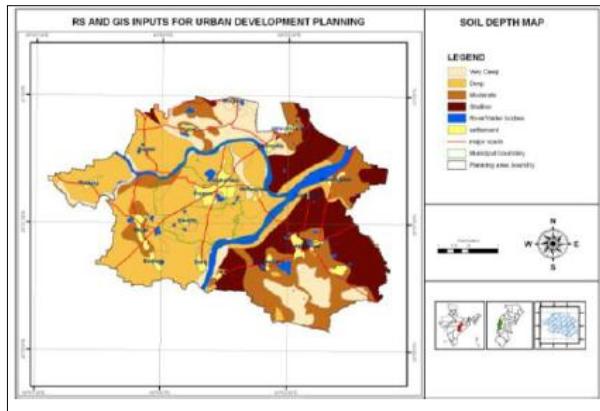
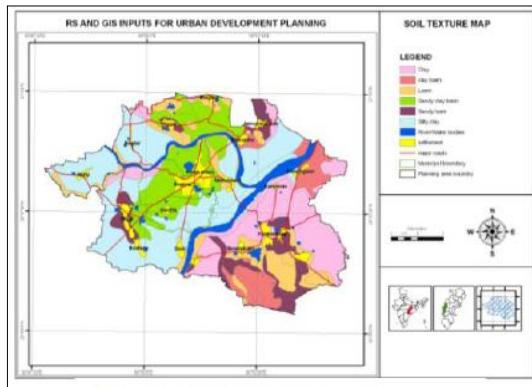


Figure 7: Soil Depth map

## 5.7 Soil Texture Map

Soil texture forms an important aspect with respect to stability of foundations. The soil information was collected from NBSS & LUP, Nagpur has been studied and soil coverage has been created. From these soil types, soil texture have been separated out and the map has been prepared separately. It has been observed that most of the area is under silty clay type. The soil texture map and area of soil texture is shown in figure 8.

Figure 8:Soil Texture map



## 5.8 Slope Map

Slope map has been generated using elevation information derived from SOI topographical maps. It is found that most of the areas are under category of nearly level (0 – 1 %) slope. The slope map and area of slope classes is shown in figure 9.

## 5.9 Flood hazard Map

The flood hazard map has been prepared by using pre and post monsoon satellite data. The areas coming under very high flood category are because of river and gentle slope. The areas coming under low flood category are because of hilly area and steep slope. The flood hazard map and area of flood hazard zone is shown in figure 10.

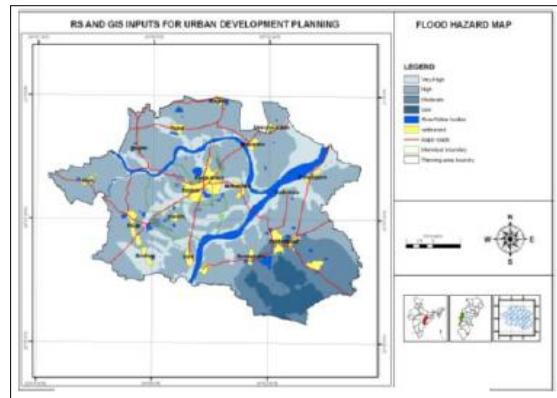


Figure 9: Slope map

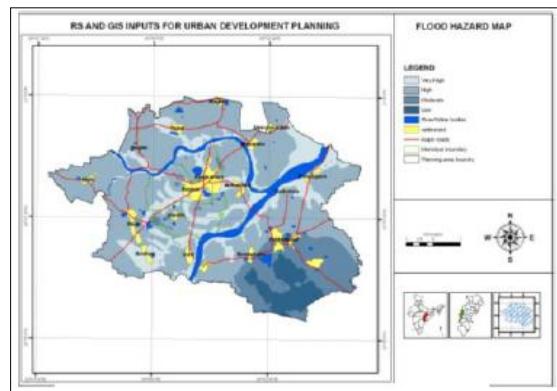


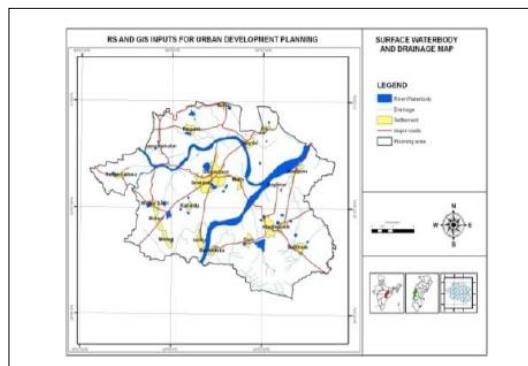
Figure 10: Flood Hazard map

## 5.10 Surface waterbody and drainage map

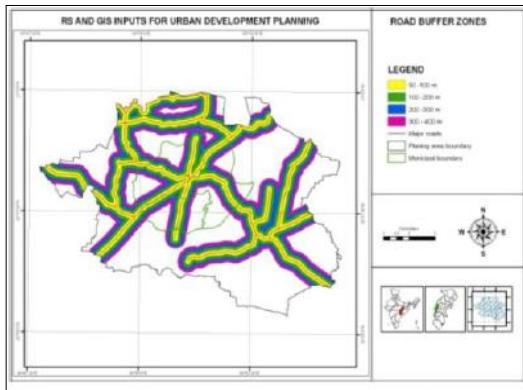
The prime surface water body in the area is the river Shivnath. The water is found in the river throughout the year. Shivnath river is flowing through KM area from S-W to N-E. Another drain i.e.Sukha-Nala is also flowing on North of Khairagarh number of lakes/ponds has been observed in the entire study area. The surface waterbody and drainage map is shown figure 11.

