

GIS BASED ANALYSIS OF ACCESSIBILITY OF URBAN GREEN SPACES IN FOUR WARDS OF DELHI

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Urban Green Spaces (UGS), Private Green Spaces, GIS, Network Analysis, Usable Green, Accessibility

1. ABSTRACT

Urban green spaces (UGS) are an essential element of development in every region as they promote a healthy and interactive lifestyle among citizens of a country. Rise in urbanization and environmental degradation has increased a loss of these urban green spaces. With increase in built up area accessibility to UGS remains a prime concern in a locality as most green spaces lie far away from a residential area. Network analysis a tool in ArcGIS was used to study four wards of North West Delhi at different green space hierarchical levels. Results show that parks at all hierarchical levels are not normally distributed especially at higher hierarchical levels. The regions with high green density can also have low accessible residential area in terms of green spaces around due to high ratio of private green spaces and highly scattered population living across these regions. This study will help planners to develop and maintain green areas for a sustainable future and will help in further development of a region.

2. INTRODUCTION

India a culturally diverse country and is a home to 1.3 billion people of which more than 800 million people were added to it after independence owing to better health and government facilities with the establishment of new democracy. Though supporting such a large population India has just 2.42% of total land area of the world.

With higher standards of living and increased need of a luxurious life more and more people are shifting towards urban hubs wherein cities are becoming a symbol of higher earning and modern lifestyle. (India, 2011) census 31% of India's population live in urban areas, and this is expected to rise to 40% by 2026. There are 27 million-plus cities in India, with Mumbai, Delhi and Kolkata having a population of over 10 million. By 2051 India will be the most populous country with a population of 170 crore and per capita land availability would only be 0.19 (Guruswamy, 2017)

Urban green spaces are open spaces not inhabited by any residential building or built up area but mainly by vegetation and tree cover and can include forests, playgrounds, golf reserves, parks, community gardens and natural greens (Shuk Wai So, 2016). But these urban green spaces are facing a novel change as with increased population, unplanned development of cities, smaller houses, congested roads and increased working hours with travel time the size of the urban green spaces is rapidly shrinking.

The World Health Organization (WHO) has prescribed that cities should provide 9sqm of undeveloped open space for (Development, 2014). It also suggests designing green area networks in such a way that all the residents live at a 15minute walk distance from the green area. Very few Indian cities have been able to meet these standards including Chandigarh, Varanasi, Gandhinagar Jaipur while Amritsar, Ludhiana, Bengaluru lag far behind. (Govindarajulu, 2014).

Master plan of Delhi has defined UGS at various hierarchical levels to specify their use to users at all levels for social use. They define totlots as the lowest level of hierarchy planned for a population of 2,500 as play-areas for children with an area of 125 sqm. Neighbourhood Park, district parks and housing area parks lying at higher hierarchical levels provides families with leisure activities and can be used as a recreational spot. District parks or city level parks at the highest level of hierarchy act as weekend spot for the whole family.

Though many previous studies have been done in this area but most of them have happened in developed countries and very few have integrated the use of Geographic Information System (GIS) to analyze the urban green density in an area especially in developing countries like India. (Gupta, et al., n.d.). Various researchers have used their own criteria's some have defined the accessibility in terms of maximum walking distance and service radius and have their own levels of hierarchies.

In this study only public green spaces are being analyzed which can be accessed by the public at a minimum walkable time and at a minimum cost. This research will help in knowing the total accessible area limit within the range of a particular park and in figuring out the total usable green park area from it with the help of tool called network analysis. Network analysis is a tool which uses the actual distances and speeds on roads and then calculates the accessibility of a region. Other methods like buffer analysis could also have been used but they

only account for linear distances from a particular area and do not modify their results based on barriers placed in route or path. Hence the result is not always reliable in this method. (Master Plan for delhi-2021, 2011) Total usable green has been found of each ward which can be defined as all the parks and recreational areas classified according to their various hierarchical levels and which are not further than 15-minute walking distance to the public from their homes.

3.1 Study Area- The study area of this research is four localities or wards of the metropolitan city of Delhi (Fig1). These wards lie in the Northwestern part of Delhi. Delhi National capital of India is one of the greenest capitals of the world. The India Forest Act 1927, Forest (conservation) Act 1980 mandates the preservation and management of the green cover and has helped Delhi to maintain about 20% of its geographical area under green cover making per capita green availability as about 22sqm. (Chaudhry., et al., 2011) (Singh, 2015) (Census of India 2011, 2011) (COMBER, et al. n.d.)

