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Impact Assessment of MRTS on Land Parameters

Case Study of Delhi Metro

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Abstract: A Mass Rapid Transit System or Metro Rail is considered to be the ideal solution in a congested transit corridor for a large city. MRTS mainly impacts accessibility, travel pattern, land use, land values etc. It can increase the accessibility of remote areas; it can act as a catalyst for urban redevelopment. On the other hand if MRTS nodes are not planned, chaotic urban transformations take place as a result of increased accessibility and consequently, increase in land value which leads to a takeover by market forces. This result in chaos and congestion, rapid developments take place along MRTS corridor and within their influence area. Often the effects of such MRTS corridors are detrimental and can be in an unintended manner. It is very important to check the real impact of MRTS after its operation for several years. Therefore a systematic study is needed to analyse the change in urban form along metro nodes and its influence zone, to guide the future developments in an organised manner. The need of study lies in understanding the intensity of the impact of transit on the terminal stations and along the corridor as a whole. The present work is an effort to identify the causes and impacts of Metro on the surrounding land values and land use pattern. The area selected for the study has a totally different character composition in comparison to the other areas where metro rail has been implemented. The corridor between two major nodes of MRTS in Delhi i.e, Anand Vihar and Yamuna Bank is an overhead section which passes through different zones within Delhi and also through the River Yamuna. This area covers metro stations like Lakshmi Nagar, Nirman Vihar, Preet Vihar and Karkardooma stations. During the study, the data is collected in form of maps from the previous studies as well as present data and primary data collection is done by mapping the existing land use of the area on software like Erdas Imagine and GIS and carrying out field surveys. For conducting the primary survey, reconnaissance survey was conducted & GPS (hand held) was used to capture location details. The survey findings revealed facts that have been analysed further as part of this study. The development controls and bye-laws have been changed without considering master plan with the implementation of MRTS in the study area. Mixed Land-Use is prominent in the study area which is increasing economy. The methodology adopted was totally on the basis of comparison of pre and post metro development of the selected corridor.

The study will enable policy makers and planners to access the impact of MRTS from the real life case study and formulate future plan of action.

Index Terms **– MRTS, Land-use, Land-value, Transit Oriented Development, Precinct.**

I. INTRODUCTION

For a city to be effective it is vital that it has a sound infrastructure and service. Urban transport is a crucial component of urban infrastructure. It provides access to commuters, supports urban economic activities and facilitates social interactions. Transportation and land use are inexorably connected. Every change in land-use has implications on the transportation corridor load and vice versa. Literature suggests and practical experiences of the existing scenario validate the fact that improvement in transit corridors directly affects the pattern of land use in the immediate and near immediate surroundings. Factors related with the integration of transport and land use, which trigger the haphazard development are related to accessibility, property value, growth & employment to support residential development. Various activities develop creating more employment opportunities & transformation of land use i.e. areas along the transportation corridor tend to commercialize & show mix use characteristics.

As per the report of Transport authority of India, the demand for transport infrastructure and services has been rising by around 10% per year with the current infrastructure being unable to meet these growing demands [Source: Transport department Delhi]. If we talk about the Present condition of Delhi, Delhi has experienced phenomenal growth in population in the last few decades. Its population has increased from 62 lakhs in 1981 to 167 lakhs in 2014, registering an increase of over 21 per cent during 2001-2011 which is above the national average growth of about 17 per cent [census 2001, 2011] and the projected population for the year 2021 is 310 lakhs. In a city, there is an inherent relationship between population density and spatial distribution of land use activities,

economic activities, between transport network and activity hierarchy and consequently, between human demands, transport network, spatial activity distribution. This gives every city a unique form and structural identity.

The inherent weakness of the city lies in the matter of its capacity for public transport by road or by other means. The natural resource are limited, land is already scarce and infrastructure including transport system at verge of breakdown. The total area of Delhi is 1486.39 sq.km. out of which 640 sq.km. is included in urbanized limits i.e. 45% of the land used for urban development [Wikipedia]. To accommodate these 31 million people by 2021, Delhi need to utilize more land resources available. The conventional approach of engulfing green areas for urbanization purpose, no more remains the sole solution to cater the problem of increasing population. In Delhi, the situation aggravates as there is no more land available. Transit oriented development is a new term gaining attention so as to solve the 'sprawling city' problem. Master plans of all cities have concentrated on developing cities in a "low rise, high density" pattern. TOD helps us utilize one limited & scarce resource i.e. 'land' more effectively.

