Journal of the Institute of Town Planners, India Vol. 9 No. 4 October - December 2012

Institute of Town Planners, India Journal 9 - 4, October - December 2012, 91-104


Accessibility as a Measure to Urban Population Density Structure: A Case of Amritsar City

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Abstract

In this paper the authors argue that earlier variations in the degree of accessibility are related to variations in population densities, employment potentials, interaction levels, land values, etc. Hence physical, social and economic structure of the city is impacted by varying accessibility levels. The paper attempts to validate the hypothesis that accessibility has direct bearing on population density of an urban area. Amritsar city, the second most populated city of Punjab, has been taken as a case study. Accessibility indexes calculated for 65 wards with respect to distance, time and gravitational factor have reflected direct results when related to population densities of these wards.

1. INTRODUCTION

Accessibility is a slippery notion, one of those common terms that everyone uses until faced with the problem of defining and measuring it. A similar note is registered by Ayeni stating that 'accessibility per se is one of the most frequently used and yet little defined terms in urban studies'. Thus defining and measuring accessibility have been a concern of continuous debate amongst the scholars since decades. However, it is generally understood to mean 'ease of reaching'. Accessibility is concerned with the opportunity that an individual at a given location processes to take part in a particular activity or set of activities. It is a function of mobility of the individual with which activities may be reached from a given location. The credit of defining the term 'accessibility' goes to W.G. Hansen. He defined accessibility 'as the potential of opportunities for interaction'. More specifically, it is a measure of the intensity of the possibility of interaction rather than just a measure of the ease of interaction. In general terms, accessibility is a measurement of the spatial distribution of activities about a point, adjusted for the ability and the desire of people or firms to overcome spatial separation. D.R. Ingram introduced two subsidiary notions of accessibility i.e. 'relative accessibility' and 'integral accessibility'. Relative accessibility is defined as 'the degree to which two places (or points) on the same surface are connected', whereas 'Integral accessibility' is defined 'as the degree of interconnection with all other points on the same surface'.

The present paper is based on an empirical study conducted for Amritsar, the second most populated city of Punjab. The city has grown through medieval

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period having a history of 400 years of growth and development. Therefore, it has diversity in population distribution in different parts of the city. For the purpose of the present study, ward has been taken as a unit of measurement for which population density and accessibility indexes have been calculated. The ward population for 2004 as estimated by Municipal Corporation of Amritsar has been considered for the purpose of calculating population density of each ward. Population density has been measured after calculating the area of a ward in GIS environment. To assess the accessibility indexes for different wards, shortest path is calculated using specially designed computer software for the said purpose. For the same, main network of Amritsar city has been considered and inter-nodal distances have been measured for 698 nodes and sub-nodes. The center of each ward has been considered to calculate the accessibility index of each ward. For the purpose of accessibility analysis of the city 'integral accessibility' has been calculated to establish relative rank of accessibility of each ward. Accessibility has been measured for distance, time and population of wards as gravitational factor. With a view to examining the relationship between accessibility indexes and population densities of 65 wards, correlation and regression techniques have been applied to validate the relationship.

2. THEORETICAL BASE OF ACCESSIBILITY MEASUREMENT

Different techniques have been used to determine the accessibility of a point. However, network technique has remained the basic tool with the researchers to measure accessibility indices. It is helpful in quick estimation and analysis of settlement structure and controlling its behavior. The network approach to accessibility measurement has been categorized into two groups, namely the graphical approach, and activity-interaction approach.

2.1 The Graphical Approach

The Graphical Approach to measure accessibility is based on the principle of networking. A network is composed of different vertices (nodes) and edges (links) representing the nesting of a system. In the urban context nodes may be considered as the activity areas (work places, market places, residential areas, etc.) and roads and rail links are the linking propositions to these nodes. In this context accessibility establishes 'relative nearness' of different points on the transport network and presents a measure of the spatial relationship between different nodes.

In 1953 Shimble suggested a graphical technique to measure integral accessibility of different nodes. Shimble's measure took into account all possible destinations for each node.

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$$A_i = \sum_{j=1}^{n} l_{ij}$$

where

A_i = the accessibility of node i with respect to all other nodes in the network.

l_{ij} = the distance (i.e. the number of links in the path containing least number of links) between node i and j.

n = the number of nodes in the network.

