Influences of Tranportation System on Land Use and Predicting the Changes in Khulna Metropolitan Area, Banglaedesh

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Abstract— This study analyzes the characteristic pattern of travel demand in relation with land-use and land cover (LULC) changes in Khulna Metropolitan Area (KMA), Bangladesh. First objective has used spatial data (Landsat Satellite Images) of KMA to identify the nature of LULC change which are classified as 'waterbody', 'vegetation', and 'built-up area'. The outcomes of the study indicated that 'waterbody' and 'vegetation' decreased by 4.84%, and 12.38% from 2000 to 2008 and by 17.30% and 11.71% from 2008 to 2016 respectively. On the other hand, from 2000 to 2008, built-up area has been increased by 28.81% and 27.81% from 2008 to 2016 Following the linear trend, the predicted changes after 10 years have been determined approximately about 715, 1615, 2683 hectares in terms of 'waterbody', 'vegetation' and 'built up area' respectively. Later, this research uses Four Step Model (FSM) to forecast the condition of travel demand of KMA, taking all 31 wards as study area divided into 7 unique zones. Travel demand forecasting for after 10 years have been performed. Trip generation, trip distribution, modal split and trip assignment have been determined and forecasted following FSM to generate idea regarding present context. Third objective has determined underlying factors affecting travel demand and land use change such as correlation between built up area, road network, driving license, income and age of respondents and fitting regression equations have been done. Taking reference from the Khulna Master Plan (2001 – 2020), recommendations regarding land use zoning control, reduction of traffic congestion, introducing bus service, construction of bridge and improvement of railway and waterway transport to reduce travel demand for future development

Index Terms— FSM, LULC, Modal split, Master Plan, Trip generation, Trip distribution, Trip assignment.

1 Introduction

With the passage of time, modern science and technology adhere the changes required for the human civilization. The earth has become the primary concern to prioritize the changes in terms of land use and transportation. Land-use change is an unremitting procedure which usually increase the mobility and refers the development with the advancement of technology. Multiple land-use change models are trailed by researchers and professionals to reconnoiter the changing aspects and drivers behind it (Agarwal et al., 2002). As change is inevitable, the factors behind the changes attributed to simple factors depending on socio-economic, political, climatic condition and the other factors attributing to city's land use land cover (LULC) change are directly or indirectly dependent on population growth (Kafi, Shafri, & Shariff, 2014) In the prospect of Khulna City, these common aspects involving the changes of LULC change since development of built structures and road network. Modelling of LULC is scientific approach as both rapidly growing urbanization is consistent and its importance of identifying the effects of the human beings on the environment (Hadi et al., 2014).

Transportation behavior of a city depends on the characteristics of nature of human being and availability of motorized and non-motorized vehicle. With the growth of population, urban transport system is provoked with the increasing population growth resulting surpassed its capacity (Sharmeen, 2014). Khulna, as being the third largest city is also facing increased population growth and rapid growth of urban built up area day by day. Defining the Khulna city's transportation sector greatly dependent on non-motorized slow-moving vehicle (Bhadra & Sazid, 2015). In order to plan transportation facilities, it is necessary to forecast how much it will required to be managed and alternatives should be implicated (Biswas & Rahman, 2015). To estimate future change, changing of travel demand should be forecasted with integrated approach to rationalize the problem that is affecting each other.

The objectives of the research are (a) To determine the land use/land cover (LULC) changes in Khulna Metropolitan area (KMA) and predict their transformation in the future (b) To investigate the travel behavior of the people in KMA and estimate future travel demand using Four Step Model (FSM) (c) To identify the factors influencing LULC and travel behavior of people in KMA.

2 Literature Review

Several researches have been conducted to measure and forecast the demand regarding land use change and travel behavior following individual and different methods according to the context. Analyzing the change in land use in a highway corridor in Bangladesh, (Ullah, 1999) had determined future land use pattern following model based on GIS. Main purpose was to develop a Markov model of land use change so as to determine the relationship between land use types and future land use patterns. The results of the analysis indicate that significant developments took place in the highway corridor between 1977 and 1995.