The advent of Metro rail has not only made it easier to access the nook & corners of the city, but also helped in a development best suited for the worsening scenario preventing haphazard development. It also acts as a catalyst for urban redevelopment. MRTS nodes shall be planned so as to avoid chaotic urban transformations. MRTS shall act as a facilitator and as lifeline connecting all important nodes of the city. But rapid development is taking place along metro line and within their influence area, without proper planning resulting in haphazard development. The very premise of transit oriented development is shaken if haphazard development remains unchecked. Therefore a systematic study is needed to analyze the change in urban form along metro nodes and influence zone, to guide the future developments in proper manner. The need of study lies in understanding the intensity of impact of transit on the terminal stations and transit corridor. The study will enable policy makers and planners to access the impact of MRTS from the real life case study and formulate future plan of action.

II. SCOPE & METHODOLOGY

It will provide the picture of impact of a Transit Project on land component of the area as land is the most important component of any development. It will also provide the development strategies involved after implementation of Transit Project. Study is based on Primary & Secondary sources of information and observation/reconnaissance survey which may have limitations regarding to accuracy.

The methodology involves studying study area characteristics which includes existing connectivity and accessibility, existing land use, existing land value and existing development regulations. This combines with literature like MRTS, TOD will give the Impact assessment of MRTS on study area compared with the characteristics of the study area in 2001. After analyzing the data, some strategies and parameters will be decided which involved after implementation of transit project for the similar areas?

III. CLASSIFICATION & PARAMETERS FOR STUDY OF MRTS

3.1 Classification

The primary impact of a transit system is the purpose or basic intent of introducing the new system. Once this modal shift is achieved it will trigger the other changes on the land system surrounding it. This work will involve taking a closer look at the tertiary impacts of a transport system, which can be further classified as Direct and Indirect land use impacts

Direct land use impacts occur in the short-run (usually during construction, as residences and businesses are displaced) and adjacent to transportation corridor. It also includes the actual conversion of productive land to transportation use. The removal of existing uses to accommodate the facility and any immediate changes to the overall character of the affected area.

Indirect land use impacts attributes to long run and widespread changes to development patterns and planning that are induced by the transportation improvement. Indirect or secondary impacts of transportation projects on land use tend to occur, over a long period and may involve changes in the overall development and growth of an area. These impacts will vary depending upon the nature of the transportation improvement and other characteristics of an area that affect growth rates.

3.2 Parameters for Impact Assessment

At the time of study, various literature reviews and various research studies clearly indicated that the impact of a transit system is manifested in the change in land attributes of adjoining areas. In the case of mass rapid transit it is the station areas where the change is most prominent. The parameters of study and basis for analyzing the area in order to assess the impact of transit system are as follows:

- Density
- Land Use
- Accessibility
- Land value

These parameters will be applicable in the influence area of the transit corridor which will be varying between 300 meters to 1000 meters. Density, Land use & Land values are studied in details because they are directly associated with the land, While accessibility being the least important among all will be dealt in comparative study only.

Density

Density is the measure of the intensity of land use; it denotes the relationship between the number of people and the area of land they occupy. It is generally expressed as number of persons per hectare.

Land-use

Various land use affects travel patterns. Land use policies and development practices can affect transportation choice and per capita vehicle use. Several transport demand management strategies involve changing land-use pattern directly. Feasibility and effectives of many transport demand management strategies are significantly affected by land use factors that affect travel: there are various factors that affect the travel behavior of people. Land use is one of the major factors in determining the demand for travel. Also the impetus to travel is determined by the intensity and kind of use.

Accessibility

"Accessibility is a term has been used by planners, engineers and others quite freely." Various authors have defined accessibility however difficult to measure in different manners on how the impedance or function factor is taken. The following are some of the definition that is based using accessibility based on impedance's of distance, time, cost, opportunities, etc. Perhaps the first definition that was given to accessibility is credited to Walter G. Hansen. In his paper "how accessibility shapes land use', he defines it as a *'function of residential development and access to each of employment, population and shopping" and measures it in terms of spatial distribution of activities about a point "adjusted for the ability of people to overcome spatial separation".*

Land-value

The land value is guided by the economic principle of the highest and the best use, which produces the highest net return over a period of time. The property value is a function of the structural attributes, the land value and rental value (both of which are guided by the land-use and location) of the property. Levels of physical and social infrastructure development are also the determining parameters. No two properties are same, the vacant plot and the constructed one in a similar area cannot be valued at the same rate. On the other hand similar structures on similar plots in different areas may have dramatically different values.

