ASSESSMENT OF TRANSIT STOPS SERVICE AREA USING GEOGRAPHICAL INFORMATION SYSTEM – A CASE STUDY OF PUNJAB UNIVERSITY TRANSPORTATION

U. Javaid, S. R. Ahmad, A. Ahmad, M. A. Javed and A. A. Taj*

Geomatics Program, Institute of Geology, University of the Punjab, Lahore, Pakistan.
*Transport Planning Unit, Punjab Transport Department – Lahore, Pakistan.
Corresponding author e-mail: umar.javaid.lhr@gmail.com

ABSTRACT: University of the Punjab, Lahore, Pakistan being a largest educational and research institution, has remarkably large network of transportation system, covering an area of approximately 1761 square kilometers of Lahore District, to provide an efficient and low cost transit facility to university students, employees and their children. Present research has focused on existing transit stops service area analysis, using Geographical Information System (GIS), of the institute's transportation system to analyze the efficacy of transit network, user's access to transit stops and spatial gaps in the transit service. A recent survey of transit stops indicated that on an average 4,076 transit users were being served with 56 buses on 41 routes within study area. Suitable walking time of 8 minute or threshold distance of 624m with walk speed of 78m/ minute has been used as a standard to find the transit stop service area. Results showed that 26.43% of transit users were in a suitable walk access distance of 624 m from transit stops. More than 70% of the transit users in study area had walk time of more than 8 minutes to get to the transit stop. The outcome of present study will help in understanding the present transport network of the university in crucial decision making in future transport planning with respect to passenger demand in study area.

Keywords: Transportation, Transit Stop, Geographical Information System (GIS), Walking Time, Service Area.

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INTRODUCTION

The abandoned increase in urbanization and motorization in mega cities of Pakistan is creating a big impact on urban land-use and transportation system (Qureshi *et al*., 2007). The reason of socio-economic imbalance in transport system is mainly due to the rapid increase in urbanization, motorization, and uneven investment in transportation planning and infrastructure in big cities of Pakistan and China, which results equity issues (Ahmed *et al*., 2008).

The reason of continuous shift of transport mode from non-motorized *i.e*., walking and cycling to motorized is due to the expansion of Pakistani cities which increase trip length for most of urban residents (Imran, 2009). The population of cities is increasing, placing more demands on transport infrastructure. With the rapid urbanization in Asian big cities, urban transportation is facing worse conditions. Transport policy makers are taking different measure to improve the transport situation (Morichi, 2005).

Accessible and proficient services are the key features of efficient transit systems (Advani *et al*., 2005). The survey results of US Federal Transit Administration (FTA) and GeoGraphics Laboratory at Bridgewater State College, Massachusetts show a clear trend toward increasing use of Geographic Information System (GIS) in transit industry (Sutton, 2005). In the context of transportation, GIS is being applied in vehicle routing, vehicle scheduling, travel demand modeling, complex trip planning, transportation hazard analysis, the determination of transit service areas and associated populations within those areas, and for many other types of transportation-related analysis (Bibaa *et al*., 2010).

Transit stop spacing is an important part of transit service (Furth *et al*., 2007). Spatial location of transit stop being the key point of contact between the passengers and the transit service, which significantly affects transit service performance and is an important factor in Transportation Management (Foda and Osman, 2010).

The distance walked by a passenger to get transit stop is a key indicator of a transit system's ability to attract people in its service area (Hoback *et al*., 2008). The presence or absence of transit service near user's origin and destination is key factor in user's choice to use transit service (Jumsan *et al*., 2005). Strategic planning to improve transit system coverage in order to increase the total population served by suitable transit stop locations and route network can contribute to the efficiency and sustainability of a public transport system (Murray *et al.*, 1998).

The marginal walking distance to transit stop is a basic parameter to estimate transit service coverage area in certain region (Jumsan *et al*., 2005). Walking or Physical access to a transit stop is interpreted in terms of the proximity of the passenger's origin or destination to the nearest transit stop (Foda and Osman, 2010). Among transit planners and researchers, it is nearly universally accepted that a 400m walking distance and a mean walking speed between 80-95 m/minute is the maximum distance that most potential users are willing to travel to reach their nearest transit stop (Finnis and Walton, 2008), although other distances have also been used in urban areas i.e. 300 m, 500 m and 800m. (Mavao *et al*., 2012).

Threshold distance of 624 m or walk time of 8 minute with walking speed of 78 m/minute or 1.3 m/s (second) is used to find transit stop service area. (Finnis and Walton, 2008).

Therefore the Present study was planned to map and assess existing university transportation system with respect to transit stop service area and to extract percentage of served user's population within a standard time zone or walk catchment.

MATERIALS AND METHODS

Study Area: The study area was District Lahore, the Capital of Punjab, Pakistan. It comprised of approximately 1761 sq. km area having an extent of 74° 00´ to 74° 40´ degrees longitude and 31° 14´ to 31° 45´ degrees latitudes. It was bounded on the north and west by Sheikhupura District, on the East by India (International Border) and on the south by Kasur District. (Fig. 1) showing Punjab University transit network in the study area.

