Proceedings of IOE Graduate Conference, 2017
Volume: 5 ISSN: 2350-8914 (Online), 2350-8906 (Print)

Driving factors of Energy consumption in Transport Sector

Anita Prajapati [a], Tri Ratna Bajracharya [b], Nawraj Bhattrai [c]

[a, b, c] *Department of Mechanical Engineering, Pulchowk Campus, IOE, TU, Nepal*
Corresponding Email: [a] anita.praj@gmail.com, [b] triratna@ioe.edu.np, [c] bnawraj@yahoo.com

Abstract

The main aim of this paper is to analyze the determinants of road transport energy consumption. Based on the literature study, four major factors are identified as major drivers of transport energy: transport intensity, energy intensity, per capita GDP and population. The correlation with transport energy consumption is analyzed and time series multivariate regression model is developed. The correlation of transport intensity (ton-km/Nrs.) and energy intensity (TJ/ton-km) with transport energy consumption is observed to be highly significant and per capita GDP with transport energy consumption significantly. The contribution of each factor to transport energy is then analyzed using Logarithmic Mean Divisia Index (LMDI) decomposition method over the period of 2003-2016. The result shows that transport intensity and per capita GDP have positive impact whereas energy intensity has a negative impact on transport energy consumption. It implies that improvement in energy intensity helps lower transport energy demand whereas economic growth and transport activity increase transport energy consumption. It thus concludes the need for energy efficiency measures to attain the balance between energy consumption and economic growth for the sustainable transport

Keywords

Transport energy consumption – Driving factors – LMDI decomposition method

1. Introduction

The transport sector is one of the energy consuming sectors. It plays a significant role in determining the economic growth [1, 2]. Improved access to resources, trade, growing employment, education, and healthcare opportunities, better market scope, and travel behavior are all influenced by the transport sector.

According to economic survey 2015/16, total energy consumption increases from 9 million tons of oil equivalent (Mtoe) in 2006/07 to 11 Mtoe in 2015/2016 [3]. Over the same period, transport sector energy consumption has increased from 3.5% to 7.1% of total energy consumed. There is a significant increase in transport energy consumption with an annual growth rate of 10% in the last decade [3]. The increasing energy demand for transportation has led to a number of studies in transportation including future demand projection, emission projection, the economic impact analysis but the quantification of the impact of the factors on the change in transport energy consumption has not been studied for Nepal. As research gap shows, not much research has been done to evaluate the important factors contributing road transport energy consumption in Nepal. Thus an attempt is made to identify the contributing factors that affect energy demand in the transportation sector. Since energy consumption in the transportation sector is increasing as shown in Figure 1 and almost all fuel consumed in this sector are imported. Thus a research needs to be carried out to improve energy consumption in the transportation sector to reduce dependency on imported fuel and improve energy security. Road transport dominates all modes in Nepal, so road transportation is considered for the study. The choice of the road transport sector is also guided by its strong implication on the economic and the environmental dimension of sustainable development.

Petroleum products such as petrol, diesel, aviation fuel and LPG are the major fuel consumed in this sector. Nepal imports 100% petroleum products and more than 80% of them are consumed in the transport sector [3]. The primary supply of petroleum products shows the drastic increase in sales of petroleum products [4]

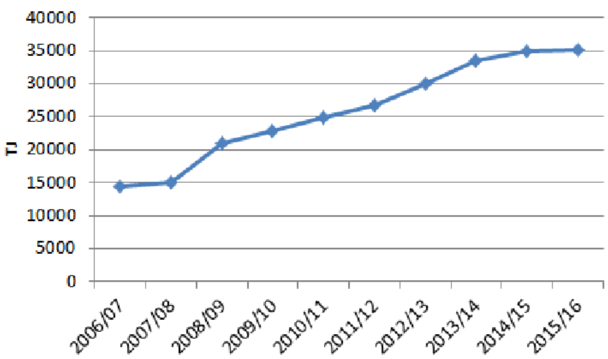

Figure 1: Trend of energy consumption in transport sector

The consumption of imported fuel in the transport sector is shown in Figure 2. Diesel and gasoline represent most of the transport fuel [5]. This implies a serious concern towards energy security, sustainability of the transport sector and negative economic impact. Thus a study needs to be carried out to explore the negative impact on the economy due to the rapid growth of petroleum products demand in order to obtain sustainable transport development [6].