IV. PROFILE

4.1 Regional Setting & Delhi MRTS

Delhi has experienced phenomenal growth in population in the last few decades. Its population has increased from 57 lakhs in 1981 to 120 lakhs in 1998 and poised to reach 200 lakhs by the end of 2014. In the absence of an efficient mass transport system the number of motor vehicles has increased from 5.4 lakhs in 1981 to 30lakhs in 1988 and is projected to go up to 65 lakhs by the end of 2014. [Master plan delhi-2001]

The Delhi Metro has been instrumental in ushering in a new era in the sphere of mass urban transportation in India. The swanky and modern Metro system introduced comfortable, air conditioned and eco-friendly services for the first time in India and completely revolutionized the mass transportation scenario not only in the National Capital Region but the entire country.

The DMRC opened its first corridor between Shahdara and Tis Hazari on the 25th of December, 2002. Subsequently, the first phase of construction worth 25th 65 kilometres of Metro lines was finished two years and nine months ahead of schedule in 2005. Since then the DMRC has also completed the construction of another 125 kilometres of Metro corridors under the Second phase in only four and a half years. Presently, the Delhi Metro network consists of about 193 operational kilometres with 140 stations along with six more stations of the Airport Express Link (See figure 1). The network has now crossed the boundaries of Delhi to reach NOIDA and Ghaziabad in Uttar Pradesh and Gurgaon in Haryana. [RITES]

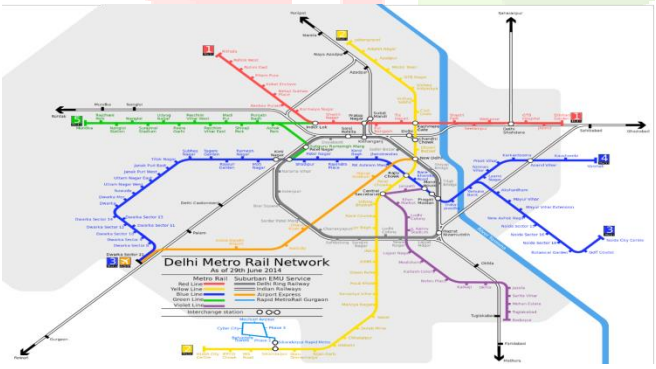

Figure 1: Delhi Metro route map as on June, 2015

4.2 Study Area

East Delhi (aka Trans Yamuna) is an administrative district of the National Capital Territory of Delhi in India. It is bounded by the Yamuna River on the west, North East Delhi to the north, Ghaziabad District of Uttar Pradesh state to the east, and Gautam Buddha Nagar District of Uttar Pradesh to the south (See figure 2).