To measure Shimble's accessibility index each link in the network is assigned a value as 1 and anxn matrix is formed by summing the number of links between two nodes. Lower sum of row total will mean a higher accessibility index and vice versa. Although Shimble's accessibility index forms base to explain the integral accessibility of different nodes but measuring the shortest path with number of links may not present a true picture of accessibility. It is because of the fact that the links may be of different lengths which may affect accessibility index of the nodes to a large extent.

Subsequent researchers have improved Shimble's accessibility index by incorporating length dimension i.e. by measuring the length in terms of distance to the link. D.R. Ingram has used distance as a measure of accessibility for Hamilton, Ontario urban area. He calculated integral accessibility as follows

$$Ai = \sum_{j=1}^{n} d_{ij}/n$$

where

A_i = accessibility index for zone i

d_{ij} = separation between zones i & j measured by time, distance, cost, etc.

n = number of zones

Lower the value of A_i higher is the accessibility index of node i.

Although application of link length dimension is considered to be a better measure of accessibility but empirical studies reveal that it is not a true measure of accessibility. Distance dimension to link gives the physical dimension to accessibility measurement. But functional dimension i.e. the condition of the links, link infrastructure, the mode of travel, etc., is measured in terms of travel time and cost. Thus measuring the spatial separation in terms of travel time or cost may change the accessibility pattern over space.

2.2 Activity-Interaction Approach

W.G. Hansen introduced activity potential to measure the accessibility index by following the gravity model. He has defined accessibility as the potential

of opportunities for interaction. Defined in this manner accessibility is a generalization of the population over distance relationship. In general terms, accessibility is taken as a measurement of spatial distribution of activities about a point adjusted for ability and desire of people or firms to overcome spatial separation. He proposed that accessibility of zone i is measured as:

$$Ai = \sum_{j=1}^{n} (S_j) / (d^a_{ij})$$

where

A_i = the measure of accessibility of zone i to activities located within the remaining zones of the area

S_j = the size of opportunity at zone j i.e. number of jobs, people, etc.

d_{ij} = travel time or distance from zone i to zone j.

^{a} = an exponent to describe the effect of the travel time between the zones.

Distance dij is not necessarily the best measure of travel difficulty and the deterrent effect of this difficulty could be measured by other functions proposed. Thus accessibility measures establish the basis to determine accessibility indices of different nodes on a two dimensional surface. The network approach is more useful to determine physical accessibility of the node whereas activity interaction approach establishes the functional base to accessibility to determine interaction levels between nodes.

3. AMRITSAR CITY, PUNJAB

Amritsar is an important city in northern India having a history of more than four centuries and is globally popular for Golden Temple and Jallianwala Bagh. It developed during the medieval period and passed through different phases of development to spread over 136 square kilometer area as per 2011 census. Overall development presents it as an organically grown city having mixed landuse pattern (Fig. 1). Physical growth of the city reveals that it has spread in all directions and economic activities are distributed all over the city except towards west due to the existence of international border. The old part of the city i.e. the Walled City presents compact but mixed type of development and sporadic development on the outskirts gives the city a completely contrasting urban design. However, the Walled City is the epicenter of economic activities apart from 3-4 more activity centers of lower order. Confused landuse pattern, defective circulation system and traffic bottlenecks have been some of the salient characteristics of city's growth. Major lines of movement, commercial areas, religious sites, and institutional areas have been the key concerns for the population to settle along or around them. Accordingly, distribution of population in different parts and directions of the city reflects an unpalatable structure of the city.

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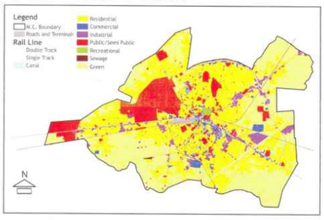
Fig. 1: Land Use of Amritsar City, 2010



Amritsar, being a popular regional trade center and located on the most important trade route, has been a popular place for population concentration. The city has registered high strides in its population growth as its population has been increasing continuously since independence (refer Table 1). As a result of establishment of Amritsar Municipal Corporation followed by reorganization of municipal space, city's population increased by about 0.14 million i.e. from a barely 0.45 million persons in 1971 it increased to about 0.59 million persons in 1981. Its population increased by about 0.12 million during 1981-1991. Urban population rose at an increasing rate due to liberalization policies and establishment of Amritsar Development Authority in 1996. City's population rose by about 0.29 million during 1991-2001, the highest increment since the origin of the holy city. In 2001, it became the second metropolis of Punjab state. Currently, Amritsar is inhabited by 1.13 million persons within its city limits. It is the second largest city in the state. Although Amritsar has registered high strides in its population increase, but its growth profile has been quite oscillating (Table 1). Thus, Amritsar city has grown in leaps and bounds since its origin but its growth has not been very smooth and constant.