Assessing the land use change models incorporating dynamics of space, time and human choice, (Agarwal et al., 2002) presented a framework to compare the models in terms of scale and complexity incorporating space, time and human decision making. 19 land-use models were studied in detail as representative of comprehensive established models. Based on fore-

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casting the research about indirect land use effects of transportation (Avin et al, 2007) had deliberated several factors having strong reactions between indirect land use effects and the induced travel demand. Policy based planning judgement, visioning and scenario building based collaborative judgement, allocation model, transportation driven models and integrated transportation and land use models are the basic approach to better inform the current practice with useful research findings and predict the future scenario using multiple models such as DRAM/EMPAL/ITLUP, MEPLAN, POLIS, UrbanSim etc

In the context of Dhaka By-Pass Road, considering the impacts of land use in prospect of local economy (Rahman, 2013) conducted the study to investigate changes in land use and also on the local economy in the areas adjacent to the Dhaka By-Pass Road. Using Landsat 5 TM images according to 13 February1989, 13 December 2003 and 20 January 2010 was used to note changes in land use and match it with that obtained from the survey. At last all the data were used for qualitative and quantitative data analysis using ArcGIS 10.1, SPSS 16, MS Excel 2007. The output of this research showed massive changes in the land use as well in the economy of areas adjacent to the By-Pass Road. The research has also identified how this came about and why such changes came about. To sum up this research, Gazipur consisted mainly of rural areas prior to construction of the Dhaka By-Pass Road. In the context of the capital city Dhaka is facing congestion for a long-time span. To optimize the traffic flow integrating travel demand and transport planning process (Sharmeen, 2014) developed a GIS based model for optimum traffic flow on selected routes keeping the pollution level within acceptable limit and not exceeding the road capacity.

To evaluate the influence over the system (McNally & Kulkarni, 1996) had directed an empirical assessment of the interations between the land use–transportation (LUT) system and travel behavior. Methodological approach was identifying the a range of LUT systems by clustering techniques with network and land use inputs. (Colona et al, 2012) had discussed on the methodological issues relating integration of land use and transportation planning. The research discussed three approaches termed as functionalist approach, environmentalist approach and personalist approach considering both space and time had been followed as methodological issues covered to answer the necessity of the integrated land use and travel demand analysis.

Simulating land use changes driven by a bridge (Ayazli et al, 2010) investigated the influence of a bridge on urbanization processes in Istanbul and beside that protected areas had been damaged was also determined. Four satellite images of 1972, 1987, 2002 and 2009 were classified with a view to analyzing the influences. Those time periods were selected deliberately as the 1st and 2nd bridge was built on Bosphorus in 1973 and 1988. The output of the research produced a map showing that 28.88 % forest and 71.43 % agricultural areas and open spaces will be transformed to urban area.

Qualitative and quantitative both methods are at the same time influencial to validate the forecasting state of an area. Problems based land development induced by major highway investments, (Ewing & Bartholomew, 2009) dictated legal requirements and good planning practices by both qualitative method as expert judgement and quantitative method as formal spatial interaction models in Delphi method, Lowry model, DRAM/EMPAL were applied as land use forecasting models and comparing the processes by judgemental panel through expert land use panel (ELUP) process. The research finally executed the intercounty connector (ICC) highway project based on the analysis in the Washington, DC.

2 Study Area Profile

The 31 wards, the smallest electoral unit, of KMA have been selected as the study area for this research (Figure-1) (Ahmed, 2012). Firstly, land use change detected through image analysis of collecting the satellite image of the KCC area. Then these 31 wards are divided into 7 zones known as Traffic Analysis Zone (TAZ). Considering significant trip production and attraction rate, conduction of survey of each zone has been performed on the major intersection points with unique characteristics. It is the third largest industrial and second largest port city of Bangladesh which is a divisional city and acts as a regional hub of administrative, institutional, commercial, academic and commercial affairs (Hadia & Misty, 2015). As main transport route is Khulna–Jessore Highway, survey locations has been selected for the research are major intersection points where significant amount of trip production and attraction regularly occurring. Following figure 1 and table 1 includes 7 zones with similar characteristics and survey locations for the research.

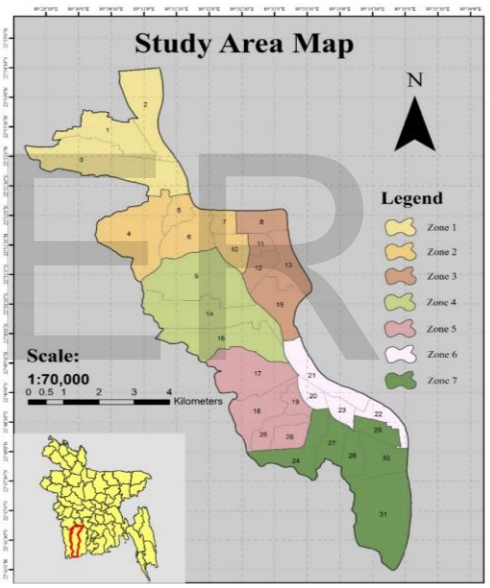

Fig. 1. Study area map (Azmain and Rahman, 2017)