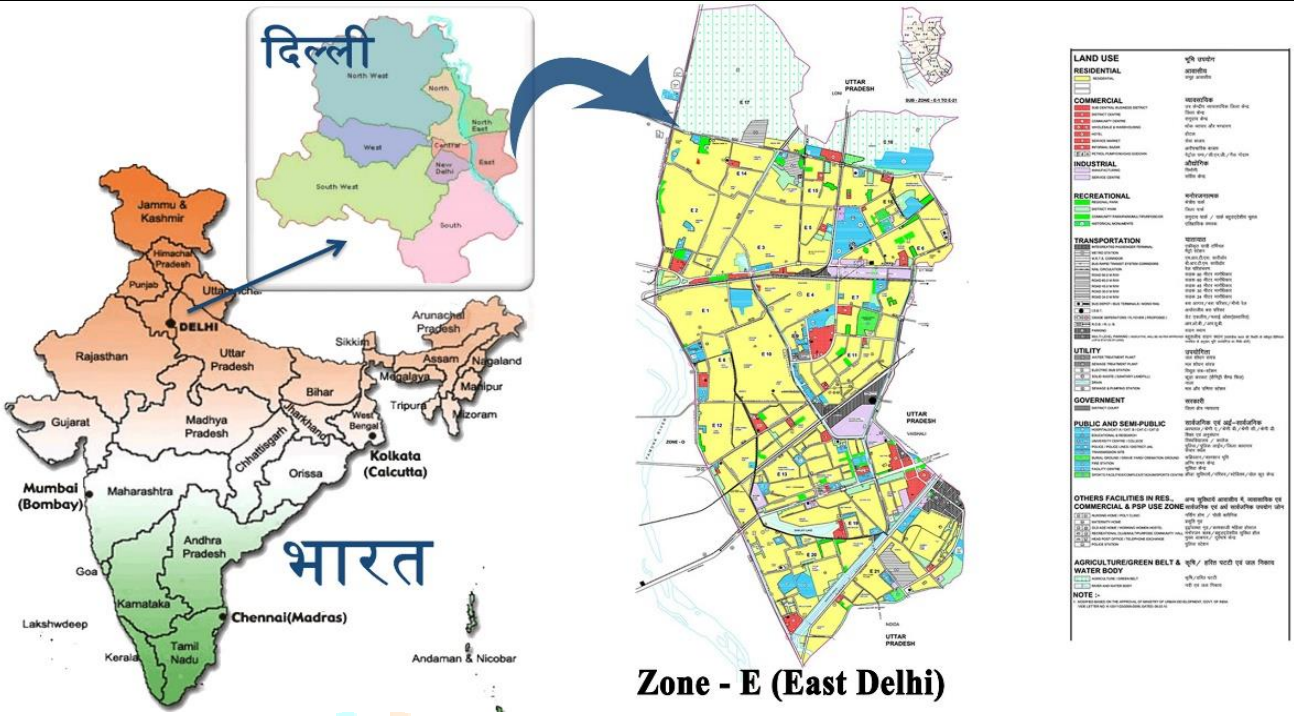

Figure 2: Key map of the Study area

According to the 2011 census, east Delhi has a population of 1,707725. As per MPD-2001 and MPD-2014 the existing population of East Delhi was much higher than holding capacity (See table1).

Table 1: Population of Delhi according to master plan 2001 & 2021

Holding Capacity (MPD-2001	Population (2001)	Holding Capacity (MPD-2021)
1,789,000	2,798,000	2,800,000

As per ZDP-2021 provisions the land-use distribution of the study area is predominantly residential. This zonal development plan didn't consider the effects after implementation of metro. According to ZDP-2021 provisions, public, semi-public and recreational areas are deficient in this zone.

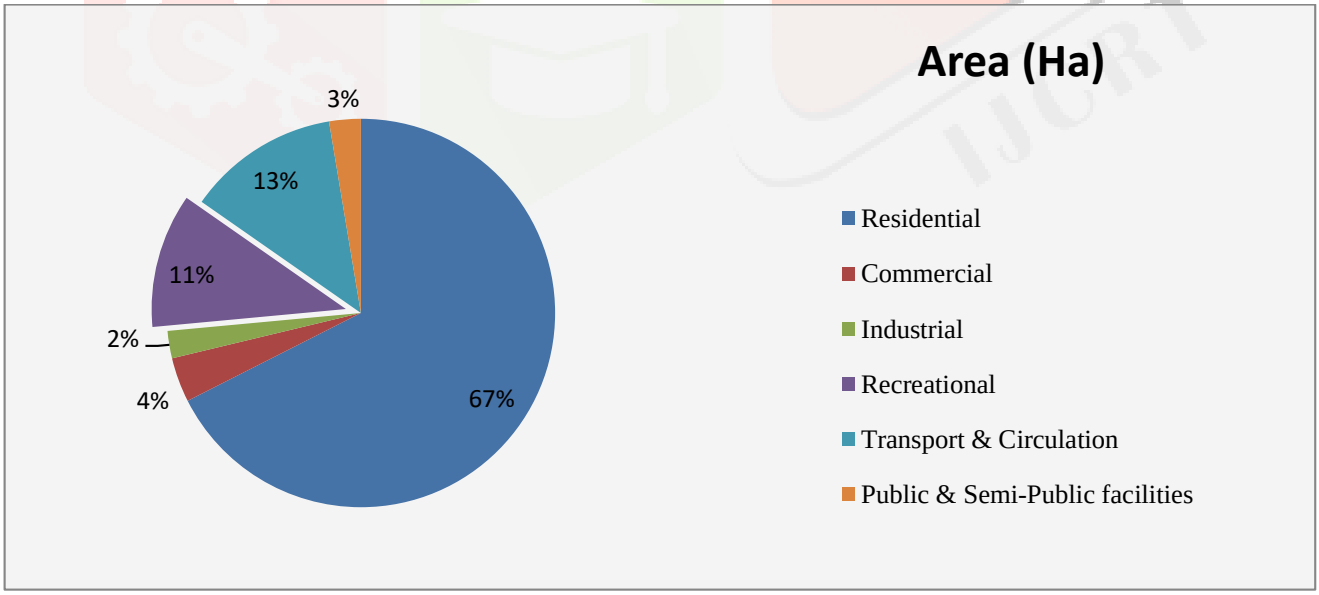

Figure 3: Land use distribution of East Delhi

Study area contains three different kinds of metro stations having various activities around their nodes. These three metro stations are Lakshmi Nagar, Nirman Vihar & Preet Vihar (see figure-4). Total stretch is having a length of 3 km and the distance between two metro stations is 1 km. only. The influence zone which is being minimum 0.3 km and maximum 0.8 km on either side of the metro corridor. The total area of the influence zone is 2.63 sq. km. which is driven by the metro stretch of 3 km. including all three metro stations.

