Baseline Study on Fuel Economy of Light Duty Vehicles (LDVs) in Nepal

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July 2019

GLOBAL FUEL ECONOMY INITIATIVE
UN environment programme
FIA FOUNDATION
gef

Clean Energy Nepal, 2019.
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Acknowledgements
Clean Energy Nepal (CEN) would like to appreciate the contribution from its staffs, Mangleswori Dhonju, Shankar Prasad Sharma and Elina Shrestha for their continuous efforts in this study and finalizing report. We are very grateful to Professor Dr. Amrit Man Nakarmi for the technical contribution and guidance throughout the study and report preparation. We would also like to thank Assistant Professor Anita Prajapati for her technical contribution in the study. Special thanks are given to Bhushan Tuladhar, our Chairperson of CEN and Bert Fabian from the United Nations Environment Program (UN Environment) for the support, suggestion and guidance for the study. We would like to express our special thanks to the Ministry of Physical Infrastructure and Transport (MoPIT), Department of Transport Management (DoTM) and Transport Management Office, Ekantakuna for their coordination, support and providing the data of registration of Light Duty Vehicles in Nepal.

We also express our sincere thanks to all the stakeholders in transport sector in Nepal who have provided their inputs and suggestion during the study.

This document is a part of the effort led by the Global Fuel Economy Initiative (GFEI), supported by the European Union, FIA Foundation, UN Environment, the Global Environment Facility (GEF) and other organizations. The GFEI is a partnership of UN Environment, International Energy Agency (IEA), International Transport Forum (ITF), International Council on Clean Transportation (ICCT), and Institute for Transportation Studies (ITS) at the University of California-Davis (UC-Davis), and the FIA Foundation.

ACRONYMS

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
ATF	Aviation Turbine Fuel
BC	Black Carbon
BEE	Bureau of Energy Efficiency
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COP	Conference of the Parties
DoTM	Department of Transport Management
DMC	Developing Member Countries
EV	Electric Vehicle
FE	Fuel Economy
FIA	Fédération Internationale des Automobiles
GDP	Gross Domestic Products
GFEI	Global Fuel Economy Initiatives
GHG	Greenhouse gas
Gt	Gigatonne
HC	Hydrocarbon
ICE	Internal Combustion Engines
ICIMOD	International Centre for Integrated Mountain Development
ICCT	International Council on Clean Transportation
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ITF	International Transport Forum
ITS	Institute of Transportation Studies
JICA	Japan International Cooperation Agency
Kl	Kilo Litres
Ktoe	Kilo tons of oil equivalent
LAPA	Local Adaptation Plans for Action
LCEDS	Low Carbon Economic Development Strategy
LDV	Low Duty Vehicles
Lge	Light Gasoline Equivalent

LPG	Liquefied Petroleum Gas
MoF	Ministry of Finance
MoPIT	Ministry of Physical Infrastructure and Transport
MoRTH	Ministry of Road Transport and Highways, Government of India
Mtoe	Million tons of oil equivalent
MW	Megawatt
NAPA	National Adaptation Programme of Action
NDC	Nationally Determined Contributions
NEA	Nepal Electricity Authority
NERC	Nepal Electricity Regulatory Commission
NRB	Nepal Rastra Bank
NTC	National Transport Commission
OECD	Organization for Economic Co-operation and Development
OICA	Organisation Internationale des Constructeurs d'Automobiles
$PM_{2.5}$	Particulate Matters
SDGs	Sustainable Development Goals
SE4ALL	Sustainable Energy for ALL
SLSEA	Sri Lanka Sustainable Energy Authority
SO_2	Sulphur Dioxide
UNFCCC	United Nation Framework Convention on Climate Change
UNEP	United Nations Environment Program
WHO	World Health Organization
WECS	Water and Energy Commission Secretariat

EXECUTIVE SUMMARY

Transport system is very vital for a land-locked country like Nepal. Efficient and economic transport is essential to take goods and services to the places where they are needed. Manufacturers need it to bring their products to consumers, and similarly, farmers need roads and transport to take their produce to markets for serving the consumers' needs. Besides, Nepal is dependent on imports of petroleum products, of which petrol and diesel are mostly used in road transport. Hence, it is of paramount importance for a country like Nepal to have environmentally sustainable, fuel-efficient, and low emission transport system in the country.

The current trends in the imports of new transport vehicles in Nepal indicate that the country is moving forwards towards inefficient private transport rather than the public transport system even though there seems a gradual improvement in fuel economy in the new registered LDVs. Vehicle registration status in Nepal in 2018 shows that 78% of the total registered vehicles are motorcycles, 6% cars/jeeps/vans, 4% tractors and trucks, 3% pickups, 2% buses, and remaining others (tempo, rickshaw, heavy equipment minibus, and microbus) (DOTM, 2017). At an annual growth rate of 14%, vehicle registration in Nepal has increased dramatically from 0.48 million in 2005 to 3.22 million in 2018. The average share of LDVs is 8% of total vehicle registration, and approximately 62% of the registered LDVs are cars followed by jeeps 16%, pickups 14%, vans 8%, and microbuses 1% respectively. The annual car registration is increasing at the rate of 12% in Nepal, and almost 93% of them are petrol-based vehicles, and the rest are diesel vehicles.

The total GHG emission from the transport sector was 2.74 million metric tons in 2015, which accounted for 26% of the total GHG emission in the country (ICIMOD, 2017). In 2015, road transport emitted 2,513 kt of CO_2 117 kt of CO, 4 kt of SO_2, and 17 kt $PM_{2.5}$ and 6kt BC in the country (ICIMOD, 2017). Moreover, Kathmandu valley alone emitted 9.6kt of $PM_{2.5}$ and 1.6 kt of BC (Ghimire & Shrestha, 2014). Vehicular emission accounted for 38% of total air pollution (JICA, 2017). At the current rate of vehicular registration, the emission from transport in 2050 is projected to be 18.98 million metric tons, that will be 35% of the total emissions (ICIMOD, 2017).