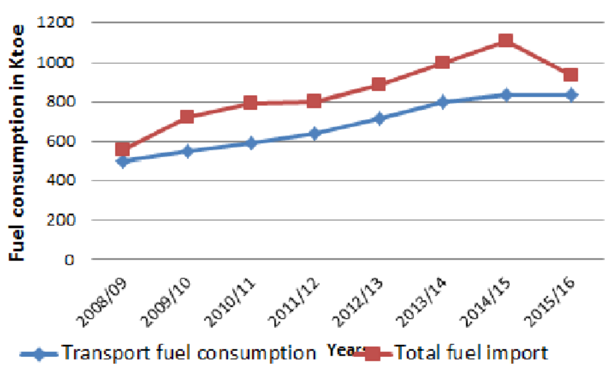

Figure 2: Fuel consumption in transport sector

2. Literature review

Energy consumption in the transport sector and its emission is discussed frequently in literature. Rapid motorization due to unplanned transport policies has raised concern over energy security, deteriorating air pollution and growing traffic congestion. To estimate energy use in the transport sector, economic, demographic and technological factors is assessed using both top-down and bottom-up approaches. Studies on identifying factors contributing energy demand in transport have been carried out in the past using decomposition analysis. In 2013, Mraihi used the LMDI technique to analyze energy consumption in the transport sector and its driving factors using economic, demographic and urban factors [7]. They highlighted the fuel intensity, vehicle intensity, GDP per capita, urbanized kilometer and national road networks as the major drivers of transport energy consumption in Tunisia. The LMDI decomposition method is used to analyze the effects of transport activity in China and evaluate energy consumption over the periods of 1980-2006 [8]. The effect of a change in transport mode, share, energy intensity and activity is analyzed and concluded that transportation activity effect is the most contributing factor in increasing transport energy consumption and energy intensity plays a dominant role in reducing energy consumption. The correlation of GDP per capita, population, transportation intensity, energy intensity and structure with energy consumption is analyzed and time series regression analysis is carried out in 2013 in China and further evaluated using LMDI method to identify the effect of factors [9]. It sheds light on the need for improvement in transport intensity to lower down energy consumption in future. Since the total energy consumption in the transport sector is influenced by various factors, it is necessary to identify the degree of change in each factor and their mathematical relation [10]. It also developed an indicators for factor selection and has selected number of trips, population, energy intensity and number of vehicles for factor analysis based on the indicator set and concluded that number of trips and population have the strongest impact on energy consumption in passenger transportation. For sustainable transport planning, the need to investigate the driving factors of energy in the transport sector is emphasized in most of the studies. The decomposition analysis is approached to analyze the CO2 emission from the transport sector in ten Asian countries for over a period of 25 years between 1980-2005 [11]. Since fuel switching is found to be influencing the most in transport energy consumption in most of the countries, policy focused on fuel switching for sustainable future transport is suggested. In India, a study was conducted using LMDI technique to analyze CO2 emission from the transport sector and concluded that GDP growth is the significant contributor in CO2 emission from road transport [12].

They suggested that energy intensity effect has the negative effect on emission which is due to technological improvement in road transport. It also highlighted the contribution of population growth and economic growth in transport energy consumption. Decomposition of different factors responsible for the change in transport energy demand in Nepal has not received much attention. In Nepal, studies done are focused mainly on analysis of historical trend and future projection, the effect of economic growth in energy consumption and emission in transport sector under different scenarios [6, 13, 14, 15, 16, 17, 18, 19]

3. Modes of Transportation

The annual registration of road transport vehicles has increased significantly from 54 thousand in 2006 to 344 thousand in 2016 with an annual growth rate of 20% over the periods [20]. This growth rate is far greater than population growth rate, the reason could be uncontrolled immigration, haphazard urbanization and increasing per capita income [1, 6]. Such a rapid motorization is responsible for increasing traffic congestion, rising road accidents, deteriorating air quality and increasing energy demand.