TABLE 1
SELECTED ZONES FOR STUDY

Zones	Ward No	Survey Locations	Population
Zone 1	1,2,3	Fulbarigate, Raligate	11859
Zone 2	4,5,6,7,10	Daulatpur	21530
Zone 3	8,11,12,13,15	Khalishpur	16968
Zone 4	9,14,16	Mujgunni,Goalkhali,Boyra	20110
Zone 5	17,18,19,25,26	New Market, Shibbari, Sonadanga	28351
Zone 6	20,21,22,23	Dakbangla	15116
Zone 7	24,27,28,29,30,31	Rupsha	42249

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4 METHOOLOGY

The methodology consists of technical and conceptual terms associated to the research. After the selection of the study area and the determination of the land use and transportation models were selected according to the context. To generate the model's numerous factors and variables were determined and questionnaire have been developed to conduct survey. Total population of the study area is 770498 in 2017. So, N was 770498.The total sample size for the study was calculated for the following study was 384.

4.1 LULC change

"Landsat" satellite images of three years have been processed to perform image analysis and to determine the quantitative changes for the following years using ArcGIS 10.1 and Erdas Imagine 14.0. Zonal and Tabulate Area tools in ArcGIS have been used to measure the area changed during the interval between the years.

4.2 Four Step Model:

Trip Generation

Trip generation is a way of prediction of number of trips originating in or destined for a particular traffic analysis zone. Four variables have been considered for this step. These are population, income level, land price and employment. Estimating the population after 10 years, the equation is:

$$\text{Population after 10 years} = \text{Existing Population}*(1+r)^{\wedge n} \quad (1)$$

Here, r = Growth Rate, n = Projected Year

Here X-inputs for production are considered as population and income after 10 years and Y- input is considered as existing trips. This is also done for attraction parameters. Finally, the following two regression equations are found. Regression Equation for Trip Attraction:

TABLE 2
GROWTH RATES OF VARIABLES

Variable	Growth rates
Population	3.61%
Income level	5.82%
Land price	15.91%
Employment	2.50%

$Y_{production} = 25064 + 0.02339\ X_1 - 0.09468\ X_2$ Where, $a_0 = 25064$ $a_1 = 0.02339$ and $a_2 = -0.09468$ (2)

Regression Equation for Trip Attraction:

$Y_{attraction} = 18047 - 0.05281\ X_1 + 7.54\ X_2$ Where, $b_0 = 18047$ $b_1 = -0.05281$ and $b_2 = 7.54$ (3)

Using these regression equations now forecasted trips, for both trip production and attraction after 10 years, are calculated (Table 4) using these equations.

Trip Production = a_0 + (a_1 ×Forecasted Population) + (a_2 ×Forecasted Income) (4)

Trip Attraction = b_0 + (b_1 ×Forecasted Employment) + (b_2 ×Forecasted Land Price) (5)

Trip Distribution

First step is to generate Origin – Destination Matrix, origin and destination displaying number of trips going from each origin to each destination in a whole day. It is assumed that trip production and attraction numbers are equal. On the basis of this assumption, to make both value equal, trip attractions are reformed through multiplying existing value by an adjustment factor.

Adjustment factor = (TotalProduction)/ (TotalAttraction) (6)
Adjusted trip attraction=Adjustment factor×Trip attraction of any zone (7)
The adjustment factor is 1.00112 and adjusted trip attraction table has been calculated using the above equation.

Transport Network Link Impedance or Resistance to Flow

Link impedance is referred as the difficulty of moving transport vehicles from one node to another in a network. Affecting factors are determined by Gravity model with adjusted distribution pattern obtained from origin-destination survey. A cost matrix is assumed by predicting the zone to zone travel cost.
The following formula is used to calculate impedance:

$$\text{Impedance factor} = e^{\wedge(-\beta Cij)} \quad (8)$$

Where, Dispersion parameter measuring sensitivity to cast, $\beta = 0.1$ (assumed)
Cij = General cost of travel from zone i to zone j
Now trip for each zone to different zones using the following formula is calculated.