Road Network: There were six inter-city roads in Lahore which connect the city to other cities of the country including Grand Trunk Road, Multan Road, Raiwind Road, Ferozepur Road, Burki Road and Bedian Road. The Major urban and inter-city road network is shown in (Fig. 2).

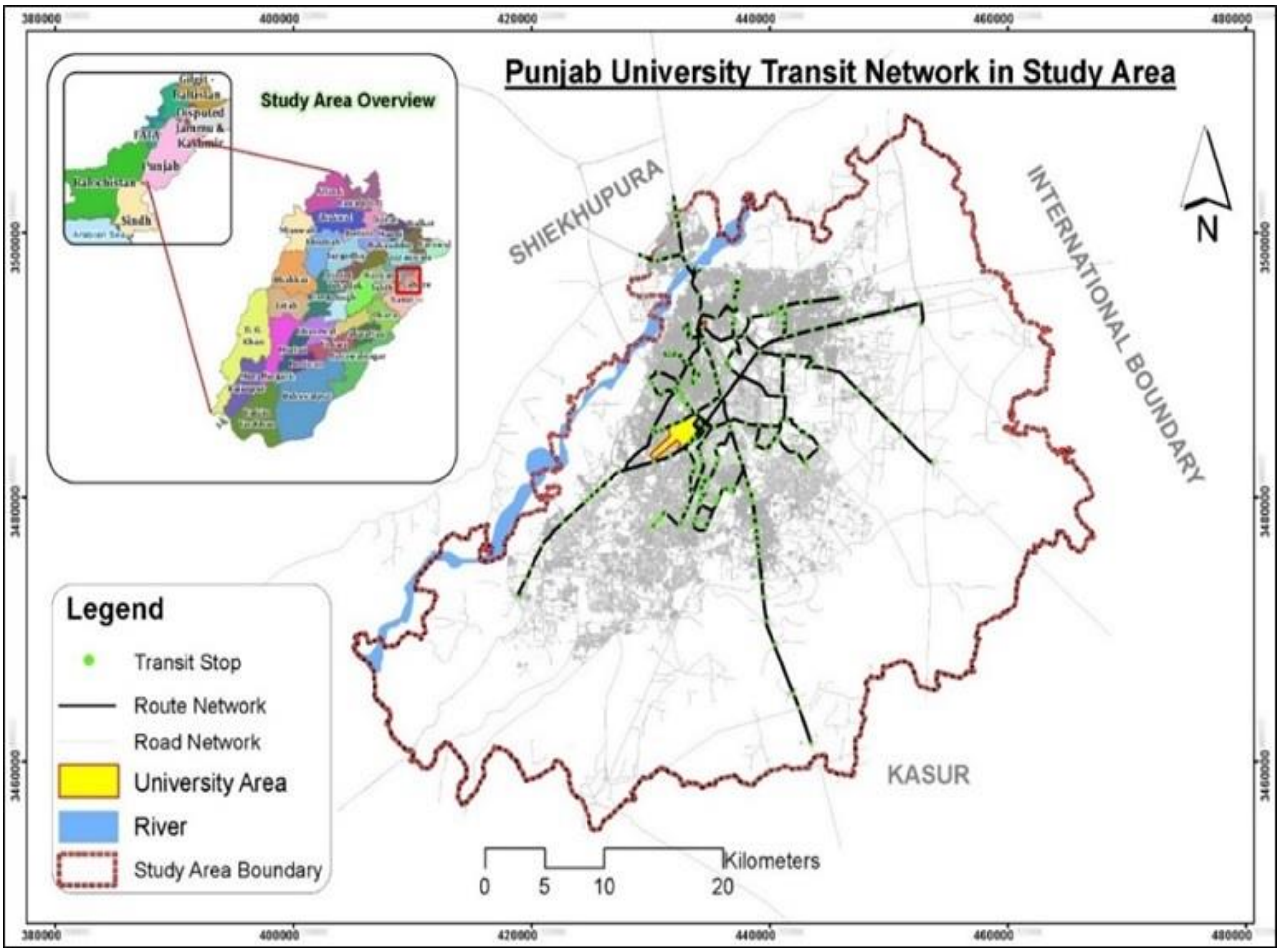

Figure 1: Punjab University tranist network in study area

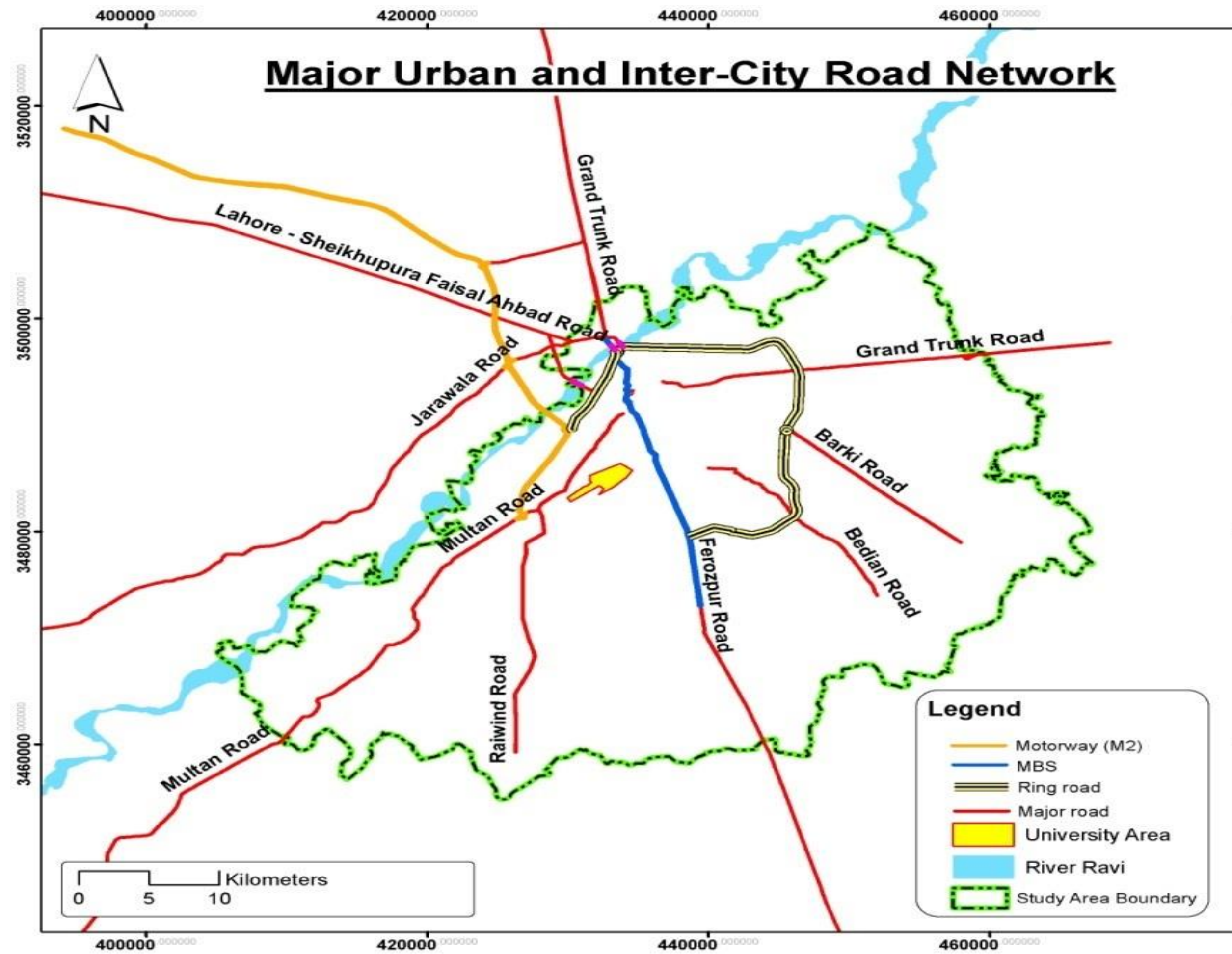

Figure 2. Major urban and inter-city road network map

Data Acquisition and GIS Analysis: Transit data of current fleet system was obtained from Transport Department, University of the Punjab. This data included names of transit stops, routes and schedules which were used to create the transit component of the network. A field survey was conducted to find the number of transit users at each transit stop. Land-use and route network data was developed using field survey and digitization of high resolution satellite imagery. A Global Positioning System (GPS) Survey was also conducted to make spatial data of transit stop. Detailed road network data was developed using digitization of high resolution satellite imagery.

Road network data was used to create the walking component of the network by measuring the walk travel time for each road segment, using the length of the road and a walking speed of 78 m/minute. Walking Distance or Walk travel time to transit stop was used to find transit stop service area, (Fig. 3).

Road Network Topology and Network Analysis: Roads and bridges were the links by which a passenger could reach at transit stop. In order to build geometrically corrected network dataset, the edge–node topology was incorporated into the road network dataset. Geometric errors were removed through topological rules e.g. must not Intersect or Touch Interior, must Not Have Dangles etc. Network analysis answered the range of questions related to linear network such as roads, railways, rivers and utilities. Common applications were route finding, route planning, identifying the closest facilities by travel time or distance and calculation of service areas i.*e*. areas within 8 minutes' walk of a transit stop etc.

The network dataset included length of each road segment, walk speed, F-node, T-node, F & T Minutes and One-way restriction attributes to depict real time road network linkage in the study area. Road Network Datas*et al*ong with edge-node topology is shown in (Fig. 4).