Table 1 : Population Growth of Amritsar City

Year	Total Population (in Million)	Decadal Variation (in Percent)
1951	0.34	-------
1961	0.39	16.05
1971	0.45	16.60
1981	0.59	30.79
1991	0.71	19.16
2001	1.00	41.63
2011	1.13	12.83

Source: Census of India Reports

3.1 Population Density Structure of Amritsar City

Presently, population of Amritsar city is accommodated in 65 wards (Fig. 2) having differentials in their areas (Table 2). Fourteen

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wards (21.53percent) have area up to 50 hectares; 17 wards (26.15percent) have area upto 100 hectare; 16 wards (24.62percent) have area up to 200 hectare; 8 wards (12.30percent) have area upto 400 hectares and

Table 2: Area, Population and Density of Population in Wards of Amritsar City, 2004

Ward No.	Area (Hectares)	Population	Gross Density
1	254.44	14225	56
2	145.87	15713	108
3	399.09	16013	40
4	556.05	14849	27
5	885.13	14641	17
6	140.10	13845	99
7	242.82	14838	61
8	98.51	13702	139
9	138.92	13684	99
10	52.42	16061	306
11	102.72	16488	160
12	34.75	15002	432
13	77.72	14886	192
14	251.22	14975	60
15	641.52	14930	23
16	582.40	13905	24
17	591.70	14396	24
18	699.99	14933	21
19	91.71	13660	149
20	187.53	15259	81
21	50.65	14005	277
22	144.16	14429	100
23	52.36	14434	276
24	56.16	14666	261
25	43.19	16632	385
26	106.52	13901	131
27	22.26	14841	667
28	24.18	15931	659
29	63.65	13918	219
30	1201.13	16746	14
31	638.12	16901	26
32	119.19	16593	139
33	290.79	14786	51
34	52.44	14231	271
35	52.48	15414	294
36	42.61	16062	377
37	252.82	15517	61
38	109.89	16605	151
39	79.33	16485	208
40	39.81	16925	425
41	38.73	14829	383
42	30.82	15299	496
43	26.83	14349	535
44	21.59	15578	721
45	31.71	15851	500
46	25.85	14464	559
47	37.04	14354	388
48	115.29	14595	127
49	89.97	14809	165
50	140.16	14252	102
51	173.17	14233	82
52	125.17	13990	112
53	108.13	14158	131
54	164.92	15429	94
55	76.34	16102	211
56	54.13	15828	292
57	28.94	16520	571
58	80.78	16142	200
59	941.60	15345	16
60	493.71	16697	34
61	96.12	15673	163
62	349.88	14581	42
63	89.81	16695	186
64	169.87	16217	95
65	717.16	15748	22

Source : Municipal Corporation, Amritsar

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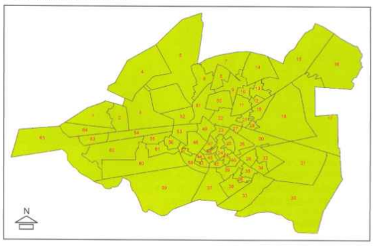
9 wards (13.84 percent) have area upto 800 hectare. One ward i.e. ward no. 30, has exceptionally large area amounting to 1201 hectares. Smaller wards are located in the Walled City area whereas bigger wards are on the periphery of the city (Fig. 2).

Fig 2: Wards of Amritsar City



Density of population in a ward in the city is as low as 14 and as high as 721 persons per hectare presenting standard deviation as high as 189 and coefficient of variation upto 89 percent (Table 3). Thus population density structure of the city presents huge variations in population density distribution over the municipal area of the city.

Variations in density pattern are amply clear from Fig. 2 where oscillations in density distribution pattern reveal significant variations. Comparing the figure with Fig. 2 reveals that wards on the outskirts have much lower densities compared to wards in the intermediate or the Walled City area of the city.