Trip of any zone = (Total trip)/(Total impedance factor)*Impedance factor for this particular zone (9)

Modal Split

Modal split is the third step of four-step transportation model. Logit model, which is most commonly used for modal split analysis has been used for this research. Generally, this model comprises with comparing 'utility' and 'disutility' of travel of different modes that are available in the zones. In this step, the matrix for travel time and travel cost is given to calculate the utilities for three modes- Mahindra, Easy bike and Motorcycle.
Utility functions for these three modes are produced using regression taking Mahindra as reference. The utility functions are as follows:

$U_{Mahindra} = 0.001421*TT-0.1052064*TC$ (10)

$U_{Easy\ bike} = -1.08+0.001421*TT-0.1052064*TC$ (11)

$U_{Motorcycle} = -1.7076+0.001421TT-0.1052064*TC$ (12)

Where, TT=Travel Time from one Zone to another zone & TC=Travel cost from one Zone to another zone.

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Then, probability matrix has been generated from using the following formulas:

$$\text{Probability}_{\text{Mahindra}} = e^{(U_{\text{Mahindra}})} / (e^{(U_{\text{Mahindra}})} + e^{(U_{\text{Easy bike}})} + e^{(U_{\text{Motorcycle}})}) \quad (13)$$

$$\text{Probability}_{\text{Easy Bike}} = e^{(U_{\text{Easy bike}})} / (e^{(U_{\text{Mahindra}})} + e^{(U_{\text{Easy bike}})} + e^{(U_{\text{Motorcycle}})}) \quad (14)$$

$$\text{Probability}_{\text{Motorcycle}} = e^{(U_{\text{Motorcycle}})} / (e^{(U_{\text{Mahindra}})} + e^{(U_{\text{Easy bike}})} + e^{(U_{\text{Motorcycle}})}) \quad (15)$$

After that calculation of modal share is done by multiplying trip numbers made from one zone to another zone in trip distribution steps with the probability. Used calculation is:

$$\text{Modal Share for any mode} = \text{Trip}_{i\text{-}j} * \text{Probability}_{i\text{-}j} \quad (16)$$

Trip Assignment

Trip assignment is the fourth step transportation modelling. The calculation of this step started with the calculation ofGeneralized Travel Cost factor for each mode. Here the process of calculating GTC is shown:

$$GTC = TC + (a_1/a_2) * TT \quad (17)$$

Where, TC=Travel Cost TT=Travel time a_1= Co-efficient of the Travel Time factor a_2= Co-efficient of the Travel Cost factor
The total number of vehicles for a particular mode can be calculated from the formula:

Total no of vehicles= Flow of that vehicle / Occupancy of that vehicle or mode (18)

Through this table future demand of three selected modes (Mahindra, Easy bike & Motorcycle) on each links has been represented.

5 Data Analysis and Recommendation

5.1 LULC change and interpretation:

Khulna City is facing similar land use change trends with the passage of time and the research has been leading to determine the changes over basic three land forms which are waterbody/wet lands, vegetation and built up area. To integrate relationship with transportation system, it is imperative to perceive the relative land use changes
Following images of figure 2 has been representing the quantity of land use covered for the years of 2000, 2008 and 2016 respectively. Three different colors which are red, green and blue have been figured to determine the amount in terms of built up area, vegetation and waterbody respectively. From above figures, it is clearly visible that built up area has been increased significantly with an average percentage of over 28% where vegetation and waterbody have been declining gradually with average rate of 12% and 11% respectively in KMA. Land-use and land cover changed greatly over the period from 2000 to 2008 in Khulna City Corporation. From 2000 to 2008, 'Waterbody' and 'Vegetation' are decreased by 4.84% and 12.38% respectively. On the other hand, 'Built up area' is increased by 28.81% in the same period (Table 2). These trends almost continued in the period from 2008 to 2016. At the end of 2016, 'Waterbody', and 'Vegetation' decreased by 17.30% and 11.71% respectively, related to 2008. Only 'built-up and construction' land had expanded by 27.81%, in the same period. Following the first objective to determine the changes occurring within 16 years among these three types, there are significant amount of changes have been found as 'Waterbody' and 'Vegetation' are decreasing in significant amount due to multiple driving forces and increased 'Built up area'. From Table 3, it is clear that the city is getting urban following the trend of other developing cities.