The vehicle segregation of LDVs registered in Nepal in 2005, 2008, 2010, 2012, 2014 and 2016, based on engine capacity shows that the weighted average displacement range of LDVs registered in Nepal is 1,538 cc. The weighted average displacement range for LDVs is 1,415 cc, 1,499 cc, 1,537 cc, 1,493 cc, 1,501 cc, 1,591 cc in 2005, 2008, 2010, 2012, 2014, and 2016 respectively. 43% of LDVs registered in the analysis period has engine capacity between 1,001 to 1500 cc. This increasing trend indicates a liking of consumers for higher engine capacity vehicles over time.

Fuel consumption trend in developed countries shows a decreasing trend compared to that of other developing countries due to the shift in electric mobility as well as fuel-efficient technologies (GEFI, 2013). The world average fuel economy in 2005 was 8.8 Lge/100km and has improved to 7.2 Lge/100km in 2017 at an annual improvement rate of 1.7%. However, the required improvement rate is 2.8% to achieve the GFEI target. GFEI has set the target to improve the fuel efficiency of light-duty vehicles fuel economy by 50% for all the new vehicles by 2030 from 2005 baseline level (GFEI, 2019b). It sets the global average target of 4.4 Lge/100 km by 2030. The fuel economy of emerging economies countries

was 8.6 Lge/100 km in 2005 and enhanced to 7.5 Lge/100 km in 2017, with an improvement rate of 1.2% per annum. Fuel economy of India enhanced to 5.6 Lge/100 km in 2017 due to the large share of small and fuel-efficient cars (IEA, 2019). In the case of Nepal, the fuel economy of Nepal was 6.89 Lge/100km in 2005 and enhanced to 5.89 Lge/100km in 2016 at the improvement rate of 1.9% per annum. At this rate, the fuel economy of Nepal will be 4.45 Lge/100km by 2030. However, to achieve GFEI target, fuel consumption should reduce by 50% from the 2005 baseline that requires the fuel economy of Nepal reduced to 3.48 Lge/100 km by 2030. The CO_2 emission factors of Nepal was 159 g/km in 2005 and has reduced to 137 g/km in 2016.

In order to improve the fuel economy and to reduce the adverse impact of emission on economy and environment, it is crucial for the government to take necessary steps towards the implementation of the policies and to institutionalize the mitigation and adaptation measures in the transport sector of Nepal. This study provides the baseline data of fuel economy, and emission factor of LDVs newly imported in Nepal, and it will help in developing policy measures to achieve better fuel efficiency in Nepal. Since there are substantial numbers of two-wheelers and public and freight vehicles compared to LDVs, it is also crucial to shed light on the fuel economy of those vehicles to achieve significant improvement in fuel consumption in Nepal. These policy implementations must also focus on sustainable development and energy security of the country.

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CHAPTER 1
INTRODUCTION

1.1 Background

Climate change has become a major global challenge. Transport sector alone contributes 23 % of global carbon dioxide emissions from the use of fossil fuels. Furthermore, fuels are one of the primary sources of urban air pollution. Carbon dioxide persists in the atmosphere for over a century with long term warming effects (IPCC, 2014). Transport also contributes to short-lived black carbon generated primarily by diesel vehicles. Transport is currently therefore responsible for nearly a quarter of all emissions, where road transport occupies a major share in the whole transport sector. There is an increase in energy demand in the transport sector where developing countries are expected to contribute in emission by an average growth rate of 2.7% annually from 2006 to 2030 whereas it is just 0.3% for developed countries (GFEI, 2010). Higher demand for mobility because of rapid urbanization, population growth, and economic growth, especially in developing countries, is causing an increase in fuel consumption. It will continue to grow in upcoming years.

In order to meet Paris Agreement, which aims to reduce emissions to limit global temperature rise to well below 2 degrees Celsius, and to pursue efforts to achieve 1.5 degrees at the end of the century, carbon emissions must be reduced from the transport sector. Doubling fuel economy will significantly reduce the expected increases in carbon dioxide emissions from transport. It also helps valuable resources go further in meeting demands in the future, reducing waste and boosting productivity.

The fuel economy of an automobile relates to distance traveled by a vehicle and the amount of fuel consumed. Consumption can be expressed in terms of volume of fuel to travel a distance, or the distance travelled per unit volume of fuel consumed. Fuel economy is the relationship between the distance traveled and fuel consumed. Fuel economy is usually expressed as liters per 100 kilometers (L/100 km).

1.2 Objective

The primary objective of this study is to establish a baseline fuel economy, and emission factors of Light-Duty Vehicles (LDVs) registered in Nepal. Based on the collected data from the Department of Transport Management (DOTM) for new vehicles registered in 2005, 2008 and continued till 2016 at a periodic interval of 2 years, the fuel economy levels and emission factors in CO_2 of LDVs are calculated. The present analysis provides the baseline fuel economy study of LDVs of Nepal. The outputs of this study aim to help in developing clean and efficient vehicle policies for encouraging more efficient vehicles plying on the roads of Nepal through fiscal policy interventions and vehicle labeling schemes in the country.

One of the objectives of the sustainable energy for all (SE4ALL) is doubling the growth rate of improvement of energy efficiency by 2030. Global Fuel Economy Initiative (GFEI) contributes to achieving the objectives of SE4ALL and Sustainable Development Goals (SDGs) by promoting and supporting government actions in order to improve the fuel economy of light-duty vehicles globally. The initiative was launched in 2009 in Geneva by the United Nations Environment Program (UNEP) and its six partners namely: International Energy Agency (IEA), the International Transport Forum (ITF), the "Fédération Internationale des Automobiles" (FIA Foundation), the International Council on Clean Transportation (ICCT) and the UC Davis Institute of Transportation Studies (ITS). It was launched to secure the real improvement in fuel economy and the maximum deployment of existing fuel economy technologies in vehicles across the world through in-country policy support, analysis, and advocacy.

