PAPER • OPEN ACCESS

Site Suitability Assessment for Neelambur Panchayat using GIS and AHP Techniques

View the article online for updates and enhancements.

Site Suitability Assessment for Neelambur Panchayat using GIS and AHP Techniques

V Navin Ganesh[1], E Sachin[2], R Ravikumar[3], S Sanjay Kumar[4] and S Vijayakumar[5]

[1]Assistant Professor (Senior Grade), Department of Civil Engineering, PSG Institute of Technology and Applied Research, Coimbatore, Tamil Nadu, India.
[2,3,4,5]UG Student, Department of Civil Engineering, PSG Institute of Technology and Applied Research, Coimbatore, Tamil Nadu, India.

E-mail: navinganesh@psgitech.ac.in

Abstract. The rapid urbanization in the fast growing cities is posing a major problem for the planning authorities. Most of this urbanization is experienced in the peri-urban areas which refer to the settlements beyond, about or around cities. They are characterized by the changing economic and employment structure along with rapid population growth, changing spatial development patterns, unregulated growth, haphazard developments, low quality housing and inadequate infrastructure facilities. Proper site suitability assessment involving detailed investigation of the land parcels with respect to the available resources required for the urban settlements which will lead to sustainable growth of the peri-urban area is required. In the current research study, site suitability assessment has been carried out for Neelambur, one of the peri-urban areas of Coimbatore city. The factors considered for identifying the land parcels suitable for urban settlement included the land-use of the study area, proximity of sites to the nearest road, proximity of sites to the nearest facilities of importance and slope of the study area. The Analytical Hierarchy Process based Weighted Overlay Method was used in Geographic Information System to identify the land parcels suitable for urban settlements in order to ensure a sustainable development in the study area.The results indicated that 5.29 sq.km of the study area was classified as highly suitable for urban settlements. The results of the current study can be used by the local planning authorities in establishing development control norms for ensuring the sustainable growth of Neelambur.

1. Introduction
In today's world, the rapid population growth is creating numerous challenges for the goal of achieving sustainable development [1]. The rapid population growth has resulted in the major cities around the world facing the problem of rapid urbanization. The rapid urbanization is a result of the lack of basic social, employment, economic and environmental sustainability and opportunities in the rural areas. This has created a lot of stress on the already congested cities. The reports indicate that 55 % of the world's population is living in the urban areas. In the context of India, 34 % of the population is living in urban areas which are projected to increase up to 40 % in 2030 and 53 % in 2050 [2]. Most of these urbanization settlements are expected to come up in the peri-urban areas of major cities. The peri-urban areas as referred to the settlements beyond the city limits are in a transition from rural to urban characteristics due to the spillover of people from the nearby core city areas and semi-urban areas. If the development of these peri-urban areas are not monitored and

controlled, it may lead to the degradation of these areas thereby affecting the sustainability of not only those areas but also the connected city [3-5]. This highlights the need of the hour which is the identification and evaluation of suitable sites for the development of urban settlements which is also a part of the general land-use planning [6]. Many researchers have attempted the GIS and AHP based land suitability assessment for the identification of proper sites for urban settlements and services planning in order to ensure a sustainable growth of those areas [7-14] The present research work aims to identify the land parcels that are suitable for urban settlements using the AHP based weighted overlay method in GIS for Neelambur, one of the peri-urban area of Coimbatore city. The need for taking up the urbanization issue of Coimbatore city arises from the fact that Coimbatore being the 15th largest urban agglomeration in India has in the recent years has experienced rapid, haphazard and ungoverned urbanization in the peri-urban areas of the city [15].