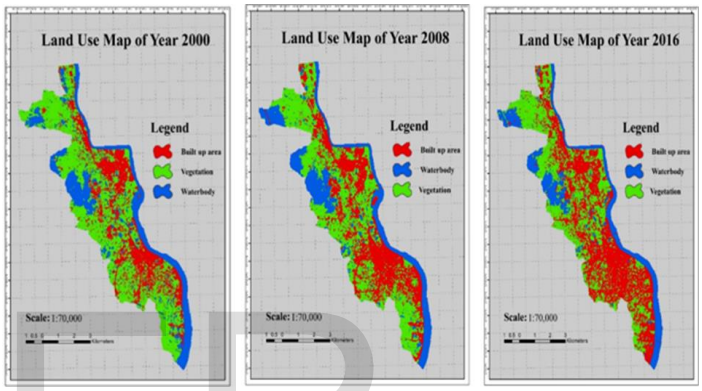

Fig. 2. Land-use and land cover map of Khulna city, 2000, 20008 and 2016 (Azmain and Rahman, 2017)

Following the linear extrapolation method regarding the amount changed three sequential year intervals following the LULC change amount from 2000, 2008 and 2016 in terms of 'Waterbody', 'Vegetation' and 'Built up area', the predicted trend of land use change after 10 years which are approximately about 715 hectares, 1615 hectare, 2683 hectare in terms of land use type of 'Waterbody', 'Vegetation' and 'Built up area' respectively.

TABLE 3
GROWTH RATES OF VARIABLES

LULC types	Changes (by the years)		
	2000 (Hectare)	2008 (Hectare)	2016 (Hectare)
Waterbody	1229.19	1169.64	967.5
Vegetation	2501.34	2191.59	1935.36
Built up area	1281.66	1650.96	2109.33

5.2 Travel Demand Analysis using FSM:

Trip generation:

To get the trip generation context of existing scenario, measures of four variables for each zone and their output after 10 years have been calculated. Highest population has been found in Zone 7 and then in Zone 5. And average zonal income is highest in Zone 4 and then in Zone 7. Similarly, highest employment opportunities have been got in Zone 7 and land price highest is in Zone 5 which consists of Sonadanga and Shib Bari like area. After 10 years, the condition of traffic

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TABLE 4
FORECASTED TRIPS FOR PRODUCTION AND ATTRACTION AFTER 10 YEARS

After 10 years		
	Production	Attraction
Zones	Trips/person/day	Trips/person/day
Zone 1	24285	17734
Zone 2	26013	18015
Zone 3	24993	18255
Zone 4	19794	17786
Zone 5	27235	18934
Zone 6	24619	19511
Zone 7	27141	17306

is reflected from Table 4. It shows that, in that time Zone 5 (ward 16, 17, 18, 19, 25 and 26) which consists of New market, Shib Bari More, Sonadanga residential area, Sonadanga bus stand and many other important features will produce larger number of trips than any other zones. After that, Zone 7 with Rupsha bus stand surrounded area comes with higher numbers of trip production. On the other hand, in case of trip attraction Zone 6 which consists of Dakbangla commercial and business prone area comes with larger number of attraction than any other zones. Here, the nearest one is Zone 5.

Trip Distribution:

Following the OD matrix that highest trip interchanges occur in 2-1 link which is Daulatpur to Fulbarigate. This is due to Fulbarigate is a trip attraction zone as university is situated here and highest trip interchange has been occurring in 7-6

TABLE 5
ORIGIN-DESTINATION (OD) MATRIX

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	ΣO
Zone 1	0	830	49	146	244	195	146	1610
Zone 2	1952	0	146	195	193	293	244	3023
Zone 3	98	488	0	98	439	927	98	2148
Zone 4	390	634	195	0	293	439	98	2049
Zone 5	293	390	98	1220	0	390	390	2781
Zone 6	781	830	244	293	293	0	1220	3661
Zone 7	98	342	195	244	244	1415	0	2538
ΣD	3612	3514	927	2196	1706	3659	2196	17810

link which is Rupsha to Dakbangla link. Here, total Trip Production= 17810 and total Trip Attraction= 17790; which is smaller than trip production.

Following trip distribution process, the step concludes with trip distribution rate after 10 years considering the present context of several links from each respective zone.

TABLE 6
TRIP DISTRIBUTION AFTER 10 YEARS FOR DIFFERENT ZONES

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Adjusted ΣO
Zone 1	0	1087	155	229	567	244	221	2503
Zone 2	1656	0	380	230	355	267	275	3163
Zone 3	116	637	0	153	1019	1156	148	3229
Zone 4	407	735	567	0	618	486	132	2944
Zone 5	337	497	305	1867	0	474	574	4054
Zone 6	817	964	712	412	620	0	1645	5169
Zone 7	115	442	612	379	561	1748	0	3857
Adjusted ΣD	3448	4362	2732	3270	3739	4375	2994	24919

Adjusted Table 6 reflects that highest number of trips is 1748 which interchanged between Zone 6 and Zone 7. This information fulfills the two criteria of trip interchanges. First one is, trip interchanges increase with decreasing distance between zones. And it has been estimated that the lowest distance among zones exist between Zone 6 and Zone 7. On the other hand, second criteria is, trip interchanges increase with zone attractiveness. And from trip generation step, it has been found that, Zone 6 attracts the highest number of trips comparing to other zones. Besides Zone 7 is the second highest trip producing zone.