1.3 GFEI Fuel Efficiency Targets

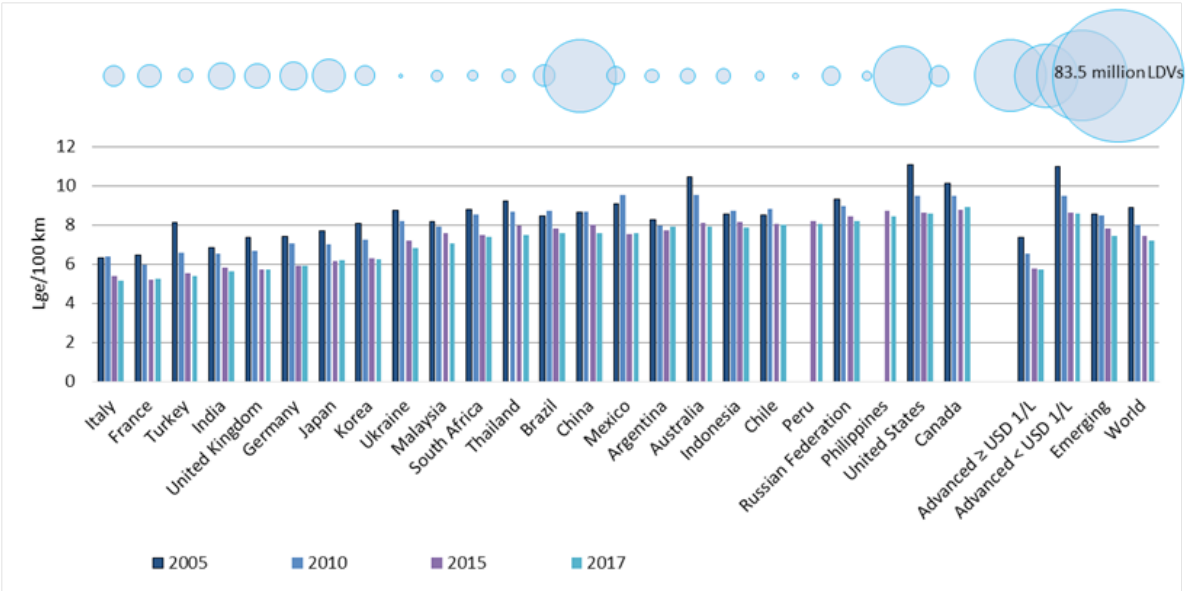
GFEI is working across the world to reduce overall petroleum consumption and decrease greenhouse gas (GHG) emission from LDVs. The initiative has set the global average fuel economy target and imposed the need of LDVs' fuel consumption reduces by 30% in 2020 and 50% by 2030 through the improvement of fuel economy and vehicle technologies (IEA, 2019). The target is to improve the fuel efficiency of all new LDVs by 50% by 2030 and all vehicles by 2050 preferably known as "50 by 50" campaign compared to the 2005 baseline levels. Moreover, from the 2015 baseline, to improve heavy-duty vehicle fuel consumption by 35% by 2035 for all new vehicles. The projected improvement would save 9 barrels of oil per day by 2035, 1-2 billion tonnes CO_2 per year by 2035 and India and China each is expected to contribute saving 25% of the average global fuel economy. The GFEI target is to double the efficiency of all new vehicles from 8.8 Lge/100 km in 2005 to 4.4 Lge/100 km in 2030. The corresponding drop in CO_2 emissions would be from an average of around 180 g/km to 90 g/km. It would save over 1 Gt of CO_2 a year by 2025 and over 2 Gt/yr by 2050 and results in savings in annual oil import bills alone worth over US$ 300 billion in 2025 and US$ 600 billion in 2050 (GFEI, 2018).

The study is structured into five chapters. Chapter 1 provides a brief overview with a contextual background of the study. Chapter 2 focuses on the fuel economy activities in the developed countries, in some of the South -East Asian and the South Asian countries. Chapter 3 sheds some highlights on Nepal's economy, energy sector, and environmental aspects. Chapter 4 details the data collection and analysis of the current fuel economy and emission status of Nepal. At the end, chapter 5 is mainly focused on the conclusion of the study.

CHAPTER 2
FUEL ECONOMY IN THE WORLD

2.1 Fuel Economy in the developed countries

Fuel consumption trend in developed countries is decreasing compared to that of other developing countries (GFEI, 2013). However, there exist different problems associated with the proper improvement of fuel economy in developed countries. Compared to statistics in 2013, improvement in fuel economy in developed countries was sluggish and was improved by 0.7% only in 2017. The needed fuel economy improvement is 3.7%. A gap of 3% in improvement is a big challenge. However, this is not impossible to be attained. A significant share of fuel consumption is in the LDVs transport segment. Due to rapid urbanization and accelerated vehicle demand, emissions of pollutants like carbon dioxide, carbon monoxide, nitric oxide, are in the rise (GFEI, 2013). Figure 1 sheds some highlights on fuel economy in different countries in the world. That is, in 2005, all countries had a high rate of fuel consumption, but as time progresses, the fuel economy has gradually improved.



(IEA, 2019)

Figure 1 Fuel economy in different countries

The gradual improvement in fuel economy is due to the penetration of advanced technology in diesel and petrol vehicles. The continuous shift towards the electric mobility in Europe and emerging markets like China also improved global average fuel economy. Worldwide, the market shares of newly sold electrified vehicles grew by 1 to 3 % (NRC, 2011). Global EV Outlook (IEA, 2019a) in its EV30@30 Scenario explores to reach 30% market share for EVs except for two-wheelers and expects EV sales to attain 43 million in 2030.

The market shares of sport-utility vehicles (SUVs) and pick-up trucks are massive in North America and Australia. Further, the number of mid-sized vehicles and small vehicles (cars) are also rising significantly, reaching the global share of LDVs to 40% (IEA, 2019). Such a shift in the car markets and efficiency improvement due to technical innovation in LDVs contributed to improvement in light-duty fuel economy.

Fuel economy is directly relating to vehicle kerb weight and other factors. Heavy vehicles consume a large amount of fuels and emit toxic gases in large quantities, including carbon dioxide (Serrenho, Norman, & Allwood, 2017). So, Latest innovation in technology like energy efficient tires, improved aerodynamics, fuel-efficient combustion technologies, engine downsizing, powertrain electrification, etc. contributes to enhancing the fuel economy of LDVs. The average weights of new LDV_S remained stable globally during the period 2005-2017 (IEA, 2019), with a slight increase in 2016-2017. During the same period, however, an increasing number (and share) of LDVs was sold in emerging economies. The size of vehicles tends to be smaller and lighter than new vehicles sold in advanced economies (OICA, 2015).