2. Materials and methods

2.1 Study area
Neelambur, the study area chosen for the current research work is a village panchayat and one of the peri-urban areas of Coimbatore city. It is situated in the administrative block of Sulur in the Coimbatore district of Tamil Nadu state in India. Neelambur is situated within the geo-coordinates 11.06N and 77.10 E. As per the census 2011, 8,382 was the total population of Neelambur. Major industries specializing in the fields of textile, manufacturing and metal casting foundries are situated in Neelambur which attracts lot of migration of people from nearby districts and villages due to the enormous employment potential and opportunities available. The study area is also covered by agricultural lands which makes agriculture a prominent economic activity of people in the study area. The presence of many educational institutions also makes the study area a potential area for migration and settlement of people from nearby villages and districts [16]. The study area map is depicted in figure 1 having a total area 19.12 sq.km.
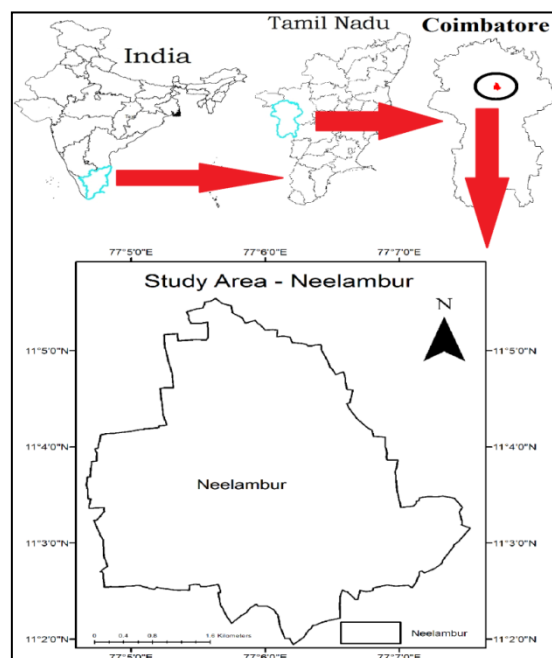

Figure 1. Study area map

2.2 Research methodology adopted
The administrative boundary map of Neelambur was used as the base map in ArcGIS for the current research. The base map was geo-referenced using the geo-coordinates obtained in the field

using hand-held GPS in the geo-reference tool. The geo-referenced base map of the study area was used for the preparation of four different thematic layers of the study area namely LULC map, slope map, road map and facility. Once the thematic layers were prepared, the maps were rasterized based on the sub-criteria of the factors considered. Then all the rasterized criteria maps were processed using the weighted overlay tool in ArcGIS by assigning criteria weights derived from the AHP analysis and sub-criteria ranks to generate the site suitability maps. The research methodology adopted in the current study is indicated in figure 2.
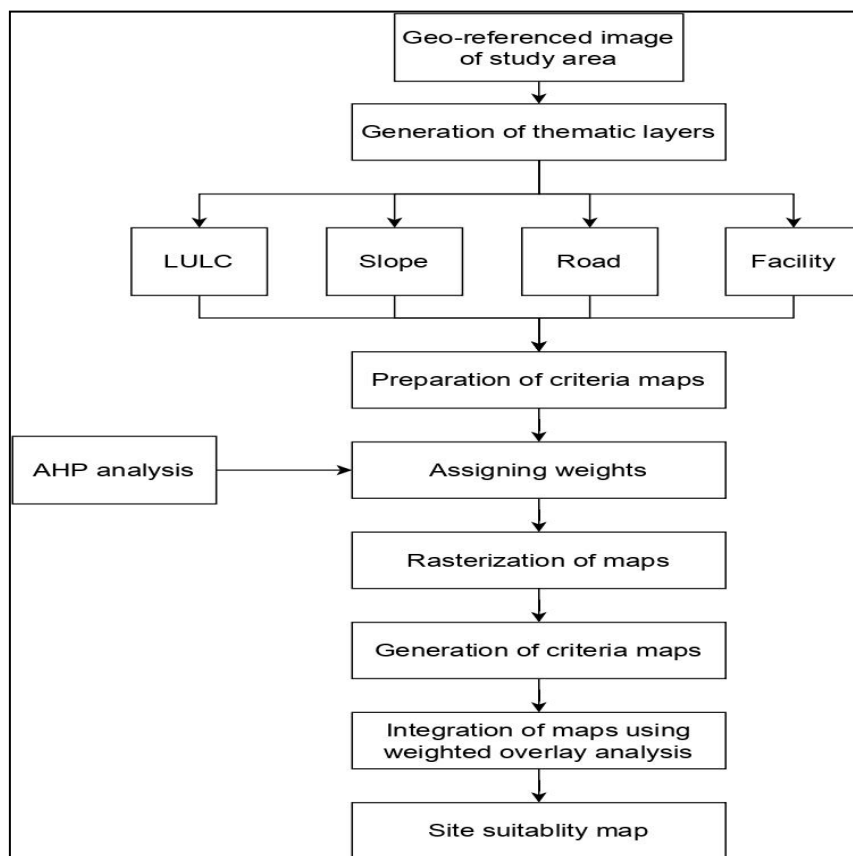
**Figure 2.** Research methodology adopted