Figure 4: Study area & its influence zone

Lakshmi Nagar is a widespread residential area in East Delhi, India. It is situated on Vikas Marg connecting ITO & Anand Vihar. Laxmi Nagar is famous for its 'Mangal bazar', meaning Tuesday market, which is a roadside shopping destination for many natives. Laxmi Nagar also has a well-known commercial complex near the Metro station on Vikas Marg. It is on the blue line of Delhi metro from Yamuna Bank metro station to Kaushambi metro station.

Preet Vihar is an upscale residential area in Delhi. It is a well-established colony in the eastern part of Delhi, minutes away from Connaught Place, considered the heart of Delhi. The area is known for the shops and educational institutes located here. Apart from this, it has a residential society that offers very good accommodation. Outlets of all well-known brands are situated here with a variety of fashion collection on display. Innumerable restaurants and food joints dot the area. Crowded with a number of small and big shops, this place is considered one of the best commercial hubs in Delhi.

NIrman Vihar is a mainly commercial area just next to Lakshmi Nagar. The major CBD area lies near to the Nirman Vihar Metro Station. Most of the government buildings like Post office, Fire station, CFE Head Office are located in this area. A shopping mall is also located in this area as a recreational hub. This area is having variety of land uses.

Overall, the study area contains various activities like commercial, residential, govt., institutional, etc. The study will give an output to the impact of MRTS on all these activities.

V. ANALYSIS & FINDINGS

The study area contains three Metro stations of the blue line and quality of every metro station is different. Every Metro station serves different variety of people. The population density of the study area is 266 ppha, which is higher as compared to the population density of Delhi 113 ppha. With increase in time this area is rapidly and haphazardly growing due to good connectivity with central Delhi. To find the intensity of developments in this zone after connectivity to the Delhi Metro, analysis of this area is done.

5.1 Change in Land-use Pattern

A comparison of land-use has been done at two points of time (2001 and 2014) using GIS techniques to find out the Land Use changes (see figure-5&6) happened after the implementation of Delhi Metro in this area. Maps are being prepared on the basis of site analysis and with the help of East Delhi Zonal Plans 2001 and 2014. The analysis shows that there is a change in Residential and Mixed Land use. Ground floor of most of the buildings on the main stretch is used as Commercial shops while upper floors are still used for residential purpose. Some of residential buildings have converted to mixed use due to commercialization (see figure-6). New commercial building has been added to the zone after implementation of Delhi Metro. Open area has been reduced by 4.3% (see table 2). New commercial buildings are coming on the vacant areas of the zone due to good connectivity.

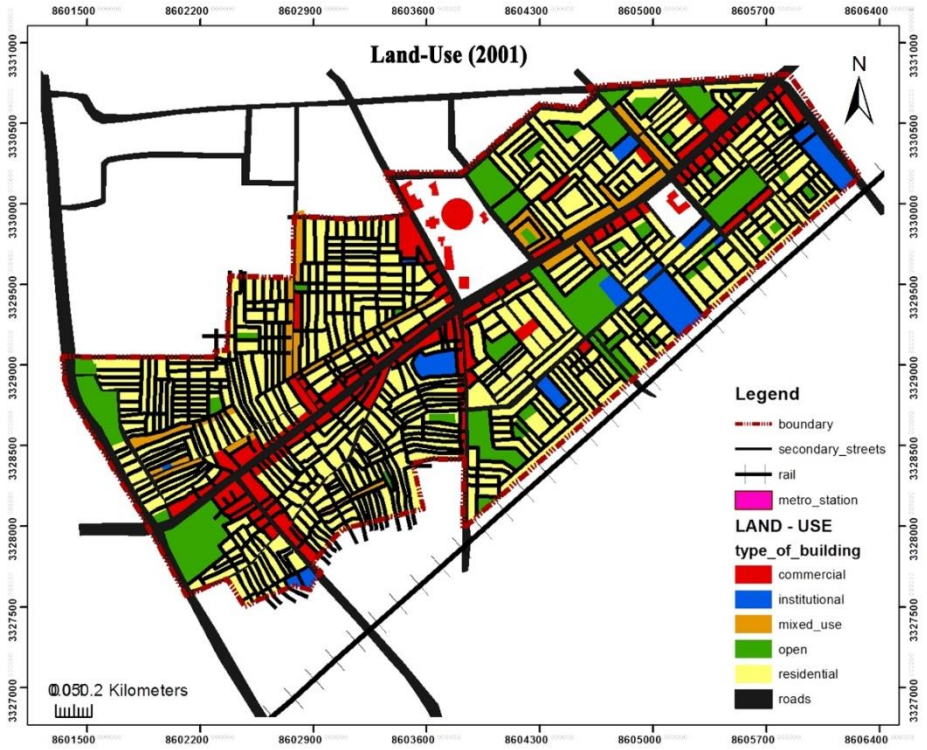

Figure 5: Land-use map of the study area (2001)