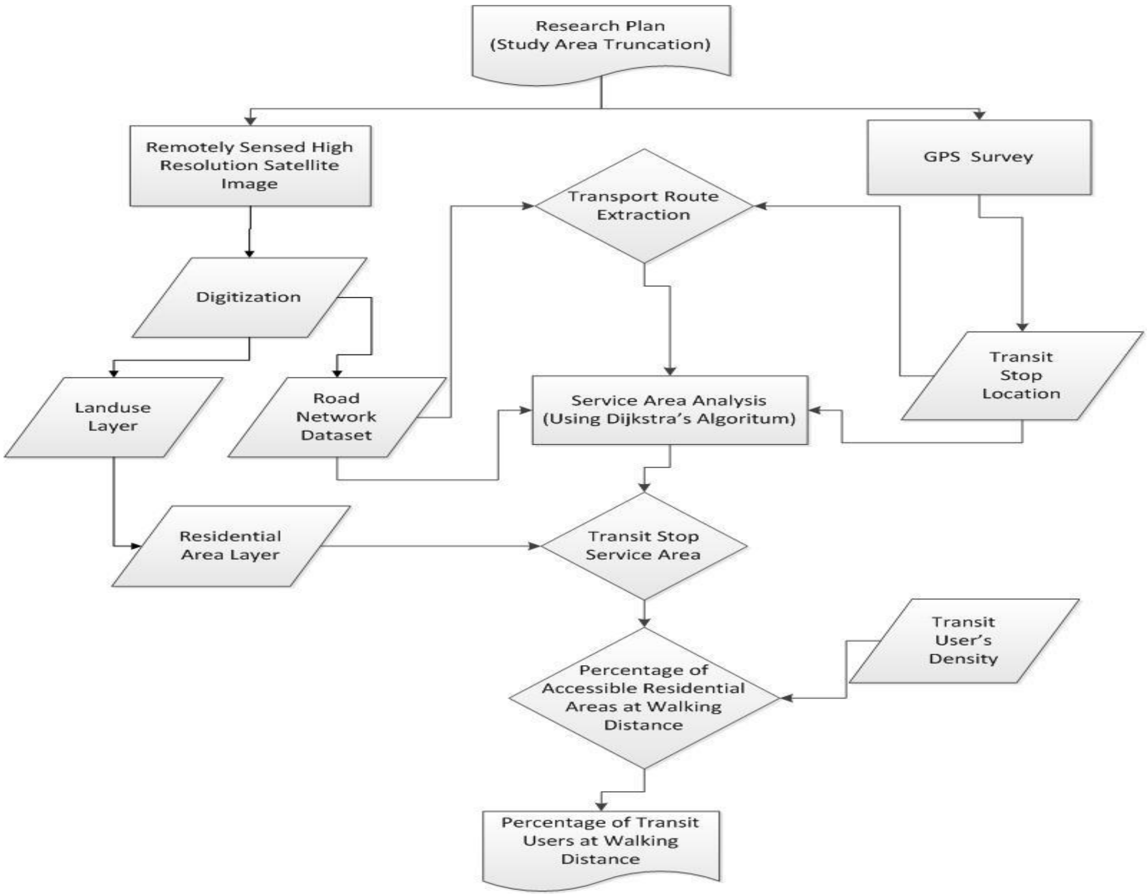

Figure 3: Methodology flow chart

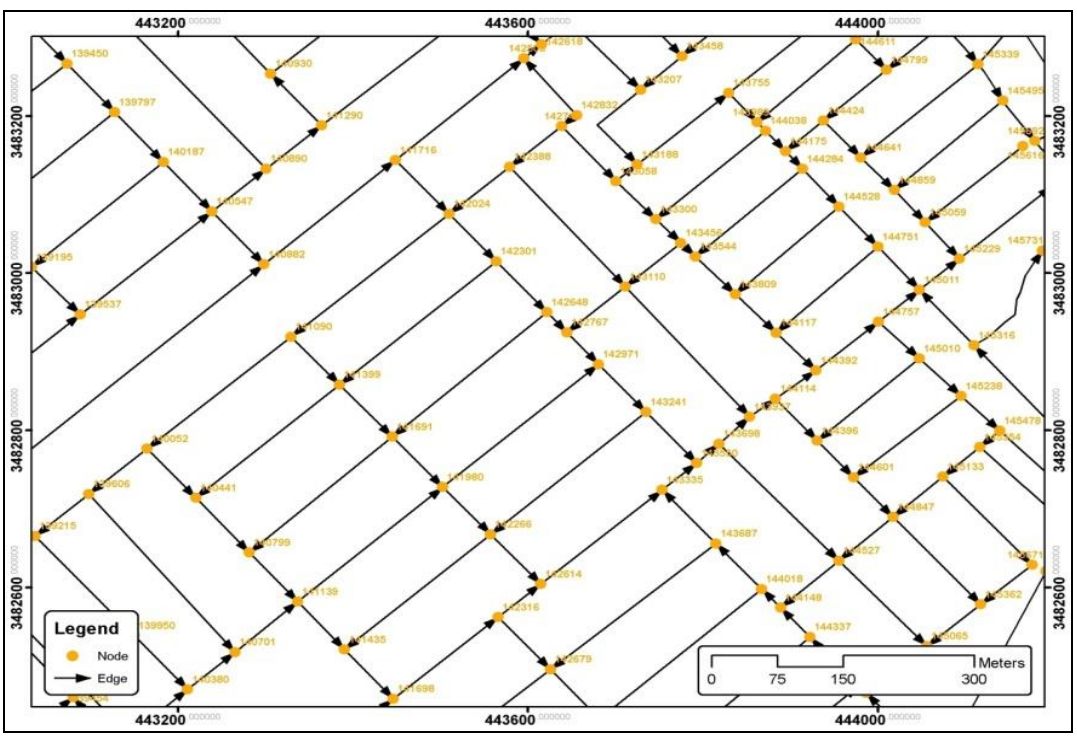

Figure 4: Road network dataset

To measure the percentage of transit users lying in a suitable access distance. It was very important to know the transit users density in the study area. For this purpose the study area was divided into three zone i.e. inner, middle and outer according to transit user's density in union council division. Transit user density was calculated using the formula represented by (Alexander, 1993).

Transit Users Density (Di) = $\frac{N_k}{R_k}$

Where N_k =Number of Transit users in the analysis zone *k*

R_k =Residential area in the analysis zone *k*

The formula for computing the transit user's population with walking access to transit with network service area method was formulated by (Bibaa, *et al*., 2010) which is as under;

$$Ti = Ri \times Di$$

Where,

Ti = Accessible transit users in the analysis zone i

Ri = Accessible residential area in the analysis zone i

Di =Transit users density in the analysis zone i

RESULTS AND DISCUSSION