However, spatial distribution pattern of density reveals that it reduces from center to periphery in all directions of the city (Fig. 3), wards in the central area i.e. the Walled City, have higher population density and as one moves towards the periphery of the city in either direction density keeps on reducing. About 37 percent wards have low density amounting to 100 persons per hectare and all of them are on the periphery of the city. There are wards that have not been developed fully till date and most of their land is either vacant or put to

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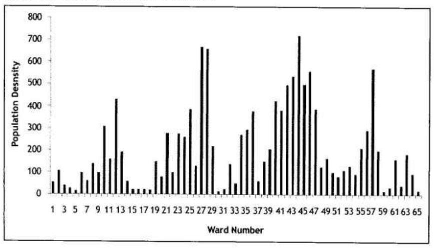
Table 3: Rank of Density of Wards of Amritsar City

Ward No.	Rank	Ward No.	Rank	Ward No.	Rank	Ward No.	Rank	Ward No.	Rank
1	51	14	50	27	2	40	10	53	35
2	39	15	60	28	3	41	13	54	45
3	54	16	59	29	22	42	8	55	23
4	56	17	58	30	65	43	6	56	17
5	63	18	62	31	57	44	1	57	4
6	42	19	32	32	33	45	7	58	25
7	49	20	47	33	52	46	5	59	64
8	34	21	18	34	20	47	11	60	55
9	43	22	41	35	16	48	37	61	29
10	15	23	19	36	14	49	28	62	53
11	30	24	21	37	48	50	40	63	27
12	9	25	12	38	31	51	46	64	44
13	26	26	36	39	24	52	38	65	61

agricultural use. Only 15 percent wards have density more than 400 persons per hectare. These wards fall within the Walled City or are located within 2 kilometer from it. These are the areas having higher concentration of economic activities including commercial or industrial.

Fig. 3 : Population Density Distribution in Amritsar



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Other 37 percent wards having density between 101 to 400 persons per hectare surround the Walled City, except in the southwest of it. Presence of basic amenities, social or physical, and better residential environment is the major reasons for medium to higher densities on the northern part of the city. Bird's eye view of the density distribution pattern (Fig. 4) presents better idea about the structure of the city.

Fig. 4 : Density Distribution Pattern in Amritsar City

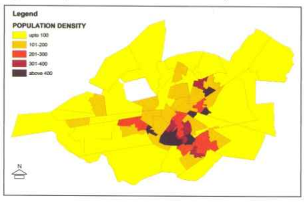


Fig. 5 : Birds' Eye View of Density Structure of Amritsar City

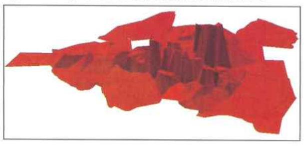
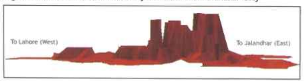


Fig 6 : East-West View of Density Structure of Amritsar City



It is clear from Fig. 5 that city's majority of the population concentrates around the Walled City, which is the epicenter of commercial activities and acts as the central area of the city. Industrial node in the northeastern part has impacted the population concentration positively as it depicts highest population density area. Cross sectional analysis of density structure along its east-west corridor depicts congregated tendencies of population around the Walled City. The density structure along east-west corridor presents near parabolic shape of population density distribution justifying the classical theory of distance density relationship i.e. the density keeps on falling with the distance from the center of the city.

3.2 Accessibility Measurements for Amritsar City

Integral accessibility indexes for 65 wards of Amritsar have been

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Table 4 : Rank of Accessibility Index of Each Ward of Amritsar City.

Ward No.	Distance	Time	Ingram	Hansen	Ward No.	Distance	Time	Ingram	Hansen
1	64	65	60	64	34	32	30	35	17
2	54	61	58	47	35	31	33	37	16
3	57	60	63	62	36	28	13	38	12
4	65	62	64	65	37	50	52	54	44
5	63	63	65	61	38	46	16	46	26
6	48	41	42	51	39	25	39	22	38
7	45	37	51	45	40	18	22	18	24
8	36	38	41	40	41	29	28	20	41
9	35	47	40	33	42	15	11	12	19
10	17	18	24	13	43	14	17	13	9
11	33	35	26	36	44	7	6	2	8
12	13	12	19	22	45	12	4	5	7
13	27	40	31	29	46	11	7	1	11
14	40	34	49	57	47	5	15	6	14
15	60	56	61	60	48	10	29	15	25
16	59	55	62	58	49	1	8	3	3
17	52	45	56	54	50	37	51	29	18
18	47	57	50	46	51	42	36	43	53
19	26	50	27	34	52	38	32	33	49
20	30	26	45	28	53	21	44	21	21
21	24	23	23	31	54	51	43	34	52
22	2	5	7	4	55	39	24	32	42
23	4	14	8	1	56	8	9	9	20
24	19	21	14	27	57	16	3	17	23
25	9	20	11	6	58	34	10	25	15
26	23	42	16	30	59	53	49	44	55
27	3	1	4	2	60	41	53	39	39
28	6	2	10	5	61	43	25	36	50
29	22	27	30	32	62	56	46	48	48
30	55	54	59	56	63	58	31	47	37
31	49	58	53	43	64	61	59	55	59
32	20	19	28	35	65	62	64	57	63
33	44	48	52	10					

calculated by working out the inter-ward shortest path over the main road network of the city. Accessibility indexes have been calculated for distance, time and spatial interaction based on gravity factor (population). After calculating the absolute values of accessibility indexes, the values have been ranked for