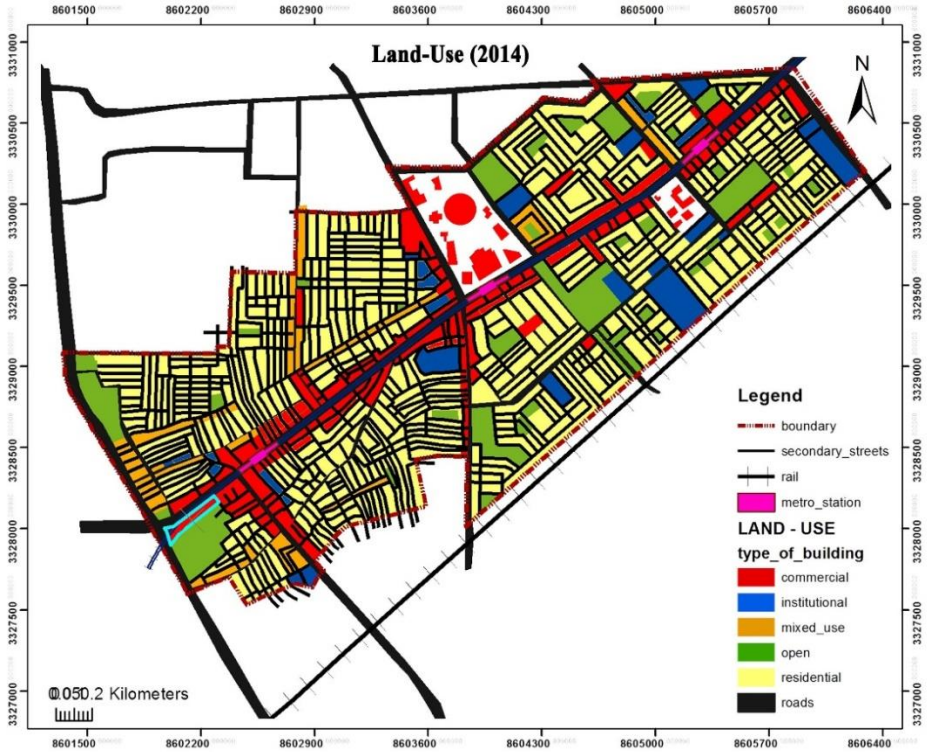

Figure 6: Land-use map of the study area (2014)

Table 2: Comparative analysis of land-use of study area (2001 7 2014)

Land-use	2001 Area(sq.km.)	%age	2014 Area(sq.km.)	%age	± change of %age
Residential	1.73	66.43	1.27	48.82	-17.61
Commercial	0.30	12.38	0.53	20.38	8.00
Institutional	0.10	4.40	0.31	12.05	7.65
Mixed Use	0.13	5.26	0.26	10.17	4.91
Open	0.34	13.75	0.21	8.38	-5.37

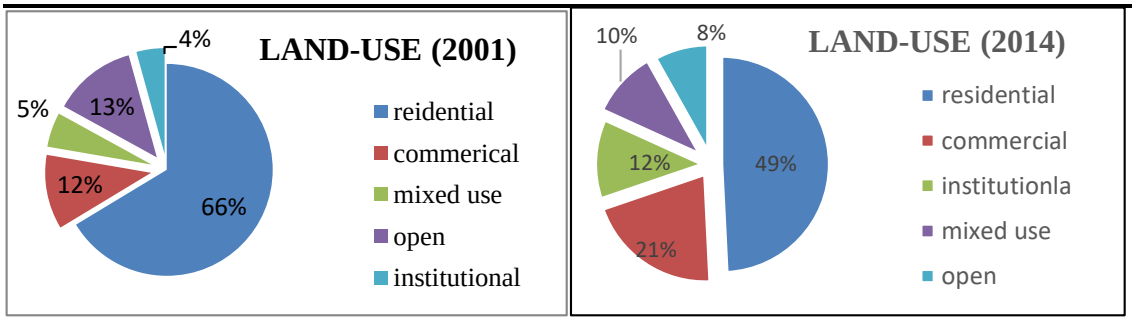

Figure 7: Land use chart of the area (2001 & 2014)

5.2 Changes in Density & Build Form

There has been a considerable change in built form of commercial areas after implementation of Delhi Metro. In 2001 the predominant height of residential areas was 9 meters (see figure 2) (G+2 and still they remains same but adjacent to the corridor of Delhi Metro some of the buildings have come up with 12 mts. height (in 2014) (G+3) (see figure-6). If we talk about commercial buildings predominantly the height of the buildings were 21mts. (G+6) but now the maximum height of a commercial building has reached 65mts. (G+20). The major changes occurred in the commercial built forms.