2.3 AHP Analysis
One of the powerful tools under the Multi Criteria Decision Making (MCDM) technique is the AHP (Analytical Hierarchy Process). It uses the pair-wise comparison matrix to determine the relative weights for the criteria which are considered in the study. An AHP pair-wise comparison matrix has been prepared in the current study based on the four factors considered namely land-use land classification, slope, proximity to road and proximity to facility and the criteria weights have been determined based on the pair-wise comparison matrix as shown in table 1, developed based on the evaluation scale of Saaty[17]. In the table, the relative importance of one factor over another factor is indicated using the numbers 1 to 9. The equal importance of two parameters is represented by the value 1, whereas the value 9 indicates the extreme importance of one factor over the other. The Consistency Ratio (CR) arrived for the AHP pair-wise comparison matrix developed was 0.05, which is less than the normal limiting values of 0.1. It indicates that the AHP pair-wise comparison matrix developed for the current research has high correctness and consistency.

Table 1. AHP pair-wise comparison matrix

Criteria	LULC	Slope	Proximity to road	Proximity to facility	AHP Weights
LULC	1	1/5	1/3	1/3	0.08
Slope	5	1	5	5	0.60
Proximity to road	3	1/5	1	1	0.16
Proximity to facility	3	1/5	1	1	0.16
Total Weight					1.00

2.4 GIS thematic Layers

The four thematic layers prepared for the current research included the land-use land classification, slope map, road map and facility map. The LULC map of the study area was prepared using the maximum likelihood based supervised image classification techniques in ArcGIS. The Lands at 8 OLI/TIRS C1 Level-1 satellite image with the image acquisition date of 11.01.2020 with path number 144 and row number 052, downloaded from the USGS earth explorer website was used for the preparation of LULC map. The prepared LULC map indicated that the study area Neelambur was covered by 3.30 sq.km of built-up land. 4.47 sq.km of the study area was covered by crop land, 10.70sq.kmwas covered by fallow land and 0.65sq.km was covered by water bodies like lakes and ponds. The LULC map of the study area is represented in figure 3.
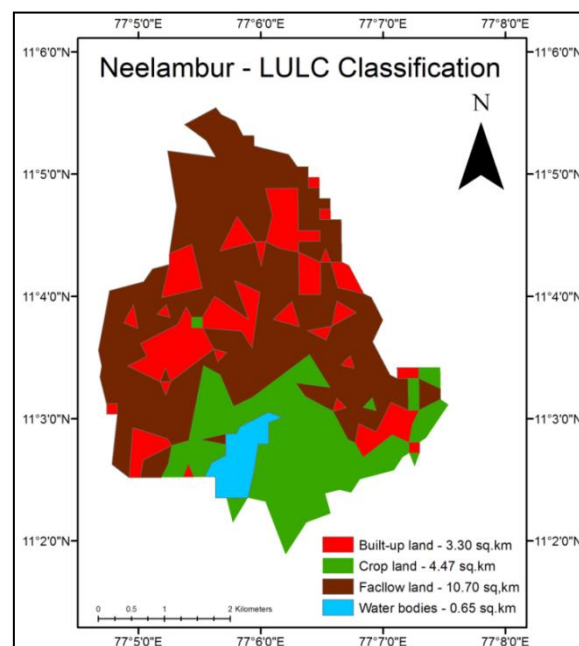
Figure 3.LULC map

The slope map was prepared using the slope tool in ArcGIS for which the SRTM DEM image downloaded from the USGS earth explorer website was used. The slope map was classified into three categories based on the slope value in degrees. Class 1 consisted of areas with slope in the range 2 degree to 9 degree. Class 2 consisted of areas with slope in the range of 1 degree to 2 degree and the Class 3 consisted of the areas where slope varied between 0 to 1 degree. The slope map of the study area is indicated in figure 4.
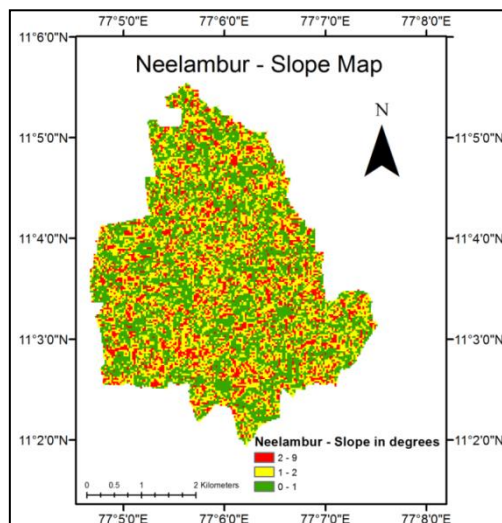
Figure 4. Slope map