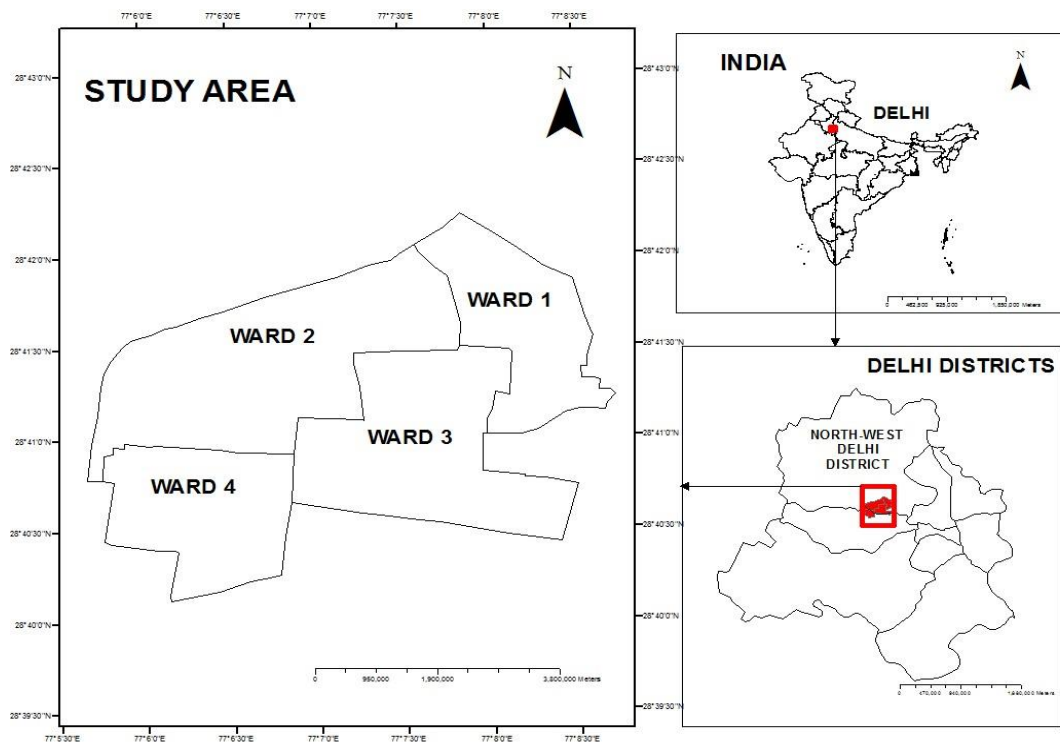


Figure 1 Location of Study Area

However high green cover does not fully justify the accessibility of different green areas in Delhi. The 2011 census states that North West Delhi has a population of 3.651.261 and had a population growth rate of 27.63% in between 2001-2011 (Census of India 2011, 2011). Kohat Enclave, Saraswati Vihar, Rani Bagh and Paschim Vihar North were chosen as study areas to analyze the distribution of green areas at various hierarchical levels with respect to each ward. These wards were developed in early 1970's when land was allotted to a group of teachers by different housing societies. Originally far from Delhi these areas have now become a residential hub where people from all economic classes reside. Most of the areas have similar demographic characteristics and 0 -6 members in each household.

Table 1 Ward Area and Population

Ward Name	Total Ward Area (sq. m)	Total Population
Kohat Enclave (Ward 1)	19,98,682	51,105
Saraswati Vihar (Ward 2)	41,20,509	41,941
Rani Bagh (Ward 3)	32,00,820	45,964
Paschim Vihar) North (Ward 4)	21,29,925	42,423

5. METHODOLOGY

5.1 Data Digitization- The data primarily used in this study has been created with the help of aerial photographs acquired by the government of India and currently under National Informatics Centre, Delhi. The data was at a scale of 1:10,000 units and was used to digitize the area falling under the four wards analyzed in PROBentley600 software. Along with-it Google Earth India was also used for reference to verify the positions of the points and lines being digitized on a global scale. The base imagery in Google earth is 30m multispectral base imagery which is pansharpened with the 15m [panchromatic] Landsat imagery. The projection used was WGS84 geodetic datum. (Anon., n.d.)