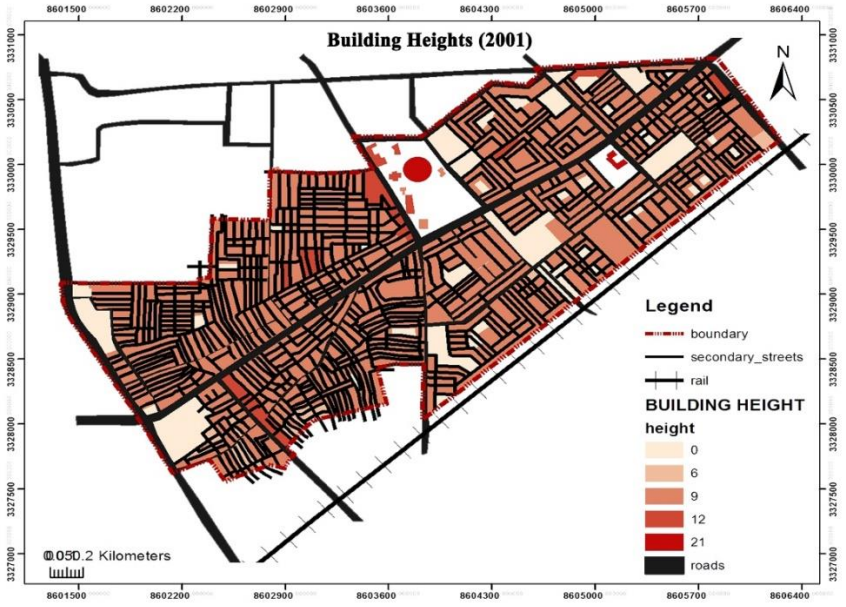

Figure 8: Building height map of study area (2014)

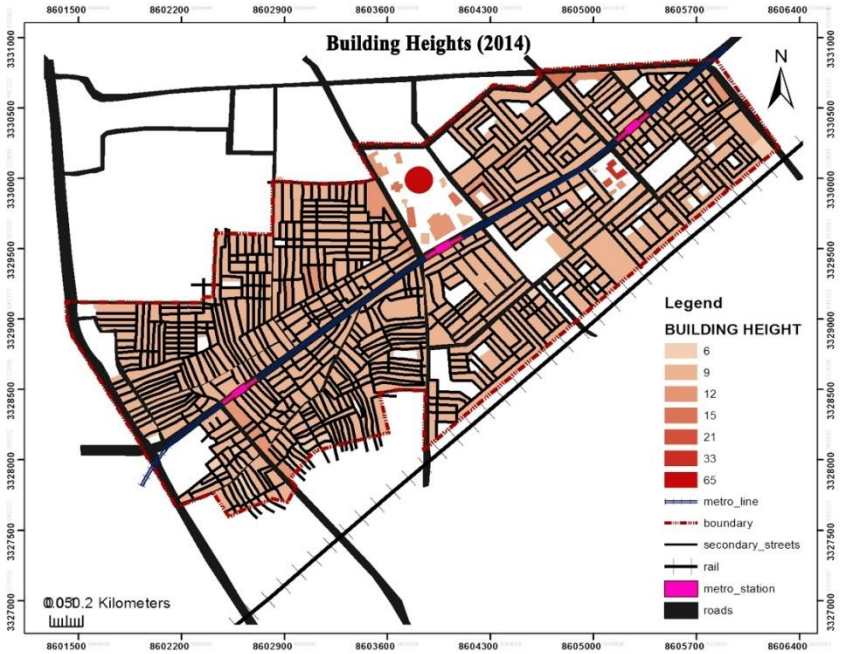

Figure 9: Building height map of study area (2014)

In the study area, some new buildings like one commercial shopping mall with height of 12 meters(G+3) (see figure-9) with 2 basement, some multistoried residential apartments with same use of FAR but increased height of 24 meters (G+7) (see figure-9) is already there in existence.