The roads within the boundary of the study area were digitized using the administrative boundary map and also using the Google maps data. The different categories of roads such as National Highways, State Highways, District roads and Village roads were considered as a single category for the purpose of digitization. Once the road map was prepared, the Euclidean distance tool in ArcGIS was used to identify the land parcels that were within the range of 200 m, 400 m and 600 m from the edge of the roads. The road map along with the Euclidean distance is represented in figure 5.
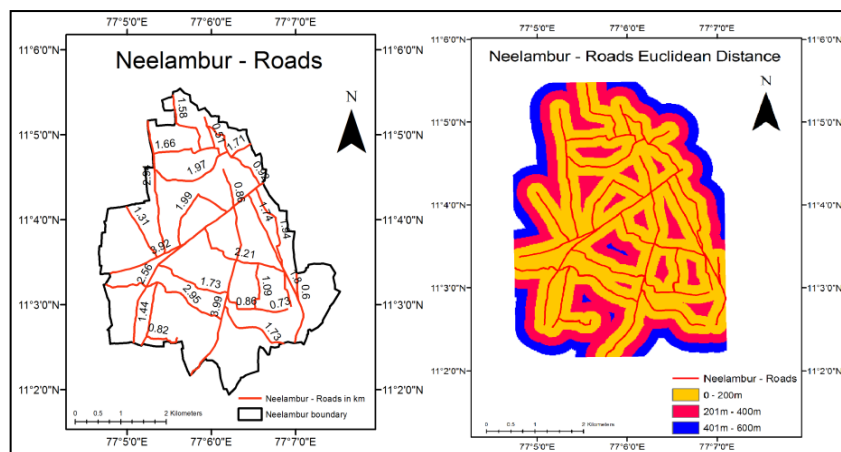
Figure 5. Road map with Euclidean distance

Since any urban settlement will be developing around a major industry, educational institution, tourism spot, etc., the geo-location of important facilities in the study area including the major industries, educational institutions, hospitals, government office buildings were recorded using the hand-held GPS and those points were digitized in the GIS system. Based on the location of points, the Euclidean distance tool was used to identify the land parcels within the ranges of 200 m, 400 m, 600 m, 800 m and 1000 m from the facility points. The facility map along with the Euclidean distance is represented in figure 6.
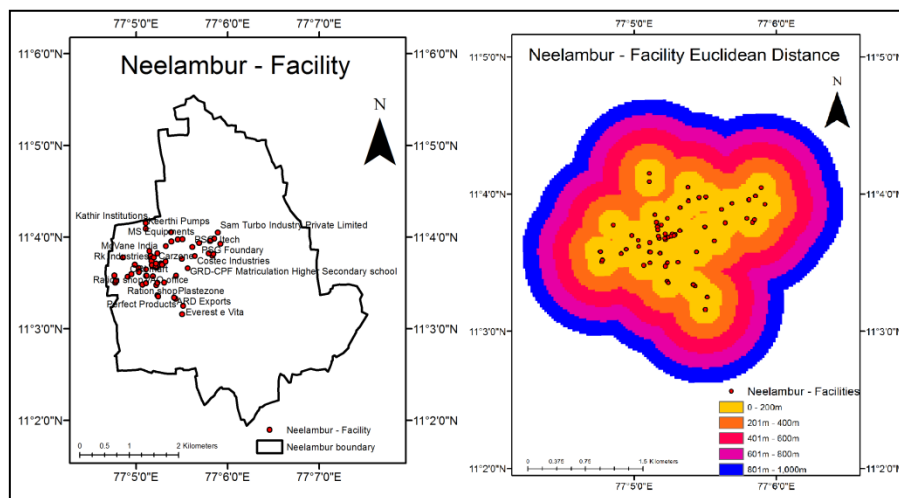
**Figure 6.** Facility map Euclidean distance

3. Results and discussions

The individual thematic layers prepared in ArcGIS were rasterized based on the sub-criteria determined for each factor. After rasterization, the individual thematic layers were given as input in the weighted overlay tool of ArcGIS where the AHP criteria weights for factors and the ranks for the sub-criteria were assigned. The sub-criteria and their corresponding ranks are given in table 2.