I. United States:

United States has LDVs sales of 16.3 million, the third largest market in the world (IEA, 2019). However, the fuel economy of LDVs of the United States is 8.6 Lge/100 km, which is lower than the global average fuel economy of 7.2 Lge/100km in 2017. The lower fuel efficiency is due to more prominent and powerful vehicles. However, there is an improving trend in fuel economy of LDVs since 2005. The United States started fuel consumption labeling for new cars as early as 1978[1].

II. Canada:

Over the period 1988-2000, the average fuel consumption of new passenger cars hardly changed, varying between 7.9 L/100km and 8.2 Lge/100km. The fuel economy of Canada was 8.9 Lge/100 km in 2017, much higher than the global average fuel economy (IEA, 2019). The high fuel consumption in Canada is due to large sales of pick-up trucks, vans, and SUVs, which have higher fuel consumption than cars. In 2000, light-duty trucks made up 43 % of the Canadian light vehicle market (GFEI, 2013).

III. Australia:

The average fuel consumption of newly registered light-duty vehicles (LDVs) in Australia reduced to 7.9 Lge/100km in 2017 from 10.5 Lge/100km in 2005 (IEA, 2019). Australia also has advanced economies with 2016 gasoline prices below USD 1 per liter at market exchange rates. Australia's light vehicle fleet is less efficient than many other countries. However, the average CO_2 emission from LDVs improved from 230g/km in 2011 to 184g/km in 2015. Whereas, the required reduction as per the taskforce report 2030, is 50% from 2005 baseline levels.

IV. Europe:

LDVs and SUVs dominate passenger vehicles in Europe. The fuel economy of LDVs in Europe ranges between 5.2 and 6.5 Lge/100km in 2017 (IEA, 2019), lower than the average global fuel economy. It is due to a significant reduction in diesel vehicles since 2015 and shift in electric and hybrid vehicles. The market share of newly sold electric vehicles grew to 3% (IHSMarkit, 2016; NRC, 2011). At the same time, the statistical data of 2018 in Europe showed that gasoline vehicles increased their market share to 57 % (Cooper, 2018).

1 https://www.iea.org/topics/transport/gfei/#controls

V. France:

France produced almost 2 million cars in 2015, placing it as the third largest LDVs producer in the European Union since 2014 (OICA, 2016). Average fuel economy of new LDVs steadily progressed, attaining 5.3 Lge/100 km in 2014 to 5.2 Lge/100 km in 2015. Although powertrains (run on gasoline) are becoming efficient, there exist a large number of vehicles, especially LDV_S, which depend on diesel (OICA, 2016). However, diesel has continued to lose market share from 2013, declining to 65% of the total markets. CO_2 emission has continuously declined in France since 2005. In 2015, the average CO_2 emissions of newly registered LDVs were 120 g CO_2/km.

VI. Norway:

Norway is at the forefront in fuel economy trend, with 47% of the total LDVs share coming from Electric Vehicles (EVs). As a result, the average fuel economy in Norway in 2018 is very low at 3.9 Lge/100 km, exceeding the global GFEI target for 2030 by more than 10% (Scheffer, 2019). Figure 2 shows the rapid shift to electric vehicles in Norway.

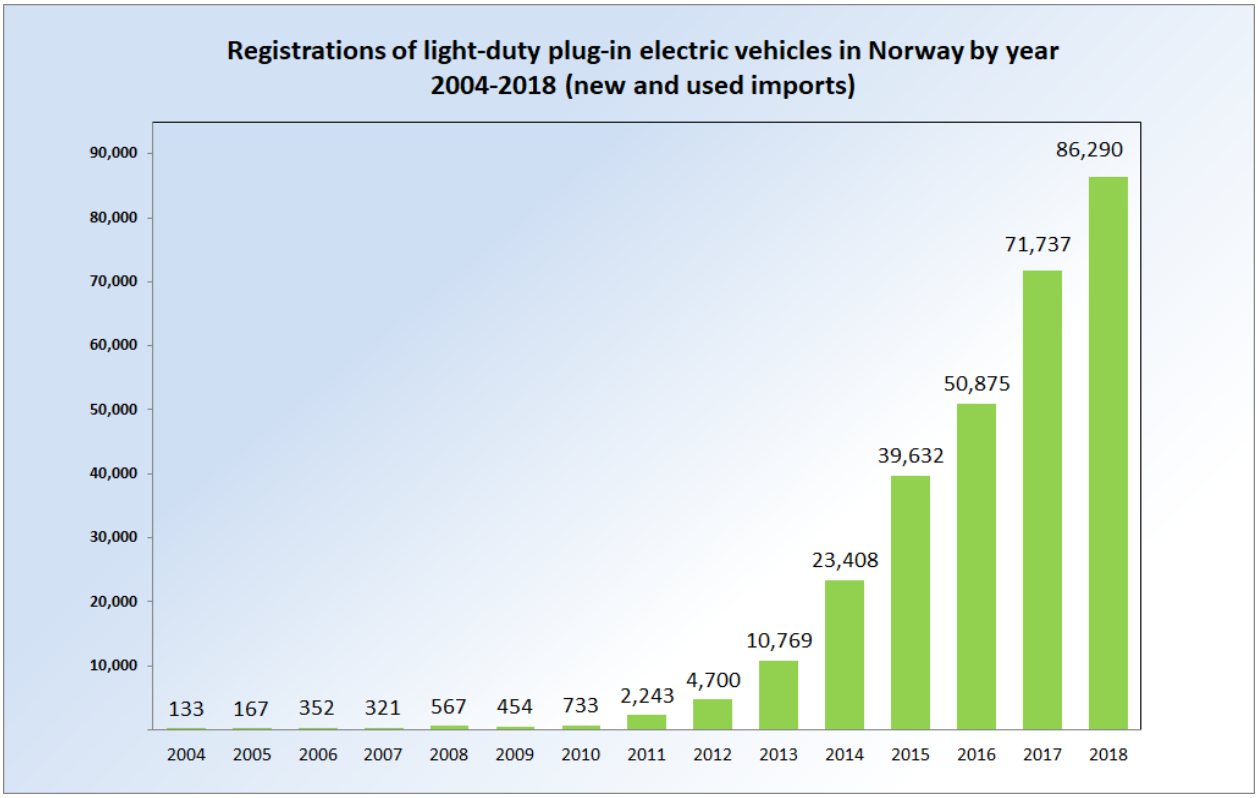


Figure 2 Number of electric vehicles registered for LDV in different year[2]

VII. Japan:

In 2017, there were approximately 78.1 million motor vehicles in Japan. Japanese fuel economy standard was first established in 2015. At that time, the cost of the vehicles was directly proportional to the weight of the vehicles. So, people tend to buy a small type of vehicle with a small engine. As a result, there are a large number of small vehicles running on gasoline and diesel fuel. Fuel economy in Japan has improved from 13.6 km/l in 2004 to 16.8 km/l in 2015[3].