Land-use Distribution: The land-use analysis indicated that a major portion of the project area i.e. around 73% was composed of agricultural land or open space. The residential buildings were spread on around 16% percent of total area while roads occupied about 2.82% of land. The commercial area or shops covered on 0.7% and the graveyards occupied about 0.17% of total area of Lahore. The existing land-use was portrayed by land-use map of Lahore-2013, (Fig. 5).

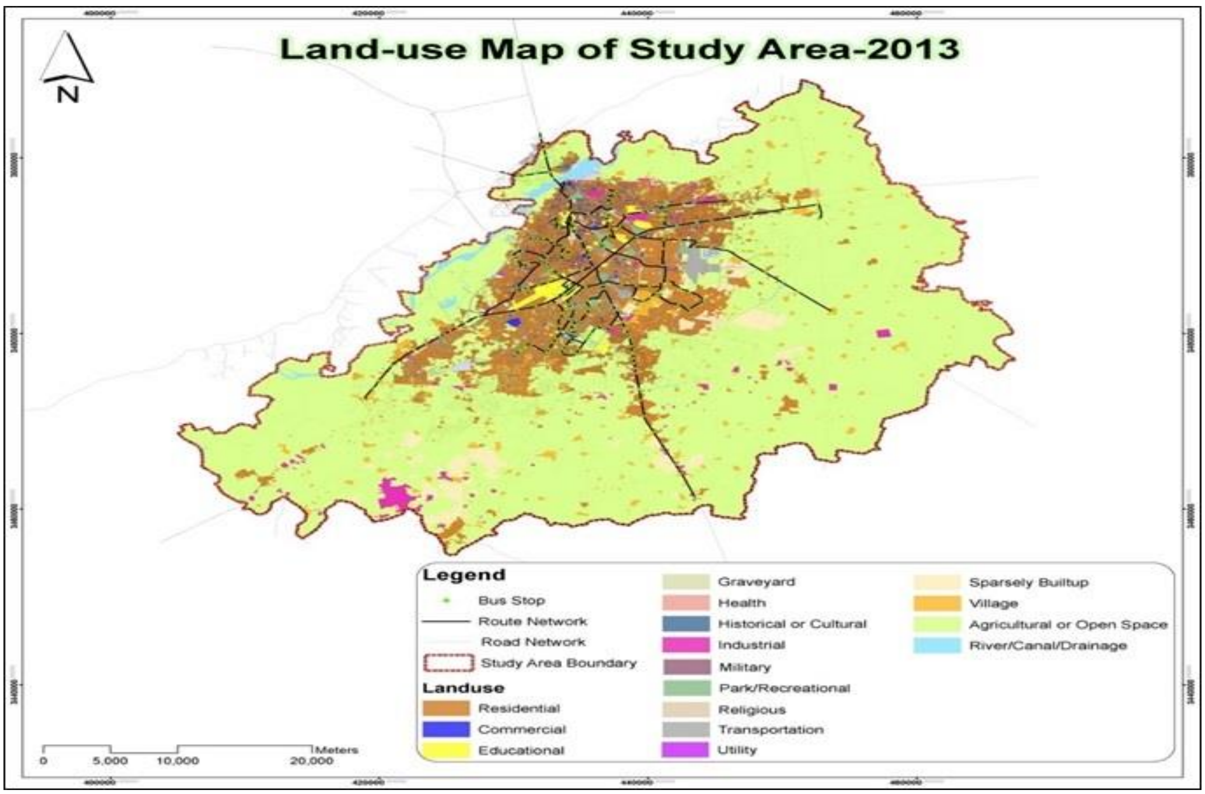

Figure 5: Land-use map of study area, Source: Punjab Transport Department

The distribution of land such as residential, commercial, industrial, education and parks over the urban areas determined the location of human activities such as living, shopping, working, education or leisure (Wegener, 2004). Land-use distribution had a potential impact on transport planning (Wee, 2002). Efficient transport system was achieved by the integration of land-use and transport planning (Curtis *et al*., 2004). Many international studies conducted, with a focus on connecting land-use and transport were carried out by (Newman *et al*., 1996).