## 5.11 Road buffer zones

The road network plays an important role in urban development as it connects different settlements. Buffer zones of 100m, 200m, 300m, and 400m on both sides of these roads have been generated for urban landuse suitability analysis. The area lying 100m distance on both sides of the road network is ranked high for development and consequently the area lying between 300m and 400m is ranked low development. The road buffer zone map and area of road buffer zones is shown in figure 12.



**Figure 11:** Surface waterbody and drainage map

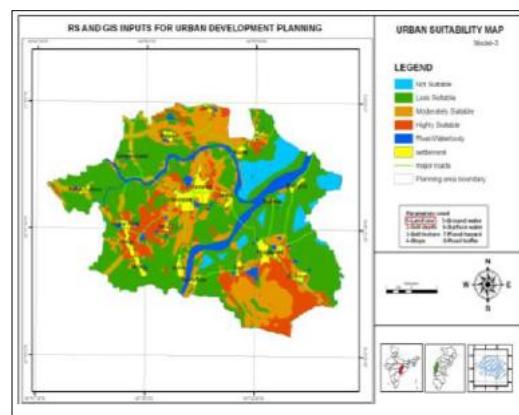


**Figure 12:** Road Buffer Zone map

## 5.12 Integrated analysis for urban suitability

As per the methodology mentioned in figure 1.0, weightage are given to physical parameters, by comparing each parameter with respect to the other parameter. The weightage assigned for all the parameters according to Satty's scale are shown below in table 13. Finally all the layers were combined in a GIS environment to prepare the final urban suitability model based on weighted index model. The urban landuse suitability map has been grouped into four categories namely highly suitable, moderately suitable, less suitable and not suitable. The urban suitability map and area of different categories is shown in figure 13

**Figure 13:Urban Suitability map**



## 6.0 CONCLUSION

Population sprawl for the period 2021 will be about 55,968 i.e. KM area will be having additional population of about 44,451 to its present population. As per the urban sprawl study the physical growth of Khairagarh and Sewatatola shows more growth because of merging of two villages. As per land use/cover statistics agriculture area tops the list with a percentage of about 79.31 followed by the forest area with about 7.58%. The area is mainly plain region. The area of 2046.867 ha has been identified as silty clay. As per the flood hazard concerned an area of about 796.85 ha has been identified as flood risk zone. The KM has 1338.621 ha as the most suitable area for urban development.

## 7. REFERENCES

- [1] Anne Vernez Moudon and Michael Hubner . 2004. “*Monitoring Land Supply with Geographic Information Systems*”, John Wiley and Sons Publication, New York.
- [2] Burrough P A and Mc Donnell R. 1996. “ Principles of Geographical Information System”, Oxford University Press, London.
- [3] Campbell James, B. 2002. “Introduction to Remote Sensing”, Taylor & Francis.
- [4] Dhawale, A.K. and Landge, S.D. 2000. “Remote Sensing and GIS Based Inputs for the Preparation of a Development Plan of Pimpri-Chinchwad Municipal Corporation (PCMC) Area for the Year 2018”, *Proceedings of Geomatics 2000 : Conference on Geomatics in Electronic Governance*, pp. 22-33.
- [5] Indore Development Plan 2011 (Draft). 2003. published by Directorate of Town and Country Planning and ISRO, Ahmedabad
- [6] Mali Sagar P. (2008), “Urban Utility Information System Using Digital Photogrammetry & GIS Technology”, Project Submitted to University of Pune.
- [7] Pathan, S. K., P. Jothimani, et al. (1989). "Urban land use mapping and zoning of Mumbai Metropolitan region using remote sensing data." *Journal of Indian Society of Remote Sensing*, Vol. 17, pp 11-22.
- [8] Pathan, S. K., V. K. Shukla, et al. (1991). "Urban land use mapping-a Case study of Ahmedabad city and its environs." *Journal of Indian Society of Remote Sensing*, vol.19, pp 95-112.
- [9] Jacek Malczewski 1999. “GIS and Multi-Criteria Decision Analysis”, John Wiley & Sons.
- [10] Masser, I. 2001. “Managing our Urban Future: The Role of Remote Sensing and Geographic Information Systems”, *Habitat International*, pp.503-512.
- [11] Sokhi, B.S. and Rashid, S.M. 1999. “Remote sensing of urban environment”, Manak Publications, New Delhi.

**Table 13: Importance Matrix for the suitability Analysis**

Sr. no	Parameter	SD	ST	Slp	Fld	Esn	Luse	GW	SW	Rdn	Rln	Weightage
1.	SD	1	5	2	3	3	3	1	1	8	7	0.238
2.	ST	1/5	1	1/3	1/2	1/2	3	1	1	8	7	0.068
3.	Slp	1/2	3	1	1	1	3	1	1	8	7	0.151
4.	Fld	1/3	2	1	1	3	3	1/3	3	8	7	0.114
5.	Esn	1/3	2	1	1/3	1	2	1/2	1/3	8	7	0.077
6.	Luse	1/3	1/3	1/3	1/3	1/2	1	2	2	9	8	0.069
7.	GW	1	1	1	3	2	1/2	1	1	9	8	0.148
8.	SW	1	1	1	1/3	3	1/2	1	1	9	8	0.104
9.	Rdn	1/8	1/8	1/8	1/8	1/8	1/9	1/9	1/9	1	1/4	0.015
10.	Rln	1/7	1/7	1/7	1/7	1/7	1/8	1/8	1/8	4	1	0.017

SD = Soil depth, ST = Soil Texture, Slp = slope, Fld = Flood hazard,

Esn = Erosion Hazard, Luse = Land use, GW = Groundwater Prospect,

Rdn = Road Network, Rln = Railway Station, SW=surface water