2 (https://upload.wikimedia.org/wikipedia/commons/thumb/9/9c/Registrations_EVs_Norway_2004_2013.png/1024px-Registrations_EVs_Norway_2004_2013.png)

3 https://www.transportpolicy.net/standard/japan-light-duty-fuel-economy/

2.2 Fuel Economy in South East Asia

South East Asia is home to 10 countries - Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. There is significant growth of LDVs in South East Asia and is projected to continue in the future. However, the fuel efficiency of LDVs in the Association of Southeast Asian Nations (ASEAN) countries is poor compared to other countries in the world. Regarding the fuel economy, Table 1 gives apparent, comparable information to that of the ASEAN countries.

Table 1: Fuel economy of ASEAN countries and the world (GFEI, 2013)

Name	Average Fuel Economy (Lge/100km)
World	7
Thailand	7.2
Indonesia	7.2
Malaysia	7.2
Philippines	7.2
Singapore	7.2

As a whole, the sales-weighted average new LDV fuel consumption for ASEAN is 7.2 Lge/100km, higher than the world average of 7.0Lge/100km (ASEAN, 2019) and Economic Cooperation and Development (OECD) average fuel economy of 6.8 Lge/100 km in 2017 (GFEI, 2017).

LDVs production in the ASEAN countries, including Indonesia, Malaysia, the Philippines, Thailand, and Vietnam, grew from 4.18 million in 2018 to 4.29 million units in 2019 (IHSMarkit, 2018). Similarly, according to the IHS Markit, Thailand, Indonesia, and Malaysia will account for about 93%, or 3.99 million units, of total light-duty vehicle production in the region in 2019. The rest are from the Philippines and Vietnam.

ASEAN vehicle sales have grown by more than 50% since 2005 (ASEAN, 2019). Sales of passenger cars are estimated to be well above 3 million cars per year by 2025, from about 1.5 million in 2015 (OICA, 2016). Overall, ASEAN light-duty vehicle production for the full year 2019 is expected to grow by 2.5%, driven by improved demand for new vehicles in Indonesia, Malaysia, the Philippines, and Vietnam. However, vehicle production in Thailand will slow down marginally as a result of inactive exports, which will offset an improvement in domestic demand.

2.3 Fuel Economy in South Asia

i. Sri Lanka:

Sri Lanka has reached a 6.8 million motor vehicle population in 2016, which is an 8 % increase from 6.3 million registered vehicles in 2015[4]. About 70% of petroleum products were consumed in the transport sector, where the primary fuel is diesel (SLSEA, 2013). The passenger and freight modal shares in Sri Lanka are shown in Figure 3.

4 Sri-Lanka spent 32-pct less on vehicle imports in 2016:CCC, https://www.lankabusinessonline.com/sri-lanka-spent-32-pct-less-on-vehicle-imports-in-2016-ccc/

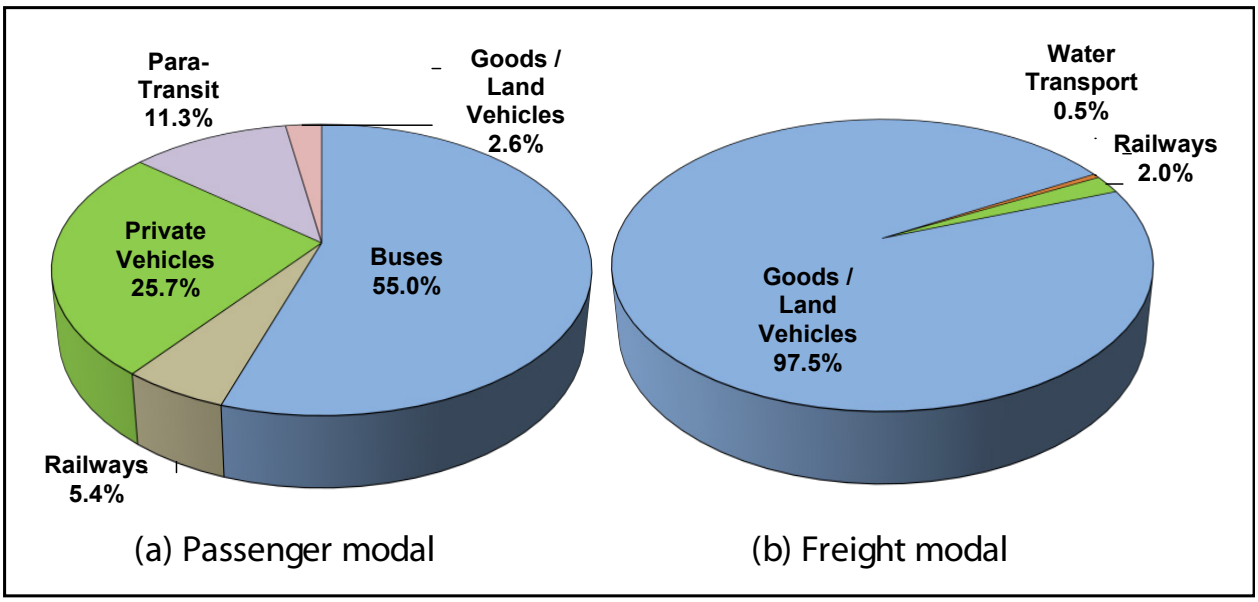


Figure 3 Passenger and freight model shares

There are about 420,000 cars in the active group, where over 75% are petrol based, and the remaining shared equally with diesel and hybrid vehicles. The number of hybrid vehicles has been in the rapid increase since 2013 and will have a significant impact on the average fuel economy of cars in the country. The annual average fuel economy and CO_2 emissions of ICE cars (first registration) in Sri Lanka is 6.6 Lge/100 km and 160 g/km of CO_2 respectively in 2015. The average fuel economy is less than the global average of 7.1 l/100 km, primarily due to the use of small capacity vehicles. Therefore, it is vital for the government to develop appropriate policies to manage the fuel economy in cars to mitigate the adverse effects on the economy and the environment (Sugathapala, 2015).