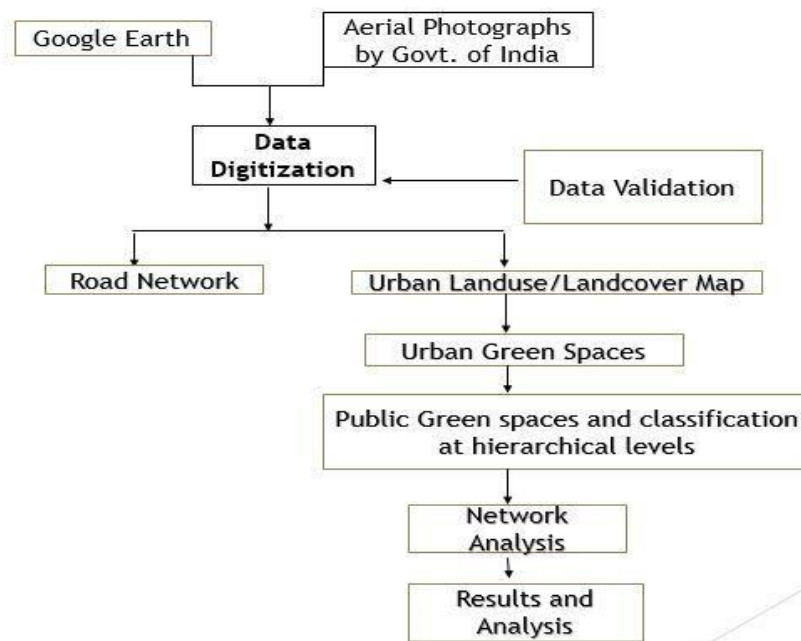


Figure 2 Flow chart of Methodology of GIS based Analysis of urban green spaces

In this study with the help of digitization the main primary regions needed for this research were digitized. The land use land cover map has been classified in the present study as follows (fig 5): Residential Area, Non-Residential Area, Parks and recreational Areas, Tree cover, Slums, roads, Residential colony gates and Park gates (Fig 5). Here only major tree covers were marked having easily identifiable dense vegetation cover.

5.2 Data Validation- Park gates are all the entrances to an urban green. To verify the validity of these points collected a sample field survey was conducted and 25 Park gates were tracked and there GPS

coordinates were recorded. It was done using GPS essential app installed in an android phone. The samples were collected in order to verify the accuracy of the information gathered in the digitized data. The park gates were at less than 20 m mean deviation from the digitized park points on the map which validated their accuracy as the GPS device used for the survey was not 100% accurate and showed an error ranging from 10- 30m.



Figure 3 Data validation of park gates using GPS

5.3 Classification at various hierarchical levels- As this study only focuses on public green spaces only parks and playgrounds were considered as accessible green areas. These were further classified into totlots, housing Area parks, Neighbourhood parks and district parks (Fig 8). The area of each park type was considered in square meter and all the parks were classified on the basis of it. Totlots at the lowest level on the basis of area while District Park at the highest level.

Table 2 Green spaces at various hierarchical levels

Park Type	Area (sq. m)	Service Radius	Walking time(approx.)
Totlots	0-1000	300 m	3 min
Housing Area Park	1000-10000	500 m	5 min
Neighbourhood Park	10000-40000	1000 m	10 min
District park	40000-80000	1500 m	15 min

To compute the accessibility of parks at various hierarchical levels simple network analysis was used. Herein simple linear distances were applied from a selected park gate at each level of UGS hierarchy to create buffer service radius and all the residential area lying within the buffer were considered for further study. The service radius used was different for all hierarchical levels. For example, it was considered that a totlots should not lie further than 300 m radius from a residential area and areas lying further than 300m away from it were considered non-accessible. A second network analysis approach was also conducted the steps and buffer radius applied were similar to first network analysis approach but this time the buffers were created from the residential colony gates and all the parks lying within the selected range were selected as usable green to find out how much a person needs to walk from a residential colony gate to reach a green area.

An average walking speed of 100m/minute was considered per person for all roads in this study. This means for a District Park lying at 1500 m distance from a person's home he/she will walk at an average for 15 minutes. Most of the public green spaces used have atleast two entrances and almost all the parks at higher hierarchical levels have 4 entrances. All the calculations were done separately for each ward and then the results were analyzed.