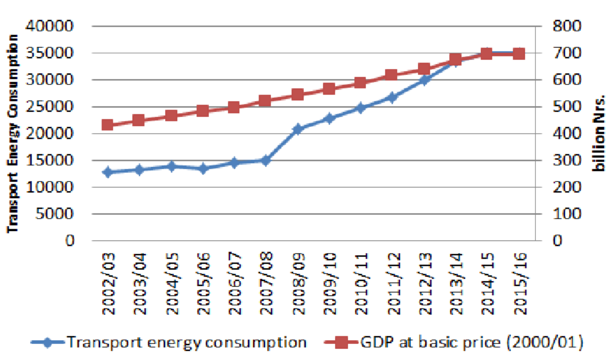

Figure 3: Transport energy consumption and GDP

The close relationship between transport energy consumption and GDP growth is as shown in Figure 3 The historical trend analysis shows increasing trend of economic activity as well as energy consumption. Energy consumption in transport increases with the economic growth. The increasing trend of transport energy indicates high demand for mobility and demand for mobility is directly affected by economic activities. Also, there are other factors that determine energy consumption in the transport sector.

Public transportation can be the solution to reduce existing traffic congestion, but the present context of rapid growth of private vehicles shows that without any serious policy to shift travel behavior, the situation will only be worst in future. In 2016, 78% of the total registered vehicle is motorcycle, 8% car/jeep/van, 3% tractors and trucks, 2% pickup, 1% Bus, and remaining others (tempo, rickshaw, heavy equipment mini bus and micro bus) [20]. This rapid growth of two wheeler is due to its affordability and efficient short distance travel [6]. Out of total registered vehicle, 93% are passenger vehicles (private and public) and remaining 7% are freight vehicles. Statistics show booming private vehicles in the roads of Nepal. There is registration of only 4% of the public vehicle (bus, mini bus, micro bus, and taxi) whereas remaining 96% are private vehicles. Thus government should take serious action to improve and promote public vehicles in order to reduce demand for imported petroleum products, improve traffic congestion and reduce vehicular emission.

In terms of passenger travel demand, in 2016, passenger travel demand is calculated to be 48 billion pkm, a rise of 79% from 2010 passenger travel demand. In terms of per capita (pkm/person), motorized passenger travel demand increased from 1023 in 2010 to 1701 in 2016, an increase of 66% over the period of 6 years. It shows the close relation of travel demand with the population. The population has increased by 8% since 2010 with an annual growth rate of 1.35% [20].

Freight transport activities are closely related to economic growth [6]. Freight transport has also increased by 71% in 2016 from 2010 with an average GDP growth rate of 4% [3]. Average freight demand is estimated to be 12 billion ton-km in 2016. Among freight vehicles, truck dominates (51%) all other modes in freight vehicles, followed by a pickup (19%), tractor (17%), mini truck (9%) and others (4%) in 2016. Figure 4 shows historical passenger and freight travel demand.

A study is thus carried out to determine factors causing change in transport sector energy consumption. It leads to explore options to reduce high dependency on imported fuel, improve energy security and move towards the path of sustainable transport. There are several factors that determine the change in transport energy consumption such as fuel use, vehicle speed, vehicle age, vehicle weight, fuel economy, travel distances, modal mix, transport intensity, population, per capita GDP, driving condition [7]. The economic, demographic and technological factors are analyzed in this study. The effect of population, economy, energy intensity, transport intensity and modal mix are analyzed in this paper. Understanding the effects of each factor contribute to formulating sustainable transport policies.