ii. Bangladesh:

The analysis of vehicle fuel economy in the country showed that there are 3.8 million vehicles in Bangladesh, the majority of which are motorcycles (OICA, 2015). 90% of passenger cars in Bangladesh are Toyota, and the data shows that the average fuel economy in Bangladesh has improved from 8.98 Lge/100 km in 2005 to 6.9 Lge/100 km in 2017. From 2005 to 2017, there was a 23.16 % improvement in fuel economy and a 24.46 % reduction in CO_2 emissions. In recent years, the imports of jeeps with improved fuel economy has increased in the LDV category, and it is one of the main reasons for better fuel economy level because of the advanced technology prevalent in the imported vehicles (GFEI, 2019a).

As Bangladesh does not have a vehicle manufacturing industry, most of the vehicles are imported. The country has an existing restriction that prohibits vehicles older than five years of age being imported. Taxes are currently based on engine size, with reductions for hybrid vehicles. Stakeholders discussed the findings and explored possible policy instruments to improve fuel economy further in the country, including supporting electric vehicles.

The country has a minimal energy reserve of oil, coal, fossil fuel, but it has a sizable volume of natural gas. These are the primary energy sources of Bangladesh (Pranti et al. 2013). Apart from this, there is a continuous and rapidly widening gap between electricity supply and demand. Therefore, it is a major challenge for the energy sector in Bangladesh.

iii. India:

Under the notification issued by Ministry of Road Transport, Highways (MoRTH) in 2004, it was mandatory for the manufacturers in India to get the vehicles produced on or after 01 April 2005 tested for fuel consumptions. However, it was not obligatory to maintain such information collected during type approval tests of vehicles. Bureau of Energy Efficiency (BEE) under Ministry of Power developed and notified fuel efficiency norms for passenger cars on 30 January 2014. The standards were in terms of sales-weighted corporate average CO_2 emissions.

The Government of India sets the target for the car industry to improve km/liter by at least 20% from the current average of 16.6 km/liter spread over 2 phases. The 1st phase was subject to launch in 2015 and the 2nd phase in 2020. In the 1st phase, the fuel economy needs to improve to 18.1 km/liter, and CO_2 emissions reduced to 129g/km, and in the 2nd phase, the fuel economy should enhance to 20.79 km/liter and CO_2 emissions reduced to 113 g/km (Thukral & Alam, 2014). However, due to objections from the auto industry, Ministry of Heavy Industry, and MoRTH, the nodal Ministry of Power delayed the implementation of standards to 2017 and 2022, respectively (MoRTH, 2018).

CHAPTER 3
NEPAL'S ECONOMY, ENERGY SECTOR, AND ENVIRONMENT

3.1 Nepal's geographical location, its population, and it's economy

Nepal has an *area* of 147,181 square kilometers. *India covers Nepal* from three sides and China's Tibet Autonomous Region to the north. Based on the geographical structure, Nepal can be divided mainly into three ecological regions: The Himalayan region, the Middle Hill region and the Terai (Plain Land) region. The highest elevation of Nepal is the summit of Mount Everest at 8 848 m, and the lowest elevation is 60 m from the sea level at the Terai.

In the 2011 census, Nepal's population was approximately 26 million people with a population growth rate of 1.35% and a median age of 21.6 years (CBS, 2011). It has long been recognized that the size and age structure of populations can have profound implications for societal processes along multiple dimensions, and ultimately for the overall economic and social development of a country. Observed regularities across societies in trends of fertility and mortality decline have been articulated in theories of demographic transition.

Agriculture remains Nepal's principal economic activity, employing about 65% of the population and providing 31.7% of GDP. The lowland Terai region produces an agricultural surplus, part of which supplies the food-deficient hill areas. The Gross Domestic Product (GDP) in Nepal expanded 7.10 % in 2018 from the previous year[5]. Nepal is one of the least developed countries in the world, with about one-quarter of its population still living below the poverty line. Nepal is heavily dependent on remittances, which amount to as much as 30% of GDP. The Gross Domestic Product (GDP) in Nepal was worth 24.47 billion US dollars in 2017. The GDP value of Nepal represents 0.04 % of the world economy.

As Nepal is a landlocked agricultural country, it's GDP dramatically depends on its remittances and local produce. Floods and natural calamities often destroy agricultural produces. Agriculture employs 75% of the workforce. Higher GDP growth not only provides better opportunities to improve access over basic requirements for the livelihood but also provides more saving and revenue to the government.

Nevertheless, the economic transformation from rural agricultural to modern industrial or service sectors is the fundamental requirement to achieve high and sustainable growth.

Nepal experiences monsoon-based growth as it witnesses an improved agricultural GDP at the time of favorable rainfall (Acharya & Bhatta, 2013). The economic structural change is often considered as a permanent shift in the fundamental structure of an economy. An agrarian economy shifts to either

5 https://tradingeconomics.com/nepal/gdp-growth-annual

industry or service based. In many countries, it primarily involves a decline in the share of agriculture to the GDP and a rise in the share of services (Maddison, 1991). Modern economic development is impossible without structural changes (Kuznets, 1971), which are mostly associated with continuous growth and transformation (Pasinetti, 1983) in the globalized and dynamic economic system. The contribution of the services sector is required to increase the participation of females in the labor force as working-wives are likely to spend more out of their earnings to the services compared to males (Fuchs, 1980). This hypothesis argues that there will be a shift to service from manufacturing due to low productivity, less progressiveness, higher costs, and higher relative prices of service compared to manufacturing.