Table 3: Analysis chart of building heights in (2001 & 2014)

BUILDING HEIGHT	2001 area (sq.km.)	%age of study area	2014 area (sq.km.)	%age of study area	± %age change
OPEN	0.34	13.75	0.24	9.38	-4.37
6.0 meters	0.047	1.81	0.047	1.81	nil
9.0 meters	2.11	81.10	1.982	76.20	-4.9
12.0 meters	0.090	3.48	0.215	8.28	4.8
15.0 meters	0.011	0.43	0.089	3.43	3.0
21.0 meters	0.015	0.59	0.00	0.00	-0.59
33.0 meters	--	--	0.0033	0.13	0.13
65.0 meters	--	--	0.020	0.77	0.77
TOTAL	2.60	100	2.60	100	

5.3 Change in Land-value

Nirman Vihar Station area shows the highest commercial value. The area shows more than 200% increase in commercial value. Retail showrooms and shops are coming up along the whole stretch. Preet Vihar station area shows a high residential value. This is due its planned residential development after implementation of Delhi metro. This area shows 150% increase in residential value. Also Lakshmi Nagar metro station area shows a mixed change in residential as well as commercial values.

Table 4: Comparative analysis of Land-value of study area (2001 & 2014)

ZONE/ RATES	Lakshmi Nagar (2001)	Lakshmi Nagar (2014)	Preet Vihar (2001)	Preet Vihar (2014)
Residential	15-25K/sq.ft.	30-35K/sq.ft.	20-40K/sq.ft.	40-50K/sq.ft.
Resi. (Rent)	05-10/sq.ft.	20-30/sq.ft.	05-10/sq.ft.	30-40/sq.ft.
Apart. (Rent)	05-10/sq.ft.	20-30/sq.ft.	05-10/sq.ft.	30-40/sq.ft.
Commercial	5-10K/sq.ft.	10-20K/sq.ft.	10-15K/sq.ft.	15-20K/sq.ft.
Comm. (Rent)	20-25/sq.ft.	50-100/sq.ft.	15-20/sq.ft.	30-60/sq.ft.

5.4 Comparative Analysis

While comparing the data related to all three parameters, we were able to find the following statements:

Table 5: Comparative study of impact assessment with respect to desired parameters

IMPACT ON	2001	2014
Land Use	The whole area was predominantly a Residential zones with some commercial markets in between with same FAR and heights. Mixed land use was only nearby local markets.	Being a highly accessible transportation node coupled with development over the station may have led to a change in land use. Most of the new commercial buildings have come up with different FAR, height etc. Residential buildings along the corridors experiences change in land use (commercial & institutional)
Land Value	Land value was same as other areas with no metro facility. All the circle rates were same and with increase in time all rates were increasing parallel and uniformly.	As residential building are turning to commercial buildings which results in change in land value. Also improved connectivity due to Metro also increase land value of the area. As shown in (table-4)
Building Height	Mostly building were of G+2 and only some commercial buildings were having heights more than 3 storey. This uniform distribution of height was making this area uniform.	Most residential buildings area still G+2 but some new apartment buildings have come up with G+7 storey height after Metro. Which resulting Increase building height with same FAR. Major commercial building increased there heights from G+6 to G+20 (see table -3) and also almost all comm. buildings increase in floors in it resulting increase in commercial space.
Accessibility	Only one connecting road was there which connects this area to the central Delhi	Delhi metro and two new roads come up to connect to central Delhi area results improved connectivity.

VI. Overall Inferences & Discussion on Policy Implications

Transit oriented development is being used in some areas which is improving connectivity and planned growth in the study area. The development controls and bye-laws have been changed without considering master plan with the implementation of MRTS in the study area (see table-5). Mixed Land-Use, commercial and institutional land use is prominent in the study area which is increasing economy. There are high chances of benefits after getting connectivity with MRTS. Redevelopment of the area was not

done with due care and development was affecting the architectural character and heritage of the study area and the study area is losing its identity. After implementation of MRTS, accessibility increased, few new developments are going along corridor near nodes. The prominent land use of the study area is converting to mixed land use as the traffic corridor is becoming source of generation economy. There has been a very high raise in the land values near MRTS notes and comparatively low land values in the core areas. Very less open spaces are left due to change in building by laws and commercialization. Public spaces are converting into markets.

VII. CONCLUSION

There is no mention of bye laws regarding the kind of development, density along the metro corridor in master plans. In existing plan, development controls has no consideration given for high rise development along the Metro corridor, which is required to redevelop the areas around the Metro station. No thought process has been given to the open areas. The considerations of open areas are not taken by the development authorities. There is no parking space available except metro station parking. The maximum impact of metro has been seen in the first 300 meters along the corridor. The physical range of impact varies around different stations (from 500m to 1.5 Km around); however the impact seems to be more at the terminal stations. The preferred type of land use immediately around the station nodes is that of mixed use development. These points should be considered in the master plan before suggesting any transit corridor in any particular area. The methodology of this study will also help in assessing impacts of MRTS on other important parameters like socio-economy, demography, environmental, etc.
This study will help the policy planner to access the impact of MRTS on Urban Land parameters from this real life case study and formulate future plans for similar future projects.

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