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each ward. It is evident from the ranks in Table 4 that accessibility measured by different methods presented almost same ranks to the same ward, thus reflecting significant correlation with each other.

Correlation Coefficients:

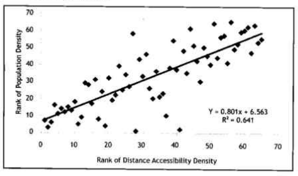
- Distance and Time : Rdt=0.84;
- Distance and Ingram : Rdi=0.95;
- Distance and Hansen : Rdh=0.87;
- Time and Ingram : Rti=0.83;
- Time and Hansen : Rth=0.79;
- Ingram and Hansen : Rih = 0.82

While looking into the ranks, it is found that the value of correlation coefficients amongst different methods of accessibility is quite high revealing strong relationship between them. The strongest of all is the correlation between distance measurement and Ingram's accessibility measure where the distance between two nodes is divided by the number of links to reach a node. Thus it can be inferred that distance presents significantly true measure of accessibility. The analysis also reveals that time and gravity measures also prove to be significantly true as their relationship with distance accessibility is also significantly high.

4. ACCESSIBILITY-POPULATION DENSITY RELATIONSHIP

Density reduces with distance from the center of a settlement. Integral measurement of accessibility betters the analysis by attaching relativity to access to each node or ward in the present context. Ranks of accessibility indices obtained for distance, time or gravity criteria have been regressed with ranks of density for different wards of Amritsar city to examine the relationship between them. R-square values have been calculated to test the strength of the relationship between them.

Fig. 7 : Relationship between Ranks of Distance Accessibility and Density of Wards



4.1 Distance-Density Relationship

Plotting the rank of distance accessibility index with the rank of density of each ward reveals positive and direct relationship between the two variables. Nearness of points of interactions of the variable to the trend line shows

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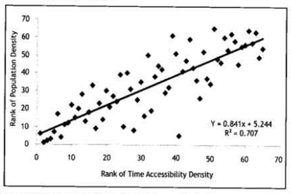
the strength of relationship of the variables. It is clear from Fig. 7 that a linear relationship exists between distance accessibility index and density revealing higher density means higher density. R-square value 0.641 reflects higher degree of relationship between the variables under study.

Fig. 8 : Relationship between Ranks of Time Accessibility and Density of Wards



4.2 Time-Density Relationship

Distance to reach an activity area or ward in the present context has direct bearing on intensity of development or concentration of population at that place. Similarly, time dimension, which reflects the limitations of road and traffic conditions on the network to reach an area impacts the density of population in an area. Analysis of time measurement of accessibility indexes when compared to density of population reveals that a better relationship emerges between time accessibility measure and density of population in the wards of Amritsar City (refer Fig. 8).

Linear relationship exists between time accessibility and density of population. R-square value 0.707 reflects very high degree of relationship between the two variables under study. Thus it can be inferred that lesser the time taken to reach a ward leads to higher concentration of population in that ward. Also, when compared to distance accessibility measures, it can be inferred that although physical connectivity determines the density distribution pattern in a city, time accessibility provided functional dimension to it. It is also a reflection of better road infrastructure on the routes travelled by the passengers.

4.3 Ingram's Accessibility-Density Relationship

While distance and time travelled have a bearing on ease of reaching a point, number of links travelled and junctions crossed also add to difficulty of reaching a point. Ingram's accessibility measure reflects the difficulty level of reaching the point. Accessibility indexes calculated by Ingram's method for wards of Amritsar city reflects the similar picture as that of distance and time (Fig. 9).