Modal Split:

The results from three modes shows that probability of using Mahindra is greater than 70 percent in 1-7, 4-5, 4-6, 6-1, 6-4 and 7-1. Highest probability of using Easy bike is near about 30 percent in 3-5 link. This huge difference in probability is due to speed of Mahindra is higher than Easy bike and the fare is almost same in both modes.Besides, highest probability of using motorcycle is about 28 percent which is in 3-6 link. Comparing with the remaining two modes this is lowest which is because of ownership ability.

TABLE 7
MODAL SHARE MATRIX TABLE FOR MAHINDRA

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Zone 1	0	313	16	32	28	21	11
Zone 2	477	0	72	54	30	38	23
Zone 3	12	120	0	21	83	77	7
Zone 4	57	172	78	0	146	94	11
Zone 5	17	41	25	441	0	139	137
Zone 6	69	136	47	79	182	0	471
Zone 7	6	37	30	32	109	500	0

TABLE 8
MODAL SHARE MATRIX TABLE FOR EASY BIKE

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Zone 1	0	93	6	12	11	4	3
Zone 2	142	0	27	20	19	14	9
Zone 3	5	45	0	11	65	62	2
Zone 4	22	63	40	0	43	26	4
Zone 5	7	27	19	131	0	54	48
Zone 6	12	51	38	22	71	0	168
Zone 7	1	15	8	13	47	179	0

TABLE 9
MODAL SHARE MATRIX TABLE FOR MOTORCYCLE

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Zone 1	0	150	25	39	114	52	53
Zone 2	229	0	58	33	57	49	54
Zone 3	19	97	0	25	172	177	31
Zone 4	69	104	91	0	107	88	27
Zone 5	68	80	52	323	0	64	88
Zone 6	172	175	109	75	84	0	264
Zone 7	27	87	129	78	86	281	0

Final output of modal share for the selected modes are shown in Table 7, 8, 9 for Mahindra, Easy Bike and Motorcycle respectively. The results represent the trips made between one zones to anther zone by different modes of vehicles. Highest numbers of trips using Mahindra, Easy bike and Motorcycle are respectively 500, 179 and 281 in 7-6 link. There are several factors that influence the choice of mode. Characteristics of trip maker, journey and transport facility are some of them. The share of Mahindra is highest because of most family trips choose Mahindra for fare and speed. On the other hand, here motorcycle share the second highest number of trips because Zone 6 and 7 are to respective high-income zone which holds the capability of buying motorcycle.

Trip Assignment:

The shortest distance between nodes for different modes has been calculated in terms of GTC using Dijkstra's Method. All

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or Nothing assignment has been considered for calculating the traffic flow for different modes from one node to another. In case of forecasting of trips on daily a daily basis traffic assignment is generally done for peak hours. Here in this report it is assumed that 15% travel occurred in the peak hour (Ahmed, 2012). As a result, 15% flow of total trips per link according to shortest path has been calculated for four modes. Now using the GTC, the calculated values of GTC for different

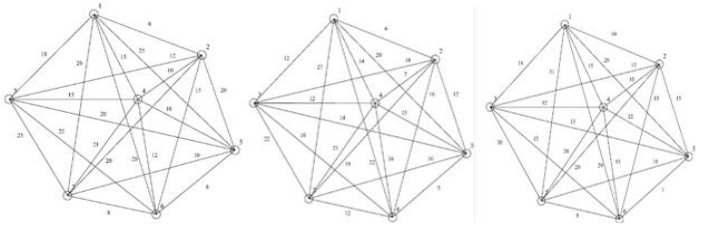

Fig. 3. GTC for Mahindra, Motorcycle and Easybike (Azmain and Rahman, 2017)

modes are put into the different links of the assumed network at Figure 3. The flow of traffic from one node to another for different modes have been considered for traffic at peak hours.