6. RESULTS AND ANALYSIS

All the data acquired and digitized using ArcGIS 10.3 has been processed to achieve all the above objectives. The study area of Delhi was analyzed for accessible residential area and usable green in terms of the area digitized in each ward.

The residential and total green cover of each ward was calculated with the help of digitized urban land use/land cover map (fig 4). Ward 2 has the highest amount of green cover but more than 40% of the area is covered by private or non-accessible to public for social use green spaces. Ward 1 has the least area in terms of private green spaces but ward 4 has lower green cover. The higher ratio of green cover in ward 2 and 3 is because of government restricted military area and railway area in these zones which cannot be used for recreational purposes.

Table 3 Residential and Green Area of each Ward

Ward Name	Total Residential Area (sq. m)	Total Park Area (sq. m)	Private Green Spaces (sq. m)	Total Green (sq. m)
Kohat Enclave(Ward 1)	7,54,791	3,33,732	12,450	346182
Saraswati Vihar(Ward 2)	8,57,797	6,08,569	4,43,278	1051847
Rani Bagh (Ward 3)	5,15,862	1,74,167	4,83,568	657735
Paschim Vihar) North (Ward 4)	5,55,793	1,79,481	59,655	239136



Figure 4 Residential area and Total Green per ward

The urban land use/land cover classification is as below: -

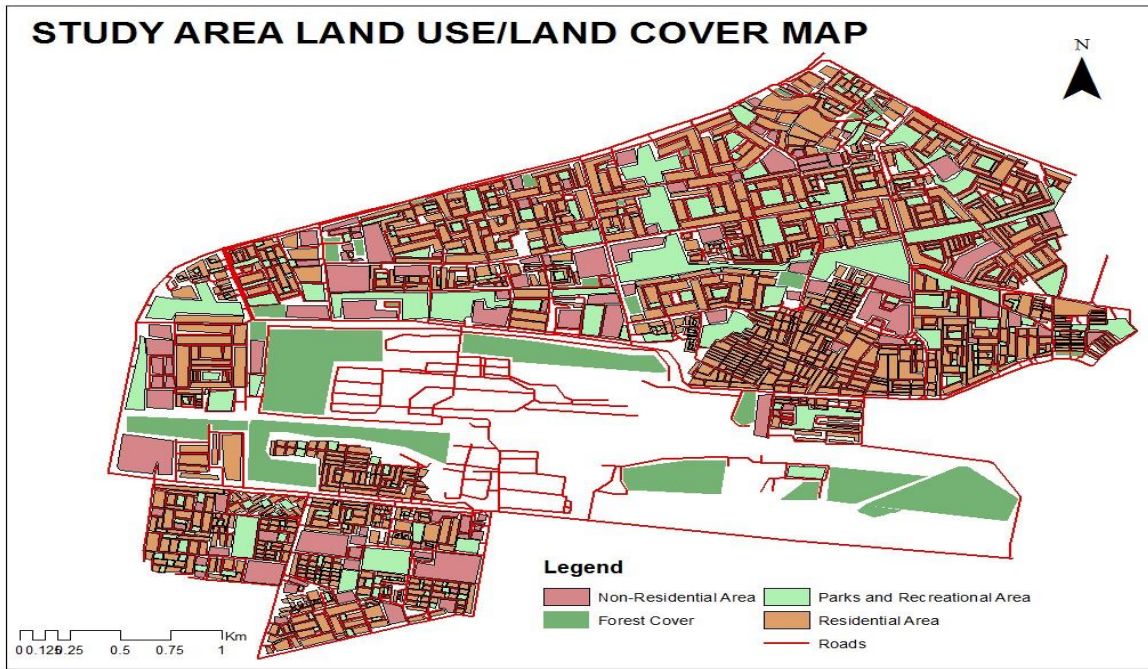


Figure 5 Study Area Land Use/Land Cover Map

Ward 1 and 4 have the highest population density and lowest green density. Ward 2 has relatively high green area per person with low population density but most of the green spaces are private. (Table 4).

Table 4 Population and Green Density

Ward Name	Population Density (Per hectare)	Green per person (sq. m)
Kohat Enclave (Ward 1)	250	6.77
Saraswati Vihar (Ward 2)	100	25.07
Rani Bagh (Ward 3)	140	14.3
Paschim Vihar) North (Ward 4)	190	5.63

Standard of green according to the world standards (Table 5). According to the world WHO standards only Rani Bagh and Saraswati Vihar match the green space per person standard.