Land-use information and mapping was a keen and important factor in transportation planning (Newman and Kenworthy, 1996). In this study the land use mapping was done by acquiring and processing the landuse vector data, afterwards this data was validated by the classified satellite imagery. Landuse mapping helped out in identification of the tansit stops, falling in the kind of class and on the basis of percentage of the commuters in that specific area measured (Lei and Church, 2010). Landuse mapping and analysis were quite helpful in redefining and realigning the transit stops and bus routes of the university (Dorsey and Mulder, 2013).

The area wise land-use distribution is presented (Table1).

Transit Users Density: The results showed that the inner zone was the most populated region where 66% of total transit users resided where as 28% and 6% transit user resided in the middle and outer zones respectively. The results obtained in this study showed that the transit user's density decreased while moving from core of the study area towards its periphery (Currie and Senbergs, 2007).

Results revealed that inner zone which was most populated zone constituted only 29% of transit users lying in suitable walk time while middle and outer zone encompassing the 22% and 16% population respectively. Adopted method in this research to determine the accessibility of the peoples to the transit stops provided better and realistic picture as compared to the traditional methods (Bibaa *et al*., 2010). The transit stop service area measured, represented various demographic and accessibility indicators found in inner, middle and outer zone through spatial analysis were found to be same as represented by (Currie and Senbergs, 2007).

Table 1: Land-use Distribution

Land-use	Area (sq.km)	%age
Agricultural or Open Space	1283.91	72.90
Canal or Drainage	3.31	0.19
Commercial	12.33	0.70
Educational	12.50	0.71
Graveyard	2.93	0.17
Health	2.57	0.15
Historical or Cultural	0.64	0.04
Industrial	22.71	1.29
Institutional	5.17	0.29
Military	0.52	0.03
Park	10.89	0.62
Recreational	1.74	0.10
Religious (Mosque & Church etc.)	0.08	0.00
Residential/Village	279.93	15.89
Road	49.64	2.82
Sparsely Built-up	44.89	2.55
Transportation	13.21	0.75
Utility	0.43	0.02
Water Body	13.87	0.79
Total	1761.25	100.00