It is clear from Fig. 9 that scatter has thickened compared to distance criteria. The outliers do to seem to be too many. Ingram's accessibility indexes also have

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Fig. 9 : Relationship between Ranks of Ingram's Accessibility and Density of Wards

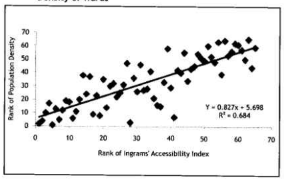
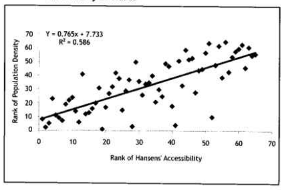


Fig. 10 : Relationship between Ranks of Hansen's Accessibility and Density of Wards



direct and linear relationship with the densities of wards of the city. The relationship reflects that one does not need to travel more number of links to a ward from the ward of origin. Thus the difficulty level of reaching a ward is significantly less. R-square value nearing 7 reveals very high degree of relationship between the variable under study.

4.4 Hansen's Accessibility-Density Relationship

Gravitational force acts as a magnet to attract most of the things towards it. While calculating accessibility of a node Hansen suggested population, work force, FAR, etc. as gravitational forces to add pull factors to that node. Like other measures of accessibility Hansen's measure also reflected similar relationship (Fig. 10). It also establishes direct linear relationship between accessibility and density of wards.

Density of scatter around the trend line reveals better relationship between Hansen's accessibility measure and density of population of wards. Although R-square value is not that high (0.586) but it is sufficient to prove the significance and strength of the relationship between the variables.

5. CONCLUSIONS

From the analysis it is clear that accessibility to a node or ward has a direct and strong bearing on attracting population to settle at that node. The flatness or steepness of the trend line reflects the elasticity of relationship between

accessibility index and density of population. Different measures of accessibility have proved that higher correlation coefficient exists between different measures of accessibility to a node. Higher degree of relationship between accessibility and density of population proves to act as a guide to master planning for different cities by proposing densities of different wardsor sectors after establishing their accessibility levels. Once exact projections and proposals for density of population are made, then it will become easy to provide near exact infrastructure facilities. In this way deficiencies in infrastructure provisions can be reduced to a larger extent. Also, accessibility measures may act as a tool to rejuvenate the decaying areas and bring development and spatial growth to less preferred areas in a city. Accessibility provisions shall act as a tool with transport planners to improve transportation systems of cities in a manner that accessibility to all sites is improved. In a way it will pave way to achieve the objective of 'mobility of all' as envisaged in the Urban National Transport Policy and Jawaharlal Nehru National Urban Renewal Mission. Although distance, time and gravity measures prove to be significantly good tools to assess the accessibility in a settlement, still provisions of public transport systems may add additional meaning to accessibility measurement.

REFERENCES

Baxter, R.S. and Lenzi,G. (1975) The Measurement of Relative Accessibility, *Regional Studies*, Vol.9, pp.15-26.

Black, J. and Conroy,M. (1977) Accessibility Measures and the Social Evaluation of Urban Structure, *Environment and Planning* A, Vol. 9, pp.1013-1031.

Hansen, W.G. (1959) How Accessibility Shapes Land Use, *Journal of American Institute of Town Planners*, Vol.25, No.2, May, pp.73-76.

Hay, A. (1977) *Transport Networks*, The Open University, Luton. pp. 18-37.

Ingram, D.R. (1971) The Concept of Accessibility: A Search for an Operational Form, *Regional Studies*, Vol.5, pp.101-107.

Jones, S. R., (1981) *Accessibility Measures: A Literature Review*, TRRL LR 967 Monograph, Transport and Road Research Laboratory, Berkshire.

Leake, G.R. and Huzayyin,A.S. (1980) The Impact of Accessibility on Trip Production and Trip Attraction Models, *Traffic Engineering and Control*, Vol.21, No.10, pp.469-471.

Muraco, W.A. (1972) Intra-urban Accessibility, *Economic Geography*, Vol.48, No.4, pp.387-405.

Raju, M.P. (1996) *Accessibility as a Determinant of Intra Urban Public Transport Model Share with Delhi as Case Study*, An unpublished Ph.D. Thesis, Department of Transport Planning, School of Planning and Architecture, New Delhi.

Patton, T.A. (1970) *The Effect of Accessibility on Residential Density*, Special Report Number 7, Department of Civil Engineering, Transport Section, University of Melbourne.

Scheurer, Jan and Curtis, C. (2007) *Accessibility Measures: Overview and Practical Applications*, Working Paper No.4, Accessibility Measures.

Wingo, L. (1961) *Transportation and Urban Land*, Resources for the Future Inc., Washington, D.C.