Urbanization and its Impact on Transport Sector Energy use in Kathmandu Valley

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Abstract: This paper tries to explore the relationship between urbanization and transport sector energy use in the Kathmandu valley. The paper uses econometric analysis to first obtain the elasticity of urban population and Gross Domestic Product (GDP) to forecast the future energy demand in transport sector. The base year is 2013 and energy demand and emission is forecasted up to 2030. The result of the research shows that the demand in 2030 increases by more than four times its value in 2013. Similarly, the pollutants emitted from gasoline vehicles increased more than that from diesel vehicle. The emission of CO_2 increase by less than 3.5 times while that carbon mono-oxide (CO)and Methane (CH_4) increased by as much as 5 times. It shows there is a need of policy to reduce consumptionof imported fossil fuels there by reducing local and global environmental emissions for sustainable development.

Keywords: Urbanization, Transport energy, Econometric Analysis, Emission, Pollutants

1. Introduction

The objective of this study is to explore the relationship between urbanization and energy consumption in road transportation in Kathmandu valley. Kathmandu valley is the capital and largest urban city of Nepal. The population of Kathmandu valley is around 3 million. The population density of Kathmandu valley is around 97 per square kilometer while that of Kathmandu metropolitan is 13,225 per square kilometer (KMC, 2013). The valley is 1300 m above mean sea level (msl) and is surrounded by hills ranging from 2000 to 2800 m above mean sea level (msl). The topography and high emission makes this city one of the most vulnerable in the world. The concentration of particulate matters in the valley is found to exceed the National Ambient Air Quality Standards (NAAQS) while other pollutants like SO2, NOX, CO and HC are found to be increasing in recent years (Shrestha&Rajbhandari, 2010). Brick kiln and cement factories and street dust along with vehicles are major contributors to emission in the valley.Road transport is the only means of transport inside the valley and is characterized by congestion, inadequate infrastructure, diversity in modes and age and unmanaged traffic. Majority of the people live in the urban areas and with increasing population the city has entered into haphazard and uncontrolled urban settlement. Until the mid-1980’s the settlement was confined within the 27 km ring road and two major clusters, Bhaktapur and Kirtipur. However, it has expanded in all direction and rapidly along the transportation corridor (Dhakal, 2006). The population is expected to rise and the outskirts of the city are likely to be exploited

More than half of the world’s population lives in urban areas. The urbanization rate in developing nation is expected to be higher than that of developed countries. By 2020, the total population in urban areas in less developed region is expected to be around 3.3 billion (UNDES PD, 2012). Cities which cover only around 2% of total population consume about 75% of resources (Pacione, 2009). Changes in the urban population will affect economic growth, energy consumption and consequently greenhouse gas (GHG) emission. Urban transport will be the major source of energy consumption and GHG emission (Dhakal, 2003).The urban population in Nepal predicted to be around 8.4 million by 2020 (UNDES PD, 2012).

2. Literature Review

Urbanization has been linked with energy use and GHG emission in various studies. Parikh and Shukla (1995) studied the relation between urbanization, energy use and greenhouse effect in developing countries. They found that urbanization and greenhouse effect were positively related and fuel use shift associated with urbanization has greenhouse increasing potential. Sadorsky (2014) used STIRPAT model to study the impact of urbanization on CO2 emissions. He found two opposing effects of urbanization with net effect difficult to predict. Another study by Madlener & Sunak (2011) has identified the need co-ordination of local, national and global agents to achieve sustainable urban development. The author has acknowledged the need for higher taxation for motor vehicles, development in urban infrastructure and efficient organization of urban logistics and supplies to reduce mobility related energy consumption and emission.

Schafer and Victor (2000) predicted the future mobility and transport modes for various 11 regions in the world. They found that with rising income the mode of transportation becomes faster and this in dependent upon land use and infrastructures. Chemin (2008) has identified urbanization as one of the major factors shaping transport demand. Urbanization will impact the transport demand in cities where the major source of transportation is mass transit or in the cities where passenger vehicle accounts for majority of travel. In industrialized nations daily obligations and leisure are factors determining transportation while in emerging nations travel for work dominates. APERC (2007) has observed that energy demand grows parallel to urbanization. The demand initially increases for industrial sector but with increase in sub-urbanization the demand for transport will rise eventually. This is because of increase in travel distance and motorization. Rodrigue, et. al, (2006) argued that urbanization affects, both freight and passenger transport in two ways. First, by increasing the movement of freight and transport and another, by implying longer travel distance. Jones (2004) found that urbanization affected transport energy demand in three ways; by increasing the movement of raw materials, semi-finished or finished product, increasing the transport of food from outside cities and longer distance travel to workplace. Finally, Poumanyvong, Kaneko and Dhakal (2012) studied the effect of urbanization in low, middle and high income countries. Change in urbanization was found to have greater impact on high income countries. However, in case of middle income countries the impact was found to be lower than low income countries.