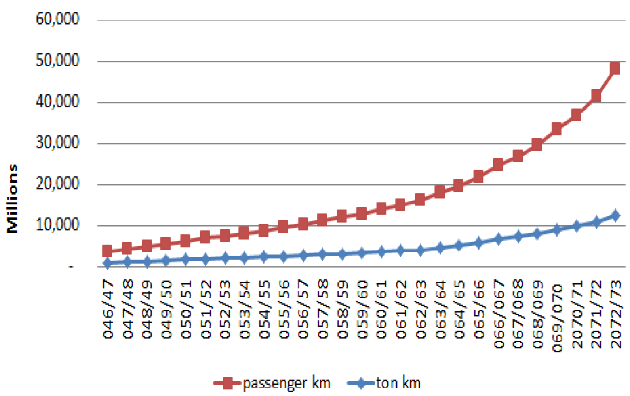

Figure 4: Trend of Passenger and Freight travel demand

4. Methodology

Index decomposition analysis (IDA has been successfully used so far to quantify the impact of different factors on the change of energy consumption and emission. In the context of decomposition analysis [21] provided a useful summary of the various methods and their advantages and disadvantages and concluded that the LMDI method is the preferred method, due to its theoretical foundation, adaptability, ease of use and result in interpretation, along with some other desirable properties [22], [21].The decomposition analysis is one of the most effective tools to analyze the factors influencing energy consumption and it's environmental impacts. Most of the studies used this method to relate transport with energy [7]. This technique of decomposition is used to identify the underlying factors of transport activities to formulate sustainable transport policies. The logarithmic Mean Divisia Index (LMDI) techniques of decomposition analysis have been used in this paper. Decomposition analysis is used majorly in three fields of application: one is making a future forecast based on decomposed effects, second is analyzing the differences in future energy projection under different scenarios and third is quantifying the drivers of energy consumption and comparing the projection [21]

In this study, LMDI decomposition method is approached for the analysis of effects of driving factors of energy consumption in the transport sector. The additive decomposition analysis is preferred in which arithmetic change of an aggregate indicator is decomposed. In standard IDA method, there are generally three factors: activity, structure, and intensity effects. The major objective of this method is to decompose the change in transport energy consumption into various affecting factors. It identifies the contribution of each factor to energy consumption by decomposing them into various level thus impact of each factor in energy consumption is determined. There are numbers of factor affecting energy consumption in transport. Some of the factors that are widely popular for analysis are Population, GDP per capita, transport activity, energy intensity, transport structure. Those factors possess either positive or negative impact on energy consumption. Factors are decomposed to the level of data availability. For the analysis, Kaya identity method is used which provides a basis for decomposition. It is shown by the equation below [21, 23]:

$E^t = \sum_i \frac{E^t}{V_i^t} * \frac{V_i^t}{V^t} * \frac{V^t}{GDP^t} * \frac{GDP^t}{P^t} * P^t$ Where the subscript "t" represents years; the subscript "i" represents four important modes of transport E_t denotes total energy consumption in year t, GDP is gross domestic product, P is population scale, V_i^t is the transportation turnover of transportation mode (pkm/ton-km) "i" in year t and is given by $V_i^t = \frac{V_i Pkm^t}{C} + V_{iton-km}^t$

The conversion coefficient, C, is defined as one person per ton, which means that the turnover of transporting one ton of goods to 1km is equivalent to the transporting one passenger to1km. The coefficient value of C in calculating total converted ton-kilometer turnover is assumed 5 for highways [22]. V^t Indicates the total converted turnover in year t. The first equation is decomposed into following equation shown below [21, 23]:

$E^t = \sum_i E_i^t = \sum_i G_i^t * S_i^t * K^t * L^t$

Where, $G_i^t = \frac{E^t}{V_i^t}$ is the energy consumption by converted turnover of the i^{th} mode at time t,
$S_i^t = \frac{V_i^t}{V^t}$ is the share of the i^{th} mode at time t
$K^t = \frac{V^t}{GDP^t}$ is transportation intensity at time t, and
$L^t = \frac{GDP^t}{P^t}$ is the share of per capita economic growth at time t Since, road transport mode is used in this study, result of S is avoided in the analysis. With the principles of addition, the equation to measure every factor's contribution to energy consumption can be obtained. The change in energy consumption ΔE between the base year (2002) and target year(2015) is thus calculated. It is decomposed into five effects: the contribution of transportation structure, the contribution of transportation intensity, the contribution of per capita GDP, the contribution of energy intensity and the contribution of population scale. The contribution effects are presented in the additive form as shown in Equation 3 below [21, 23].

$\Delta E = E_t - E_0 = \Delta E_G + \Delta E_S + \Delta E_K + \Delta E_L + \Delta E_P$
Where, ΔE_G the contribution of energy intensity to energy consumption,
ΔE_S the contribution of transportation structure,
ΔE_K the contribution of transportation intensity,
ΔE_L the contribution of per capita GDP and
ΔE_P the contribution of population scale
According to the LDMI method, each effect on the right side of equation 3 can be written as follows:

$$\Delta E_G = \sum_i \Delta E_G^t = \int \begin{matrix} \Delta E_G = 0 \, if E_i^t x E_i^0 = 0; \\ \Delta E_G = \sum_i L(E_i^t, E_o^0) Ln(\frac{G_i^t}{G_i^0}, if E_i^t x E_i^0 \neq O^\Delta \end{matrix}$$