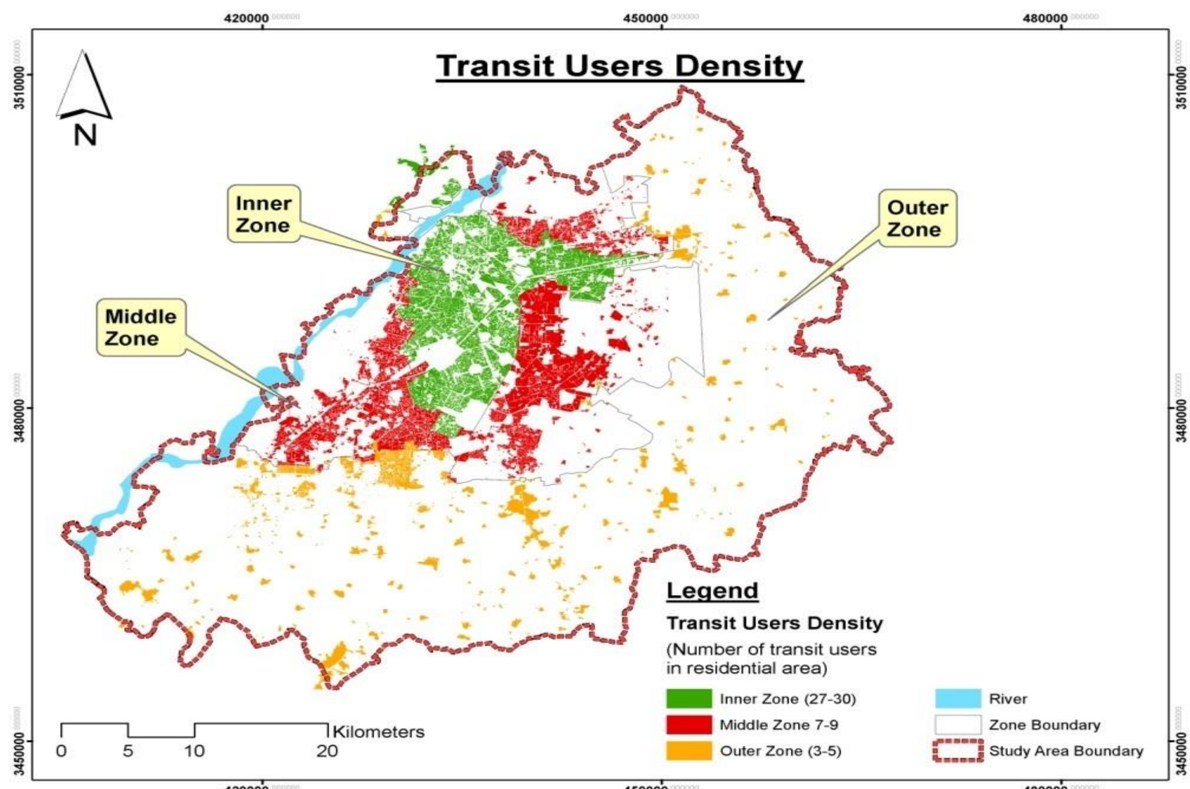

Figure 6: Transit users density in the study area

Service area analysis was performed by using road network and pedestrian network data being the most reliable method in transit user density measurement (Foda and Osman, 2010). To measure or determine the transit user's density a walk time of 8 minutes and 624 m coverage distance of transit stop or threshold based on road network was considered for a comfortable walk for most people under normal conditions (Mavao *et al.*, 2012). The distance criteria could be changed by considering the local circumstances or terrain, (Murray *et al.*, 1998). The above Standards were used to find transit stop service area using Network Analyst Extension in Arc GIS 10.1.

Fig. 8 showing the serviceability status of the different parts of the study area, furthermore area with no coverage and which are beyond defined walk time by transit stops also shown in this figure.