Now occupancy for each mode has been calculated using DUTP report. Here, occupancy for Mahindra is 6, for Motorcycle it is 2 and for Easy bike it is 2. Using these values of occupancy, the no. of Mahindra, Motorcycle and Easy bike in the

TABLE 10

TOTAL TRIPS IN EACH LINK FOR DIFFERENT MODES AT PEAK HOUR

Link	Mahindra			Motorcycle			Easy bike		
	Flow	Occupancy	Number	Flow	Occupancy	Number	Flow	Occupancy	Number
1-2	171	6	28	73	2	37	195	6	33
1-3	73	6	12	24	2	12	49	6	8
1-4	49	6	8	0	2	0	73	6	12
1-5	342	6	57	73	2	37	317	6	53
1-6	366	6	61	98	2	49	366	6	61
1-7	98	6	16	49	2	24	73	6	12
2-3	49	6	8	24	2	12	122	6	20
2-4	98	6	16	24	2	12	146	6	24
2-5	366	6	61	122	2	61	439	6	73
2-6	415	6	69	98	2	49	390	6	65
2-7	195	6	33	73	2	37	220	6	37
3-4	73	6	12	49	2	24	98	6	16
3-5	98	6	16	24	2	12	49	6	8
3-6	73	6	12	24	2	12	98	6	16
3-7	49	6	8	49	2	24	73	6	12
4-5	122	6	20	24	2	12	98	6	16
4-6	73	6	12	24	2	12	73	6	12
4-7	146	6	24	98	2	49	122	6	20
5-6	171	6	28	73	2	37	195	6	33
5-7	195	6	33	73	2	37	244	6	41
6-7	195	6	33	122	2	61	366	6	61

peak period in different links is calculated (Table 10).

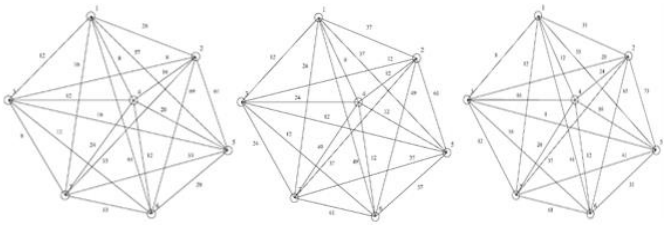

Fig. 4. Total no of Mahindra, Motorcycle and Easy bike in each link (Azmain and Rahman, 2017)

Here, the highest expected number of Mahindra, Motorcycle and Easy bike are respectively 69 in 2-6 link, 61 in 2-5 and 6-7 link and 73 in 2-5 link. In 2-5 link number of flow is 439 which is largest among other links. Daulatpur is a medium income zone (from trip generation step) and huge number of people are associated with easy bike for their livelihoods, which made easy bike is a popular mode in this link. That is why Easy bike has been chosen in case of large number of trips. This reason also affects the motorcycle flow just as inversely.

6. FACTORS AFFECTING BOTH LULC CHANGE AND TRAVEL DEMAND:

(Hualou et al. 2006) indicates population is the major driving force to growth of rapid urban areas where in the context of Khulna City, according to (Khulna Statistics, 2011), population growth rate is not increasing like the rising nature from other prominent cities. Yet, the household size has been decreasing as the the concept of being a part of big families is not common now a days (Sarkar & Pia, 2015) and seperation is occuring because of the greater income opportunities to more progressive urban cities such as Dhaka. Moreover, (KCC-License Section, 2015) database shows that a number of medium and heavy industries were falling apart and replaced by several small and medium industries including cottage industries. The income level per person has increased from tk.12000 to tk.20500 during the year of 2000 to 2014 (Sarkar & Pia, 2015).

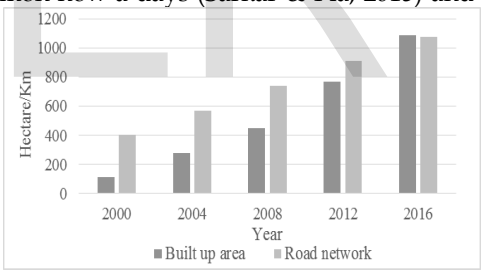

Fig. 5. Relationship between Built up area and Road Network

6.1 Built-up area and Road Network:

Analyzing the data from secondary sources from 2000 to 2016, built-up area and road network have significantly increased due to increased travel demand and locational aspects. There is highly positive relationship between these two numeric values regarding the land use and travel behavior of the metropolitan area.

Road Network and Driving License :

Several driving forces such as land use pattern, land use intensity change, zoning regulation change, trends followed by

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respective municipalities (Gennaio, Bürgi, & Hersperger, 2008) are leading the way to increase the road network as constant changing behavior of the following factors. Analyzing the data from per year license permit and the road network, there is significant positive relationship between these two variables following linear regression having r-value of 0.99 and significance level of 0.001.

6.2 Income status and Age of the respondents:

Above 64% of the respondents have income status while remaining are unemployed and students where income level of tk. 20000 to tk.40000 having the age range between 20 to 40. The significance level between these two variables is 0.001 having r- value of 0.391. That linear relationship reflects that the respondents with the income level of tk.20000 to 40000 generating maximum number of trips among all the zones and the age range is between 20 to 40.