As shown in Figure 4, in 2015 contribution GDP drastically decreased due to natural calamities - devastating Earthquakes in April and May 2015 and undeclared trade blockade Nepal has to face subsequently in later part of 2015/2016 fiscal year. However, in 2018, the contribution of real GDP (7.1 %) of Nepal was proceeding in an excellent growth path.

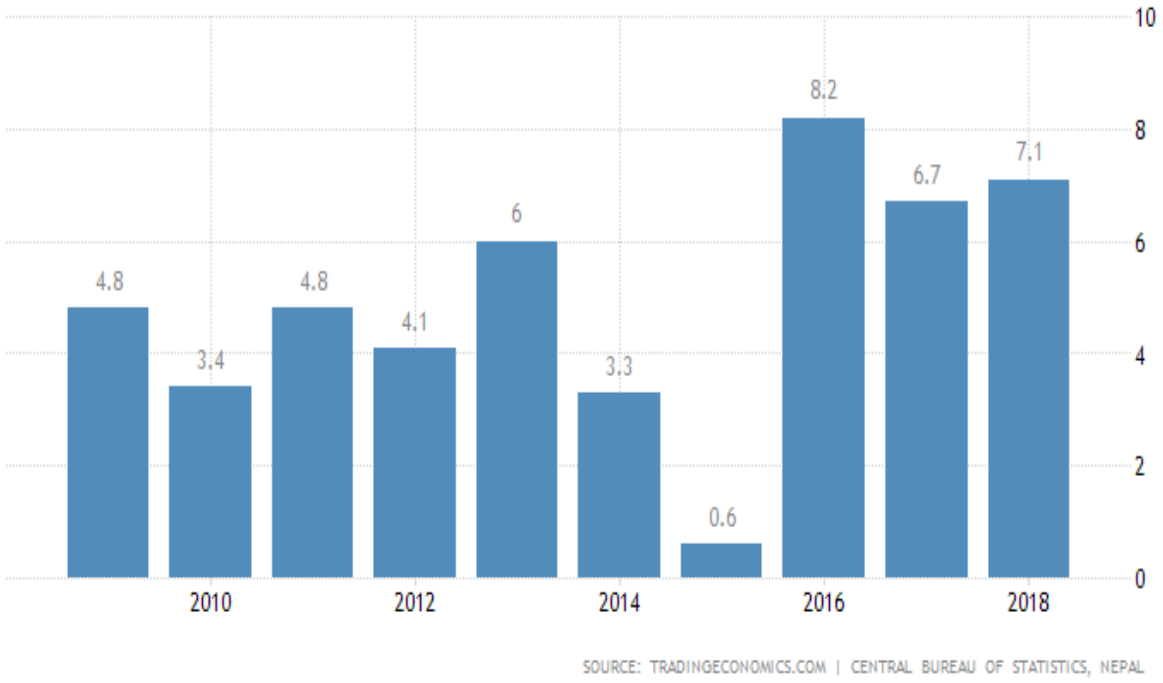


Figure 4 Nepal's GDP annual growth (in %)

3.2 Energy consumption status in Nepal

Biomass is the primary source of energy, particularly in rural Nepal. Fuelwood from forest resources, charcoal mainly from woody biomass, residues from different crops and animal dung are the primary biomass-based energy resources. Coal, petroleum products, and electricity are the commercial sources of energy that are utilized in Nepal. The overall energy consumption of Nepal is mostly dominated by the use of non-commercial forms of energy, such as fuelwood, agricultural residue, and animal waste (Figure 5). However, the country spends a considerable amount of its foreign exchange reserves for the import of petroleum products. According to economic survey 2015/16 (MoF, 2016), total energy consumption increased from 8.9 million tons of oil equivalent (Mtoe) in 2006/07 to 11.8 Mtoe in 2015/2016 at an annual growth rate of 3%. Traditional energy sources met about 78 % of total energy consumption,

commercial energy about 20%, and the rest by renewable energy sources (MoF, 2017). Approximately 80% of total energy is consumed in the residential sector followed by industrial (8%), transport (7%), commercial (3%) and agriculture (1%) in 2012 in Nepal (WECS, 2013). The share of commercial energy has increased from about 12 % in 2006/07 to about 20 % in 2015/16 at an annual growth rate of 9%.

Similarly, there is a growing trend in renewable energy consumption from 0.6% to 2.5% during the same period. Within the commercial sources, approximately 63% of fuel comes from petroleum products, followed by electricity 17% and remaining from coal in 2014/15. However, commercial fuel consumption petroleum products are known to increase by about 8% annually and electricity consumption by 12%. Traditional fuel consumption is increasing at an annual rate of 2%. It depicts the shift in fuel consumption pattern from traditional to commercial and renewable energy sources over time.

Nepal has abundance in hydropower resources, and switching to electricity in energy access is a better option from the point of economic efficiency, sustainability, and energy security. Nepal Electricity Authority (NEA) is responsible for developing, operating, and distributing hydropower in Nepal. Currently, there is a demand for 1,444 MW of electricity in the country, and the 65% of it is supplied by from domestic generation, and the remaining 35% is imported to fulfill the demand (NEA, 2018). With the coming into operations of Nepal Electricity Regulatory Commission (NERC) in 2019, many reforms in the electricity sub-sector are expected for future sustainable development, energy efficiency and energy security in each economic sector in the country.

The primary source of energy in the residential sector is fuelwood, agriculture residue, animal waste, biogas, and other biomass. Hydro and solar energy substitute traditional energy in an urban residential area, mainly for cooking and lighting. The industrial sector consumes coal, fuelwood, diesel, and electricity as a leading source of energy with a 63% share of non-renewable energy consumption. Transport sector consumes 99% of gasoline and 87% of diesel fuel imported in the country (Malla, 2014). Diesel, petrol, and ATF constitute a significant fuel source in the transport sector with minimal contribution from electricity in this sector.