Similarly, various studies have been done in the transport sector of Kathmandu Valley. Dhakal (2003) analyzed the past and future trends of energy demand and environmental loading from transport sector. The author used Long-range Energy Alternatives Planning (LEAP) System framework to formulate various scenarios related to improvement in traffic, public transportation and electric vehicle penetration. A similar study was conducted by Dhakal (2006) to study the contemporary status of emission of air pollutants and carbon di oxide (CO2). The research discusses the future scenarios and helps to identify the plausible mitigation measures. He found that under base case the energy consumption increased by 2.2 times its 2005 level to reach more than 10,000 thousand GJ in 2025.Shrestha and Rajbhandari (2010) analyzed the energy consumption and emission of CO2 and local pollutants. Under base case their projection showed road transport energy demand to reach more than 33,000 thousand GJ in 2030.A more recent study by Shresthaet. al (2013) estimated emission from on-road traffic fleets in 2010 using the International Vehicle Emission (IVE) model. The emission from bus, motorcycle, taxi and other road vehicle were determined.

3. Methodology

3.1. *Data description*

The data on energy consumption was obtained for last ten years from Nepal Oil Corporation. The consumption pattern of High Speed Diesel (HSD) and Motor Spirit (MS) is shown in figure 1. The consumption of Liquefied Petroleum Gas (LPG) was obtained from report by Water and Energy Commission Secretariat (WECS) in 2010 and 2013. From the graph it can be seen that the consumption of HSD has risen sharply after 2065 B.S. The reason can be seen from the pattern of the vehicle registration which was higher around that period as compared to other years. Similarly, the electricity generation from diesel also increased around the same period. The consumption of LPG gas for transport sector was 170,000 GJ in 2008/09 and this increased to 220,000 GJ in 2011/12 (WECS, 2010; WECS, 2013). Figure 1 shows the sale of High Speed Diesel (HSD) and Motor Spirit (MS) in Kathmandu valley for last 19 years.

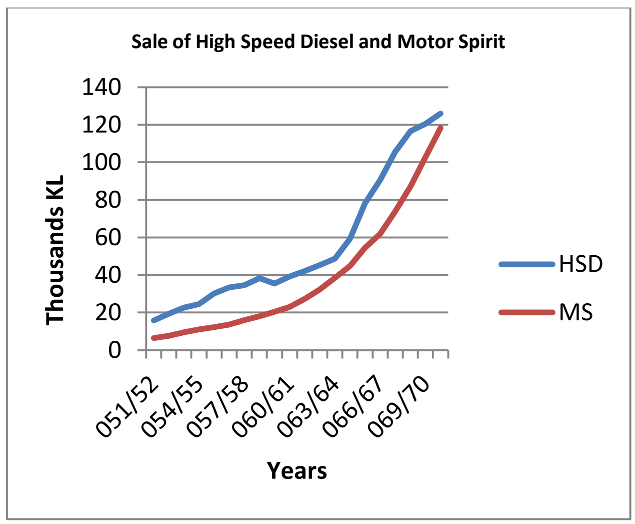

Figure 1: Sale of HSD and MS in Kathmandu valley for last 19 years

The number of vehicles registered in the Kathmandu valley was obtained from the Department of Transport Management (DoTM). Figure below shows the registration of vehicles in different years. It can be seen that the maximum number of vehicles were registered in Fiscal Year 2066/67. The actual and projected number of vehicles until 2030 is shown in figure below. It can be seen that the slope has increased from around 2008. This is mainly due to rapid increase in the number of vehicles.

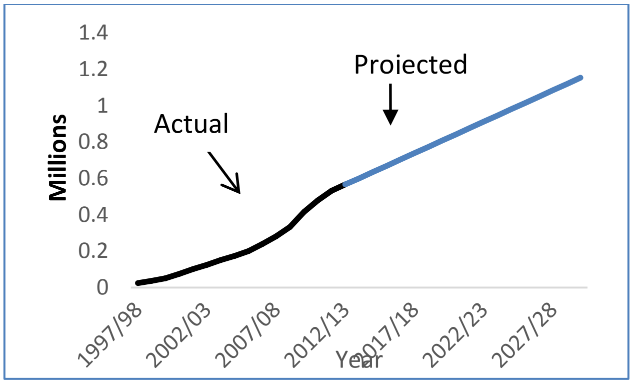

Figure 2: Actual and projected number of vehicles in Kathmandu valley (in millions)