$$\Delta E_S = \sum_i \Delta E_S = \int \begin{matrix} \Delta E_S = 0 \, if E_S^t x E_S^0 = 0; \\ \Delta E_S = \sum_i L(E_i^t, E_i^0) Ln(\frac{S_i^t}{S_i^0}, if E_S^t x E_S^0 \neq O^\Delta \end{matrix}$$

$$\Delta E_K = \sum_i \Delta E_K = \int \begin{matrix} \Delta E_K = 0 \, if E_K^t x E_K^0 = 0; \\ \Delta E_K = \sum_i L(E_i^t, E_i^0) Ln(\frac{K_i^t}{K_i^0}, if E_K^t x E_K^0 \neq O^\Delta \end{matrix}$$

$$\Delta E_L = \sum_i \Delta E_L = \int \begin{matrix} \Delta E_L = 0 \, if E_L^t x E_L^0 = 0; \\ \Delta E_L = \sum_i L(E_i^t, E_i^0) Ln(\frac{L^t}{L^0}, if E_L^t x E_L^0 \neq O^\Delta \end{matrix}$$

$$\Delta E_P = \sum_i \Delta E_P = \int \begin{matrix} \Delta E_P = 0 \, if E_P^t x E_P^0 = 0; \\ \Delta E_P = \sum_i L(E_i^t, E_i^0) Ln(\frac{P^t}{P^0}, if E_P^t x E_P^0 \neq O \end{matrix}$$

A total number of a vehicle registered in Nepal from 2002/03 till 2015/16 is taken from Department of Transport Management. Demographic data and economic data are taken from economic survey 2011/12, 2012/13, 2013/14, 2014/15 and 2015/16. Operation factor, load factor, vehicle kilometer traveled per year are obtained from Malla (2014) to calculate passenger-kilometer and ton-kilometer [6].

In this paper, energy consumption between 2002/03 to 2015/16 is analyzed for factor decomposition. The energy intensity, total energy consumption in each year, GDP per capita, transport structure and population are assumed as major factors driving energy consumption in the transport sector. It identifies the driving factors of energy consumption in the transport sector and finally generates a model that measures the contribution of every factor and provides the methodological base for formulating sustainable transport policy.

5. Results

5.1 Correlation analysis of driving factors

The factors selected for decomposition are first verified using time series multiples linear regression method. The correlation between driving factors and the transport energy consumption is analyzed. The regression model is developed using SPSS software through data processing. The correlation measurement results are as shown in Table 1. The result shows that the correlation of population (million people), per capita GDP (NRs./people), transport intensity (ton-km/NRs.) with energy consumption is highly significant and correlation of energy intensity (TJ/ton-km) is moderately significant.

A linear regression analysis is conducted to evaluate the prediction of energy consumption in the transport sector from energy intensity, transport intensity, per capita GDP. The result shows that they are positively and strongly related to transport energy consumption such that energy consumption in transport increases with increase in economic activity and transport activity. The strong relationship between energy consumption and factors are reflected in an adjusted R square value of 0.989. Approximately 90% of the variance in energy is accounted by a change in energy intensity, transport intensity and per capita GDP. Only three variables are evaluated in the regression model, the population is removed since it did not improve the prediction in the model. The energy intensity, transport intensity and per capita GDP significantly contribute to the prediction of energy consumption in the transport sector. The regression equation to predict transport energy consumption is as : $E = -53731.02 + 2.678L + 2857960.374K + 384521089 * G$

Table 1: Correlation analysis of driving factors

		E	P	L	K	G
E	Pearson Correlation	1	.972**	.981**	.869**	-.600*
	Sig. (2-tailed)		.000	.000	.000	.023
	N	14	14	14	14	14
P	Pearson Correlation	.972**	1	.993**	.907**	-.740**
	Sig. (2-tailed)	.000		.000	.000	.002
	N	14	14	14	14	14
L	Pearson Correlation	.981**	.993**	1	.881**	-.705**
	Sig. (2-tailed)	.000	.000		.000	.005
	N	14	14	14	14	14
K	Pearson Correlation	.869**	.907**	.881**	1	-.828**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	14	14	14	14	14
G	Pearson Correlation	-.600*	-.740**	-.705**	-.828**	1
	Sig. (2-tailed)	.023	.002	.005	.000	
	N	14	14	14	14	14