Table 5 WHO standards for green space per person

World Green space per person(sq.)	Total green space per person in Delhi(sq.)	Districts of Delhi			
		Kohat Enclave	Saraswati Vihar	Rani Bagh	Paschim Vihar North
9	20-22	6.77	25.07	14.3	5.63

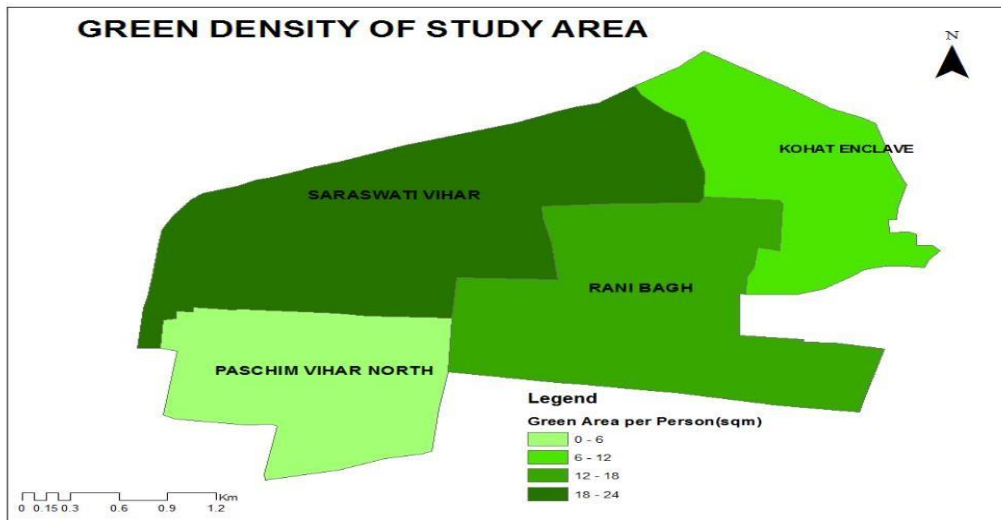


Figure 6 Green Density of the study Area

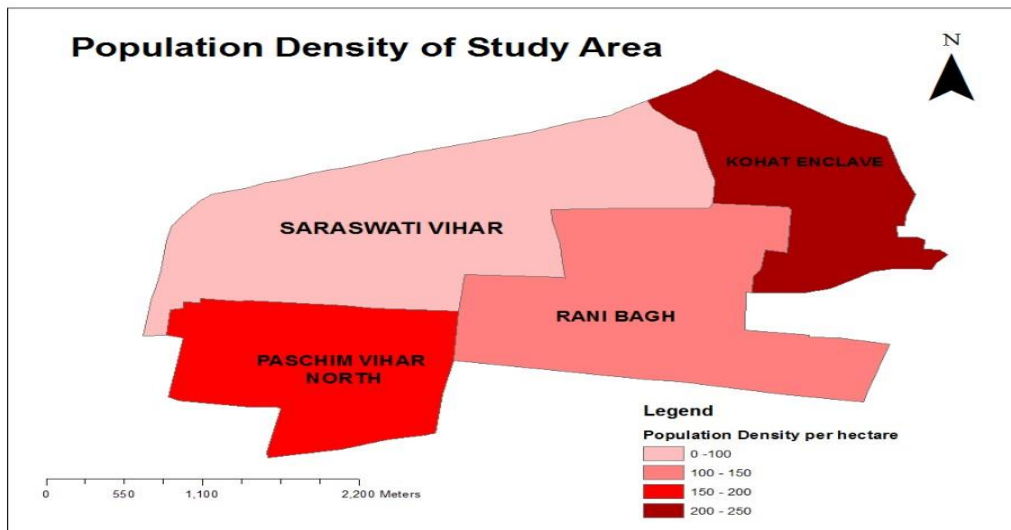


Figure 7 Population Density of the study Area

According to UGS classification 4 types of parks - Totlots, Housing Area Parks, Neighbourhood Parks and district parks were demarcated in each district. Ward 2 has the highest number of parks while ward 3 has the lowest just 27. This makes ward 3 as the least green area in terms of park cover. Ward 1 and 4 have good park cover even though they support high population density.

By the network approach it was obtained that totlots were present in highest number in all the localities and had the highest accessible service area while the district parks present in least amount had relatively low accessible residential area in its limit. Ward 3 serves the least population where network analysis estimates show that more than 10% population is not able to use the public green spaces. Ward 1 has the most evenly distributed green area and only 4% population is not able to access the parks within the given serviceable range.