The economic activity considered in this study is the Gross Domestic Product (GDP) per capita of the Kathmandu valley. Since it was difficult to obtain the time series data showing contribution of Kathmandu valley to the national GDP, the share of valley was interpolated between years 1996 and 2012. From Adhikari (1997), the GDP share of Kathmandu valley was taken 13% in 1996 and a recent survey by Nepal Rastra Bank (NRB) (2012) estimated the contribution of valley to National GDP around 23%. The total GDP value was taken from World Bank data indicators in 2005 constant $. The population of Kathmandu valley was obtained from the census report by Central Bureau of Statistics (CBS).

The population of Kathmandu valley was assumed to comprise of population of Kathmandu, Bhaktapur and Lalitpur district. The population was obtained from the CBS census reports. Similarly, urban population of valley was obtained from CBS website until 2001. The urban population of valley after that was taken as fraction of national urban population.

3.2. *Econometric Analysis*

Imai (1997) has used the equation E=Pe to analyze relation between population and environmental issues. In the equation E denotes total energy consumption, P denotes total population and e denotes per capita energy consumption. The author has linked urbanization and per capita consumption by the equation,

Lne =aU+b

where U represents proportion of urban population and a and b are co-efficient.

Similarly, Poumanyvong, Kaneko, &Dhakal (2012) in the study of impact of urbanization in the national transport energy, used the model incorporating share of services in the GDP along with population, GDP per capita and urbanization. Mathematically, the model was represented as,

$$\ln Energy_{it}=\alpha_1+\beta_1\ln(P_{it})+\beta_2\ln(A_{it})+\beta_3\ln(URB_{it})+\beta_4\ln(SV_{it})+u_{it}$$

Where i represents unit of analysis, α1, β1, β2, β3 and β4 are parameters to be estimated and u is error term. The independent variables P, A, URB and SV denote population, GDP per capita, rate of urbanization and share of service to GDP respectively.

For the research various mathematical model were developed and based on the R and adjusted R2 value, the best model was selected. The models developed during the studies are shown below.

log EC=a+blog(Pop)+clog(GDP)+dlog(UP)+e

$logEC=a+blog(UP)+clog(GDP)+dlog(GDP^2)+e$

$logEC=a+blog(Pop)+clog(GDP)+dlog(GDP^2)+elog(UP)+e$

logEC=a+blog(UP)+clog(GDP)+dlog(UA)

logEC=a+blog(UA)+e

logEC=a+blog(UP)+clog(GDP)+dlog(Gp)+elog(Dp)

logEC=a+blog(GDP)+clog(UP)+e

where EC, Pop, GDP, UP, UA, Gp and Dp represent transport sector energy consumption, population, GDP per capita, urban population, urban area, gasoline price and diesel price respectively.

Based on the R^2 and adjusted R^2 value, GDP and urban population were used as independent variable. The elasticity of GDP and urban population obtained from regression is shown in table below.

Table 1: Population and GDP elasticity obtained from regression

Parameter	Elasticity
GDP	1.07
Urban Population	1.38

3.3. *Emission calculation*

The emission was calculated based on the number of vehicles in the base year and their share in total energy consumption. The time-series data on total number of vehicles operating in the Kathmandu valley was obtained from Department of Transport Management (DoTM). The share of diesel and gasoline vehicle for this time period was used to forecast their share in the future years. The emission factors were taken from Shrestha, et al. (2013).

4. Result and Analysis

The result shows that the consumption of energy for transport purpose will increase by four times from

2013 to 2030. The total consumption in base year wasa about 8730 thousand GJ and is is expected to be around 36292 thousand GJ in 2030. The elasticity of urbanization for urban population shows that for 1 percent increase in urban population there will be 1.38 percent increase in consumption. This is comparable to the elasticity used in (Shakya &Shrestha, 2011; Shrestha & Rajbhandari, 2010). The elasticity value used in Shrestha and Shakya ranged from 1.25 to 0.18 for population and 1.01 for GDP. Similarly, in Shrestha and Rajbhandari was 1.44 for population and 0.44 for GDP.The energy consumption pattern upto 2030 is shown in figure below.