Table 2. Criteria weights and sub-criteria ranks assigned for weighted overlay analysis

Criteria	AHP Weights	Sub-criteria	Rank
LULC	8	Fallow land	5
		Crop land	3
		Built-up land	1
		Water body	1
Slope (degrees)	60	2-9	5
		1-2	4
		0-1	3
Proximity to road (m)	16	0-200	5
		200-400	4
		400-600	3
Proximity to facility (m)	16	0-200	5
		200-400	4
		400-600	3
		600-800	2
		800-1000	1

The LULC criteria were divided into four sub-categories namely fallow land, crop land, built-up land and water body. Since, the urban settlements can be allowed to develop on the fallow land; the fallow land was assigned the highest rank of 5, whereas the built-up land and water body cannot be used for the urban settlements resulting in assigning the rank of 1 for them. The most suitable site for urban settlements should be located at higher grounds than the surrounding areas resulting in assigning highest rank of 5 for slope value between 2 degree and 9 degree. Flat grounds are not preferred owing to the drainage problems resulting in assigning 3 for slope value between 0 degree and 1 degree. The urban settlements are preferred to be closer to the existing roads. The land parcels which are progressively away from the roads are not preferred for developing new settlements as access to roads and the site being located in the close proximity to roads is an

important factor in the development of urban settlements. This results in the assigning of the highest rank of 5 for land parcels falling within 200 m from the edge of the road. The sites falling within 200 m and 400 m from the edge of roads is assigned a rank of 4 and those land parcels falling within 400 m and 600 m are assigned a rank of 3. The location of major facilities close to the land parcels selected for the development of urban settlement is an important factor in making that land parcels a highly suitable site. The highest rank of 5 is assigned to those land parcels which are falling within 200 m of any important facility. A rank of 4 is assigned for the sites falling between 200 m and 400 m from the facility, rank of 3 is assigned for sites falling between 400 m and 600 m, rank of 2 is assigned for sites falling between 600 m and 800 m and rank of 1 is assigned for the sites falling between 800 m and 1000 m. Once, the criterion weights and sub-criteria ranks are assigned, the weighted overlay analysis in GIS system produces the output site suitability map for the study area which is represented in figure 7.
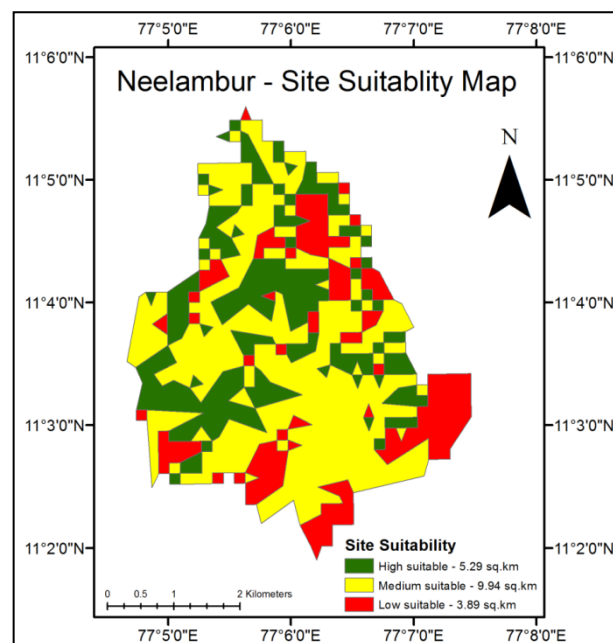
Figure 7. Weighted overlay analysis result

The output site suitability map obtained in the current study indicated that 5.29 sq.km of the considered study area Neelambur is classified to be having land parcels which are highly suitable for urban settlements. The results also showed that 9.94 sq.km of the study area was classified as having medium suitable sites and 3.89 sq.km was classified as having low suitable sites for urban settlements. More high suitable sites are concentrated on the central and western parts of the study areas owing to the high accessibility and close proximity to the roads. The presence of more facilities in the form of industries, hospitals, educational institutions, government offices, etc., is also a major reason for high concentration of high suitable sites in these areas. The low suitable sites are highly concentrated on the south west and southern parts of the study area owing to the lack of accessibility to roads and also due to the presence of more water bodies and agricultural lands. The medium suitable sited are distributed over the entire study area owing to the wide distribution of fallow lands. These medium suitable sites if properly reclaimed and developed based on stringent development control regulations can offer a better solution to the problem of lack of suitable urban settlements in the study area which can cater to the high migration of working people from nearby villages and districts.