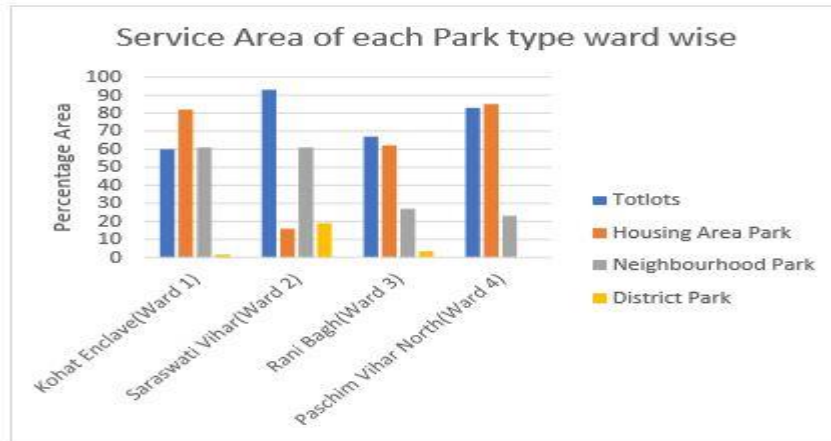


Figure 8 Service of each Park Type ward wise

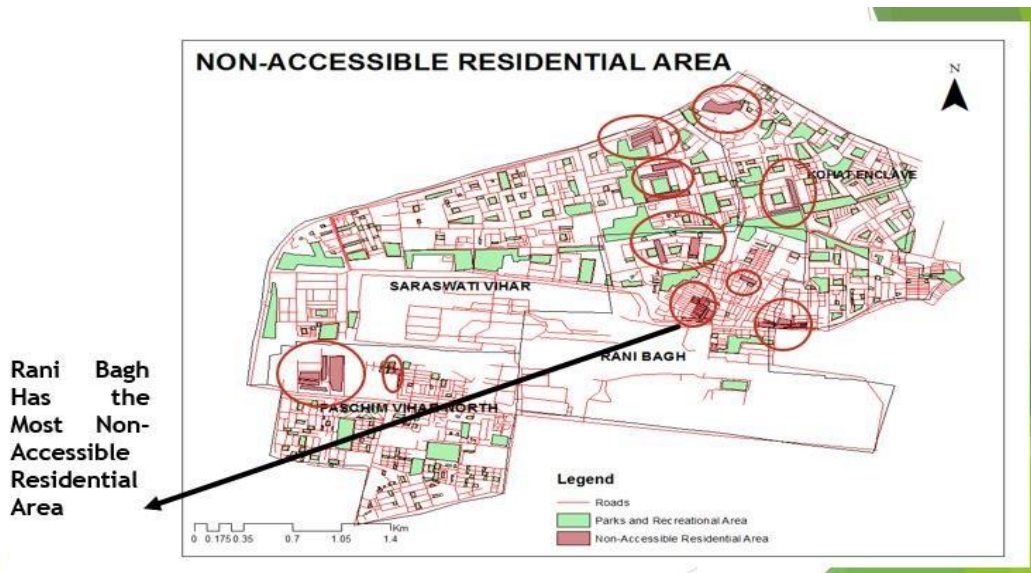


Figure 9 Non-Accessible Residential Area

When the network analysis was again conducted this time from the residential colony gates to find if green spaces at all hierarchical levels were available to the people at a maximum walking distance of 15 minutes if the service radius was created from the residential colony gates. It was found that though Rani Bagh has the least number of public green spaces but all the green area present in this region are within a walking distance of 15 minute to people residing in this locality. While ward 2 has the minimum usable green stating the fact that colonies are large and highly dispersed in this region and people have to walk large distances from the residential gates to reach a green area. Poor road network and impedances due to right and left turns on roads also increase the walking distances from the green areas which has an impact on accessibility. The total usable green is 88% of all the wards in the given study.