6.3 Fitting Regression Equation regarding Income, Origin and Destination and Occupation:

To determine comparable standard regression equation for the research income, origin, destination, occupation variables where all these are categorical variables except income data which have been converted to 5 categories. Using multiple regression model considering one for income, origin and occupation data and another equation considering income, destination and occupation data.

Processing data in R, the equation for origin location is:

$$Y\ (\text{Income}) = 0.491 - 0.192 * X_1\ (\text{Origin Zone}) + 0.573 * C\ (\text{Occupation}) \quad (19)$$

Equation (19) represents that income level is increasing with the increase of occupation type where the increased distance from origin zone decreasing the income. The equation has R squared value of 78.67% which means 78.67% data from the dataset can be answered by the equation.

The equation for destination location is:

$$Y\ (\text{Income}) = 0.019 + 0.067 * X_2\ (\text{Destination Zone}) + 0.442 * C\ (\text{Occupation}) \quad (20)$$

These two regression line intercepts each other, which means there is a relationship considering the origin and destination zone, occupation with the income level of people of the study area. On both equations p – value is < 2e-16, which means the variables are statistically significant. So, these variables can be termed as underlying factors affecting the travel demand of KMA.

7. Conclusion and Recommendation

Following the changes, the major influencing factors have been found such as built up area, road network, income, age, driving license, occupation, trip interchanges. With the increase of population, built up area and road network are also increasing day by day with travel demand. After 10 years, trip production and attraction will be on average over 14% in Zone 5, Zone 6 and Zone 7, which are already highly dense area. Following the travel demand model of the research, use of Mahindra will be highest although priority of choosing modes varies from zone to zone. BRTA should take steps to reduce use of easy bike in a systematic way which will not put negative impact on the livelihood of easy bike drivers otherwise use of Easy bike should only be permitted to drive on secondary roadways rather than in highways which will increase the efficiency of highway roads through increasing vehicle speeds. Considering the condition of land use and travel demand of Khulna city after 10 years, recommendations considering Khulna Master Plan 2001-2020 have been given below:

7.1 Land use zoning control:

According to Khulna Master Plan (2001 - 2020) chapter 12, over 48% of the area are allocated for residential use and from the research over 44% home based trips have been generated from different zones. KCC area includes 5838.85 acres of land for residential use and additional proposed area for residential use is 48.45% of the Master plan area. Among total trip production, after 10 years in Zone 5 (Sonadanga residential area) and Zone 7 (Nirala, Tutpara, P.T.I more, Miapara) the rate is both over 15% and in other zones the rate is near about 10% where attraction rate is higher in Zone 6 (Dakbanga, Boro Bazar, Railway station) as this is basically commercial area. There is no specific area determined in the Master plan where will be the proposed residential area will be located, so considering travel demand, land acquisition for residential use in Zone 5 and 7 should be under consideration for future development.

7.2 Reduction of Traffic Congestion:

Two of the major locations indicated in the Master Plan are Khan-E-Sabur Road at Daulatpur which is located at Zone 2 and another is Fulbarigate level crossing locating at Zone 1. The width of the Khan-E-Sabur Road should be enlarged as future travel demand in terms of trip production and attraction both are 14%. Travel demand is about 13% at Fulabarigate rising with significant rate as located nearby university, bus stand and railway crossing situated at the nearby location. Locating these at separate and distant locations to reduce density of traffic during peak hours should be taken care of from the forecasted travel demand at Zone 1 by KCC and KDA in future.

7.3 Introducing Bus Service:

Bus, as a cheaper means of transport is needed to allow the mobility of low income people who are located at Zone 2 (Daulatpur) and Zone 5 (Sonadanga). Approach of introducing double decker bus service is already successful in Dhaka which can be followed in the following routes as per mentioned in the Master plan:

1. Rupsha to Shiromoni following the new bypass road.
2. Rupsha to Dighalia following proposed bypass road.
3. Fulbarigate to Rupsha via Daulatpur, Khalishpur Industrial Area – Joragate – Shibbari and Moylapota.

7.4 Construction of Bridge:

Construction of proposed bridge over Mayur River can increase the travel demand of Zone 5 and 7, so associated road width should be maintained by RHD.

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7.5 Implementation of Railway and Waterway Development:

Predicting the demand and increase the efficiency of the inter-zonal railway transport with the help of railway department and waterway development with the help of agencies like BIWTA, Bangladesh Water Development Board (BWDB), KDA and other associated departments.

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