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

5.2 Contribution of driving factors

The contribution of each driving factor is as shown in the Table 2. The decomposition analysis of energy consumption over the periods of 2003-2015 shows that the total change in energy consumption is 23PJ. The accumulated effect of transport intensity is 35PJ, which accounts for 150% of the total variation of transport energy consumption. Transportation intensity is a measure of converted transport turnover (ton-km) per unit of GDP. The accumulated effect of transport intensity is positive in energy consumption. It indicates that with an increase in transportation intensity, transportation energy consumption also changes; opposite signs for certain year means that the effect of transport intensity restrains the transport energy consumption. Thus increasing the transport intensity will have a significant impact on lowering transport energy consumption.

Energy intensity is the measure of transport energy consumption per converted ton-km. It measures overall transport activity and energy efficiency. The accumulated effect is a decrease of -23PJ, which accounts for -99% of the total variation of transport energy consumption. The result shows that energy intensity makes a negative contribution to the change in total transport energy consumption. It implies that energy intensity plays a dominant role in reducing energy consumption. It attributes to the need for energy efficiency measures such as improving fuel quality, promoting new vehicle technology, improving traffic condition and upgrading road condition for sustainable transport.

The per capita GDP is the measure of production capacity per capita and services in the country. It reflects economic growth as well as the quality of living. The result shows that there is a positive effect of per capita GDP of 7.8PJ that accounts for 33.47% of total variation of transport energy consumption. This implies that there is a direct relationship between economic growth and transport energy consumption in Nepal.

6. Conclusion

The analysis of driving factors of transport energy consumption shows that transport intensity, energy intensity, and per capita GDP affect significantly in changing total transport energy consumption. The correlation of transport intensity and energy intensity h

Table 2: Contribution of each driving factors

year	ΔE	ΔE_G	ΔE_K	ΔE_L	ΔE_P
2002/03	336.068	-2375.451	2245.802	303.925	161.792
2003/04	716.598	2312.915	-1980.377	161.677	222.384
2004/05	-608.964	-5119.072	4195.570	148.036	166.502
2005/06	1731.078	-4328.661	4986.799	849.207	223.734
2006/07	540.451	-1037.778	733.036	670.381	174.812
2007/08	5975.964	4751.114	406.405	541.444	277.000
2008/09	2107.020	-6643.720	7692.218	723.790	334.732
2009/10	1917.062	8098.296	-7027.045	575.853	269.957
20010/11	1925.315	2171.289	-1399.607	864.723	288.910
2011/12	3168.309	-8712.673	10802.319	764.930	313.734
2012/13	3696.149	5300.540	-3481.505	1415.424	461.690
2013/14	1625.998	-7556.409	8032.267	658.502	491.637
2014/15	116.243	-11194.202	11262.848	-325.094	372.691
2003-2015	23381.133	-23354.300	35098.247	7825.468	3811.719

with transport energy consumption is very significant and correlation of per capita GDP with transport energy consumption is significant. The decomposition analysis shows that impact of transport intensity effect and per capita GDP effect is positive, and that of energy intensity effect is negative. The positive impact suggests that increase in economic activity and transport activity will have a direct impact on transport energy consumption. Improving the transport intensity will have a remarkable impact on lowering the transport energy change. Per capita GDP is an indicator of the living standard; the positive effect thus implies that transport energy consumption increases with income. Economic growth is directly linked to the urbanization that increases motorization, and eventually increasing transport energy consumption.

The negative value of energy intensity in decomposition analysis indicates that energy intensity restrains the change in transport energy consumption. To reduce energy consumption in transport, efficiency improvement measures need to be carried out. It reduces the import of petroleum products that further helps to reduce trade deficit as well as lessen the risk of energy security.

Thus, for sustainable transport, policies that address to improve energy efficiency should be formulated. Promotion of mass transport, limiting the growth of private vehicle, incentives for public vehicle users, regular monitoring and inspection of vehicles, promotion of electric vehicle are some of the policy recommendations for sustainable transport.