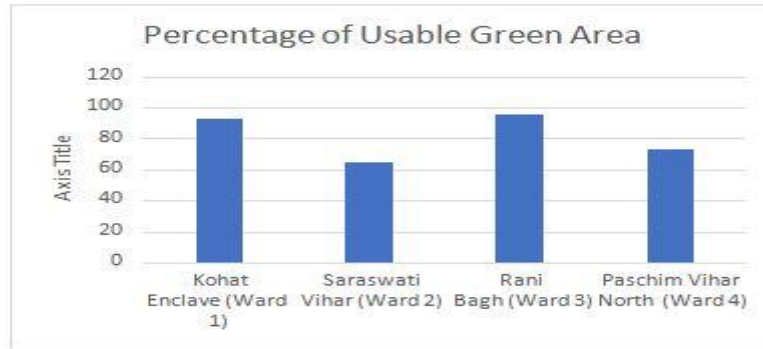


Figure 10 Percentage of Usable Green Area

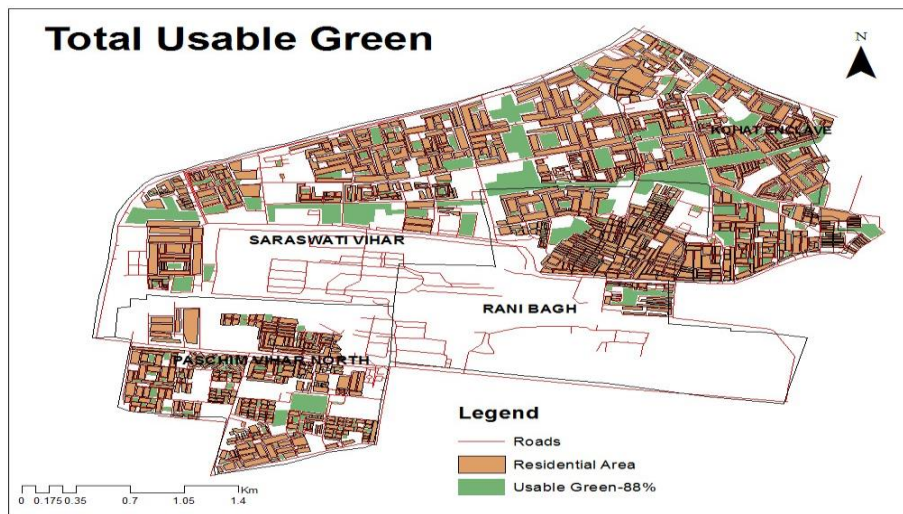


Figure 11 Total usable green

6. DISCUSSIONS AND CONCLUSION

In this study accessibility of the green area at various hierarchical levels was employed in four selected wards of North West Delhi with the help of ArcGIS tool Network Analysis. This study provides a good insight into the spread of green area and its accessibility in a locality and works on the fact that even if a locality has good number of parks in its region but increasing the distance of a park from a residential colony will decrease the amount of population which is able to take full advantage of the park especially of the green areas lying at the lower hierarchies.

Hence it is needed that the urban planners focus on optimal distribution of safe green spaces especially at lower hierarchical levels of urban green spaces. as a large number of population using these green areas are toddlers and children in between the age of 0-10 years and huge walking distances and non-maintained parks add to the non-usability of an available green area. They should focus on setting up cleaners and recycle bins in all the green areas and all the semi developed areas and vacant land within a walkable distance from the housing societies should be developed. All the green land under the government and private institutions which cannot be accessed by general public can be made available to the population at low prices. Similarly, they should ensure that these green areas are safe to the people at all times of the day.

The population influx in Delhi is very high in the present date and will continue to increase for more than decade. With this high migration rate the city planners can ensure that the pollution doesn't continue increasing and people do not continue suffering both mentally and physically due to this modern city lifestyle. In developing regions like Delhi investment on development of green areas with the help of GIS is a way out towards a healthier and better environment

7. LIMITATIONS

During the course of this research there were some unavoidable limitations. Firstly, this research was conducted in a period of 8 weeks, due to this limited time frame all the digitized park gates and residential colony gates survey was not possible and only a sample field survey was done in which 25 park gates were analyzed. Therefore, the data itself the road network, population of each ward, park gates can cause errors.

Secondly the digitization process was done at a scale of 1:10000 units though all the areas were observed and then digitized carefully but 100% accuracy of the information at this resolution is not guaranteed. This might have caused errors in the datasets. Thirdly, this study does not take into account all the aspects that will affect accessibility of a green area like the quality of the roads, lifestyle of the population living in each ward and the maintenance or cleanliness of each category of green space.

Further study on green space accessibility can take into account and find solutions to these specific problems to get a more accurate result.

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