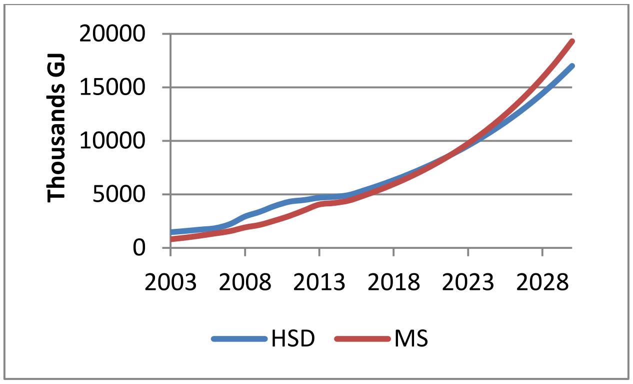

Figure 3: Total energy consumption by fuel type

Figure 4: Transport sector energy consumption under base case

From the figure it can be seen that the consumption of gasoline exceeds that of Diesel by 2022. This is due to increase in the number of private vehicles and motorcycles which basically run in motor spirit. Similarly, the total CO_2 emission during the period is shown in figure below. It can be seen that the total emission of CO2 increased by 3.5 times from its 2013 level.

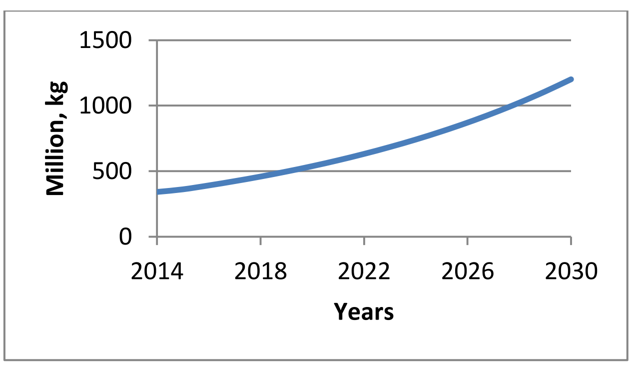

Figure 5: Carbon-di-oxide emission trend (in million kg)

Similarly, the emission of other pollutant is also expected to rise sharply. The CH4 emission is expected to increase by more than five times its value in 2013. Similarly, the emissionCarbon-mono-Oxide also increases by more than four times its value on 2013..

The emission of other pollutant is also expected to rise. Figure 3 shows the emission of methane and carbon-mono-oxide.

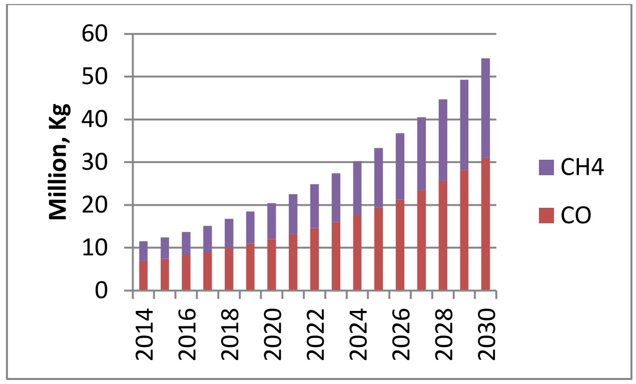

Figure 6: Total emission by pollutant type

The results show that emission in the valley is expected to increase at high rate if there is lack of policy intervention in the future. The high emission of CH4 and CO is due to rapid increase in the number of motorcycles.

5. Conclusion and Recommendation

From this it can be concluded that the amount of energy consumption in the valley for transport purpose will increase by more than three times its value in 2013 to 2030. The major contributor to the emission will be petrol based private vehicles. Modal shift from private to public will not only reduce congestion but also decrease emission of pollutants and energy use. Currently, gasoline vehicles are responsible for around 48% of the total energy consumption in the valley. This means that introduction of mass transit vehicles would be a good option to decrease the emission in short term. Some methods to reduce the growth in private transport could be increased parking price inside the valley, restriction in certain hours to use private vehicles inside the ring road and drastic improvement in the public transport means.

The elasticity of urbanization is estimated as 1.38 in this study. It shows that energy consumption in valley is greatly affected by the number of people living in urban areas. The city needs to use land available in a centralised way to reduce private transport use. Reducing work places in a designated part of the city will reduce the energy use by encouraging walking or use of public transport. Similarly, regulatory policies like fuel economy and emission standard for vehicles, auto age restriction, awareness campaigns could be some other measures to control emission and energy consumption by transportation in the valley.

The research has limitations of its own, Although it focuses on road trasnport, electric and LPG vehicles are not considerd in the study because they have remained largely static since their introduction. Similarly, the number of vehicles in Kathmandu district is considered to be 80% of total vehicles in Bagmati zone.

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