References

[1] Mehdi Sadeghi and Hossein Mirshojaeian Hosseini. Integrated energy planning for transportation sector: A case study for iran with techno-economic approach. *Energy Policy*, 36(2):850–866, 2008.

[2] HC Ong, TMI Mahlia, and HH Masjuki. A review on energy pattern and policy for transportation sector in malaysia. *Renewable and Sustainable Energy Reviews*, 16(1):532–542, 2012.

[3] *Economic Survey, Ministry of Finanace, Governement of Nepal, 2016*, 2017 (accessed July 18, 2017.

[4] *Ministry of Finanace, Nepal Oil Corporatoin, 2016*, 2017 (accessed July 18, 2017.

[5] *Final Report on National Survey of Energy Consumption and Supply Situation in Nepal*, 2013.

[6] Sunil Malla. Assessment of mobility and its impact on energy use and air pollution in nepal. *Energy*, 69:485–496, 2014.

[7] Rafaa Mraihi, Khaled ben Abdallah, and Mehdi Abid. Road transport-related energy consumption: Analysis of driving factors in tunisia. *Energy Policy*, 62:247–253, 2013.

[8] Ming Zhang, Huanan Li, Min Zhou, and Hailin Mu. Decomposition analysis of energy consumption in chinese transportation sector. *Applied Energy*, 88(6):2279–2285, 2011.

[9] SUN Qipeng, JI Jiao, and XU Cheng. Energy consumption driving factors and measuring models of regional integrated transport system. *Journal of Transportation Systems Engineering and Information Technology*, 13(3):1–9, 2013.

[10] Jian Jiang. A factor decomposition analysis of transportation energy consumption and related policy implications. *IATSS research*, 38(2):142–148, 2015.

[11] Govinda R Timilsina and Ashish Shrestha. Why have co2 emissions increased in the transport sector in asia? underlying factors and policy options. 2009.

[12] Monika Gupta and Sanjay Singh. Factorizing the changes in co2 emissions from indian road passenger transport: A decomposition analysis. *Studies in Business and Economics*, 11(3):67–83, 2016.

[13] Iswor Bajracharya and Nawraj Bhattarai. Road transportation energy demand and environmental emission: A case of kathmandu valley. *Hydro Nepal: Journal of Water, Energy and Environment*, 18:30–40, 2016.

[14] Shreejan Ram Shrestha, Nguyen Thi Kim Oanh, Quishi Xu, Maheswar Rupakheti, and Mark G Lawrence. Analysis of the vehicle fleet in the kathmandu valley for estimation of environment and climate co-benefits of technology intrusions. *Atmospheric environment*, 81:579–590, 2013.

[15] Shobhakar Dhakal. Implications of transportation policies on energy and environment in kathmandu valley, nepal. *Energy Policy*, 31(14):1493–1507, 2003.

[16] Shreekar Pradhan, Bhakta Bahadur Ale, and Vishwa Bhusan Amatya. Mitigation potential of greenhouse gas emission and implications on fuel consumption due to clean energy vehicles as public passenger transport in kathmandu valley of nepal: a case study of trolley buses in ring road. *Energy*, 31(12):1748–1760, 2006.

[17] SM Nepal. Impact of transport policies on energy use and emissions. In *Proceedings of the Institution of Civil Engineers-Municipal Engineer*, volume 159, pages 219–229. Thomas Telford Ltd, 2006.

[18] Reinhart Kühne. Electric buses–an energy efficient urban transportation means. *Energy*, 35(12):4510–4513, 2010.

[19] Shree Raj Shakya. Economy-wide implications of low carbon electricity based mass transport in nepal. *Journal of the Institute of Engineering*, 9(1):142–165, 2014.

[20] *Department of Transport Management, Ministry of Physica Infrastructre and Transport, 2017*, 2017 (accessed July 20, 2017.

[21] BW Ang. Lmdi decomposition approach: a guide for implementation. *Energy Policy*, 86:233–238, 2015.

[22] Houda Achour and Mounir Belloumi. Decomposing the influencing factors of energy consumption in tunisian transportation sector using the lmdi method. *Transport Policy*, 52:64–71, 2016.

[23] Beng Wah Ang and Fang Q Zhang. A survey of index decomposition analysis in energy and environmental studies. *Energy*, 25(12):1149–1176, 2000.