4. Conclusions

The research work presented in this paper aimed at identifying the land parcels suitable for urban settlements which will ensure the sustainable growth of the study area Neelambur. The research methods used in the current study applied the Weighted Overlay procedure in the Geographic Information System technique based on the criteria weights derived using the Analytical Hierarchy Process to identify the land parcels that were suitable for urban settlements over the long run thereby ensuring the sustainability of the study area. The final results of this study indicated that only 27.7 % of the study area was suitable for development into urban settlements, whereas 20.3 % of the study area was not suitable for further developments. The results also showed that 52 % of the study area was medium suitable for the development of urban settlements indicating the need for development control exercise in these areas. The study presented a novel and minimalistic approach for identifying suitable areas for developing urban settlements based on GIS and AHP techniques. The results of the study when taken up and applied in the field by the respective administrative and planning authorities with the necessary development control regulations can ensure the sustainable development of the peri-urban area Neelambur.

References
[1] Department of Economic and Social Affairs, Population Division 2019 *World Population Prospects 2019 Highlights* (New York: United Nations)
[2] Department of Economic and Social Affairs, Population Division 2019 *World Urbanization Prospects 2018 Highlights* (New York: United Nations)
[3] Kolbl R and Haller R 2008 *Periurban* – A comparison between India and Western countries *Association for European Transport and Contributors*
[4] WP 7 deliverable Dissemination 2006 A comparison between the periurban developments in the EU & US and India (PERIURBAN)
[5] Dutta V 2012 Land Use Dynamics and Peri-urban Growth Characteristics *Environment and Urbanization* (ASIA) **3** 277-301
[6] Qiu D and Zhang J 2011 Urban residential land suitability index system and its comprehensive evaluation – A case study of Wenzhou *Procedia Engineering* **21** 439-445
[7] Parry J A, Ganaie S A and Sultan Bhat M 2018 GIS based land suitability analysis using AHP model for urban services planning in Srinagar and Jammu urban centers of J&K, India *Journal of Urban Management* **7** 46-56
[8] Duc T T 2006 Using GIS and AHP Technique for Land-use Suitability Analysis *Proceedings of International Symposium on Geoinformatics for Spatial Infrastructure Development in Earth   and Allied Sciences*
[9] Mukhopadhaya S 2016 GIS-based Site Suitability Analysis: Case Study for Professional College in Dehradun *Journal of Civil Engineering and Environmental Technology* **3** 60-64
[10] Sarath M, Saran S and Ramana K V 2018 Site Suitability Analysis for Industries using GIS and Multi Criteria Decision Making *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences* **4** 447-454
[11] Liu R, Zhang Ke, Zhang Z and Borthwick A G L 2014 Land-use suitability analysis for urban development in Beijing *Journal of Environmental Management* **145** 170-179
[12] Santosh C, Krishnaiah C and Deshbhandari P G 2018 Site suitability analysis for urban development using GIS based multicriteria evaluation technique: a case study in ChikodiTaluk, Belagavi District, Karnataka, India *IOP Conference Series: Earth and Environmental Science* **169**
[13] Dong J, Zhuang D, Xu X and Ying L 2008 Integrated Evaluation of Urban Development Suitability Based on Remote Sensing and GIS Techniques – A Case Study in Jingjinji Area, China *Sensors* **8** 5975-5986
[14] Anugya, Kumar V and Jain K 2017 Site Suitability Evaluation for Urban Development Using Remote Sensing, GIS and Analytic Hierarchy Process (AHP) *Proceedings of International Conference on Computer Vision and Image Processing, Advances in Intelligent Systems and Computing* 377-388
[15] Yagya A 2017 Sustaining urban growth through ecological restoration: The Case of Coimbatore (New Delhi: Observer Research Foundation)
[16] Navin Ganesh V, Pricilla D, Rajkumar R and Vishnuvardhan K 2020 Spatial Assessment of Ground Water Quality for Neelambur using GIS and AHP Techniques *Journal of Critical Reviews* **7** 1387-1395
[17] Saaty T L 1980 The Analytic Hierarchy Process (New York: McGraw Hill)