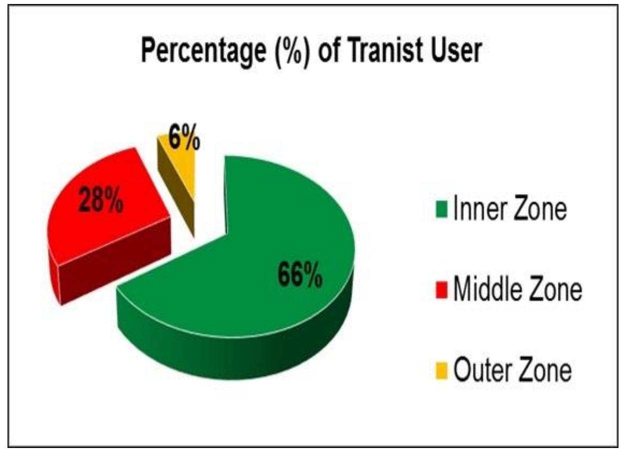

Figure 7: Percentage of transit users

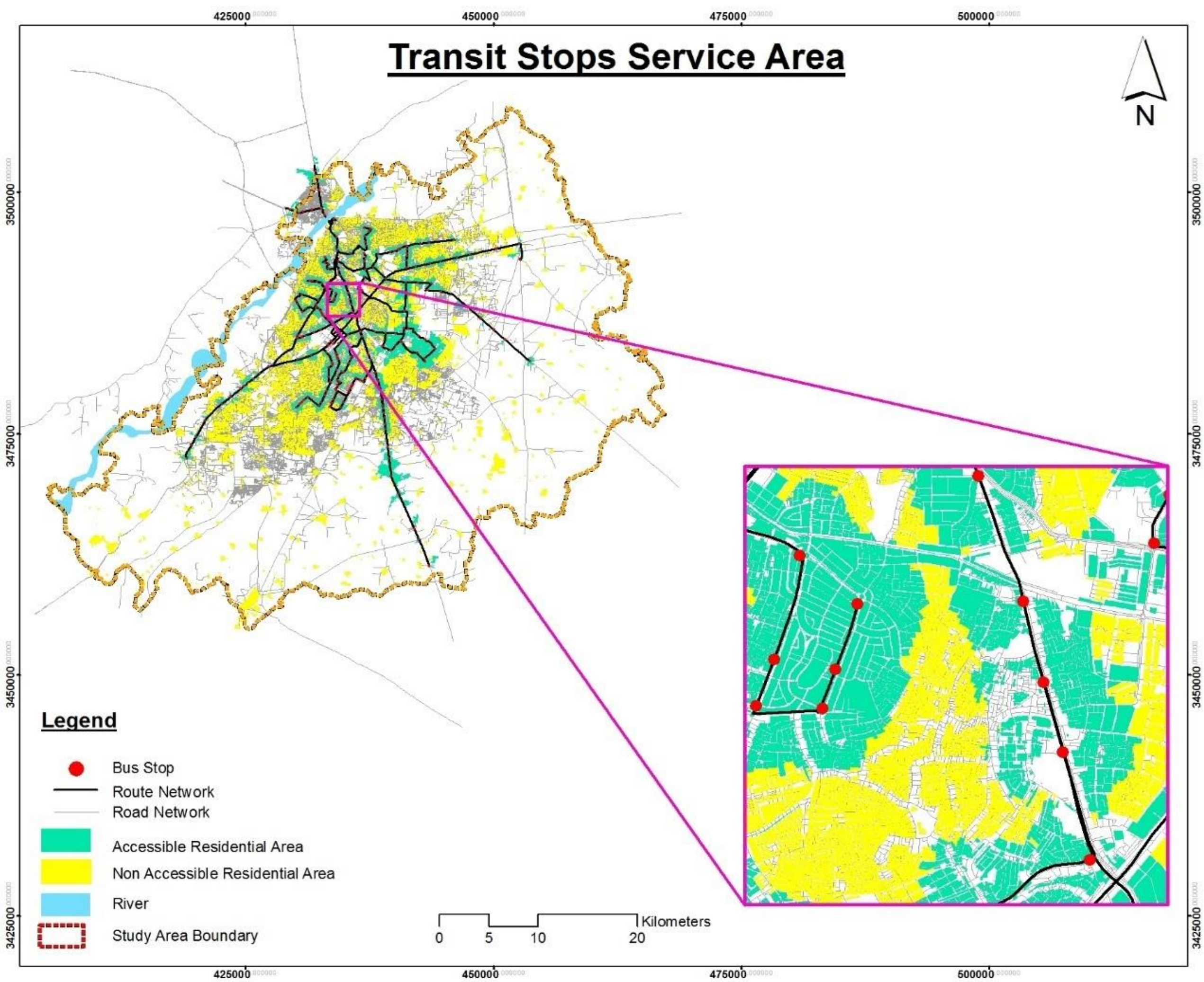

Figure 8: Transit stop service area

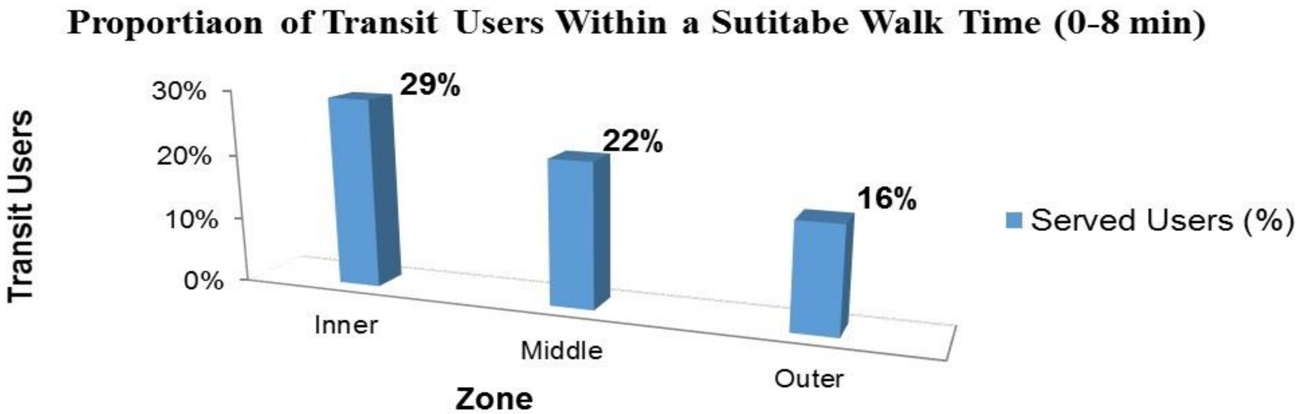

Figure 9: Proportion of transit users lying in suitable walk time

Table 2: Transit Stop Service Area Measures

Indicators	Inner Zone	Middle zone	Outer zone
No. of Union Councils (UCs)	103	29	19
Total number of Transit Stops	136	61	13
Average number of transit stop in each UC	1.32	2.103	1.46
Area of all UCs (sq.km)	188.72	450.3	1113.26
Residential Area (sq.km)	96.14	125.67	66.68
Proportion of Residential Area	51%	27%	6%
Accessible Residential Area	27.89%	32.28%	9.61%
Proportion of transit users	66%	28%	6%
Accessible Transit Users	29.11%	22.37%	16.01%

CONCLUSIONS AND RECOMMENDATIONS

This study elaborates and substantiates the capability of GIS by using network based accessibility approach in the assessment of the existing transport system of the biggest educational institute in Lahore district, Punjab. This study explicates that the areas with dense pedestrian/road network and close to transit stop are more accessible in comparison to those transit users which are beyond 8 minutes walking distance from stops. Consequently, present study reveals that unplanned and insufficient road network in combination with inappropriate spatial distribution pattern of transit stops causing accessibility issues to the transit users in foremost portion of the study area.

By keeping in view the above discussions it is observed, there is a dire need to reconsider or plan the transport network/stops of the university by focusing the land-use distribution pattern and actual demand locations. Furthermore, it has been observed that improvement in road/pedestrian network in those areas which are falling in poor zones of accessibility could decline the accessibility issues. It is also worth mentioning that research institutes and government agencies should conduct these kind of studies on periodic basis to determine the ascending gaps and needs in planning and infrastructure management system as per general public requirement.

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