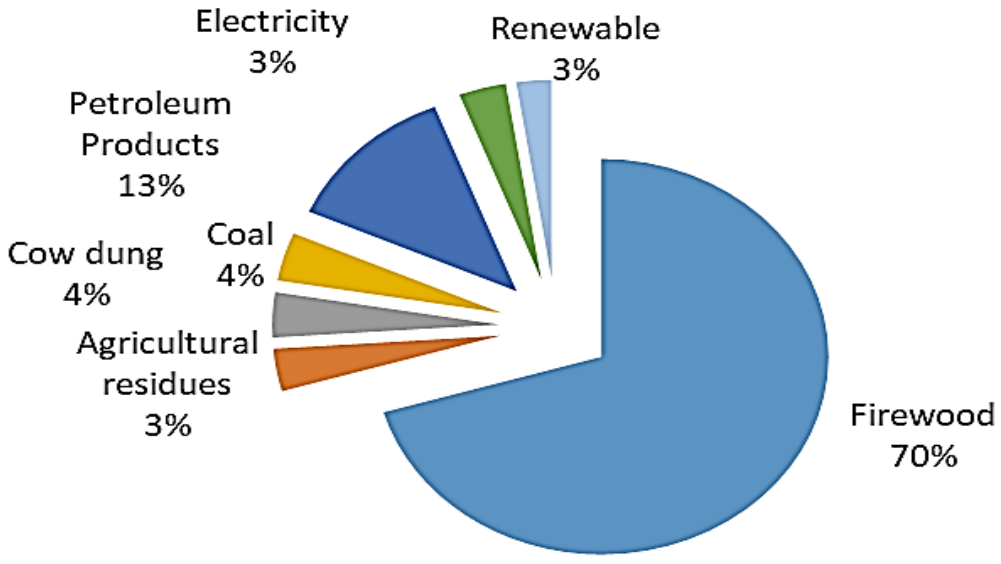


Figure 5 Energy consumption by fuel type in 2015/2016 in Nepal

3.3 Transport energy demand in Nepal

According to the National Survey of Energy Consumption and Supply Situation in Nepal, energy consumption in the transport sector in 2015/16 was 836 ktoe, and an annual growth rate is 7% (MOF, 2016). Petroleum products such as petrol, diesel, aviation fuel, and LPG are the sources of fuels in this sector. Nepal imports 100% petroleum products and more than two third of them consumed in transport sector alone (Malla, 2014), and remaining is consumed in other sectors (household, industry, commerce and services and agriculture). According to Nepal Oil Corporation (NOC), Nepal imported 2.3 million kilolitres of petroleum products in 2017/18[6]. Energy consumption in the transport sector is influenced by energy intensity, vehicle efficiency and modes of transport (Gupta & Singh, 2016; Qipeng, Jiao, & Cheng, 2013; Zhang, Li, Zhou, & Mu, 2011).

The trends for primary supply of petroleum products in Nepal is as shown in Figure 6, along with its different product consumptions. The figure highlights the sharp increase in the consumption of petroleum products from the year 2008/09 onwards. The total petrol and diesel consumption was 484,781 Kl and 1.59 million Kl respectively in 2018. The consumption of petrol and diesel increased in 2018 by 21% and 23% respectively than in the previous year. Moreover, the consumption rate is increasing at the rate of 17% and 18% for petrol and diesel respectively per annum over the last decade (NOC, 2018). The drop in 2015/16 is due to blockade in Nepal that also affected fuel imports. However, the import soars exceptionally since 2016. The high consumption of diesel is due to the increasing use of diesel for the production of electricity from captive gensets for over the years. However, the significant increase in diesel consumption in last two years is attributed to import of a large number of vehicles, the high fuel consumption in freight vehicles, construction equipment and machinery, high diesel consumption in industries, and infrastructural development.

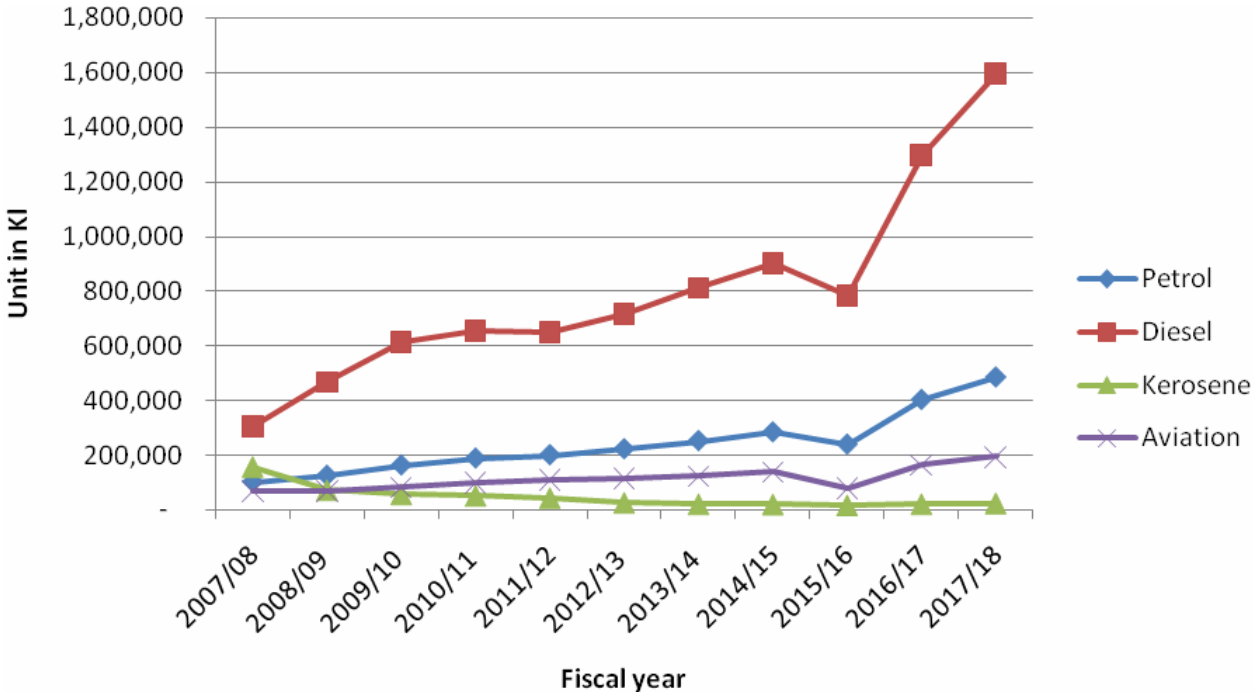


Figure 6: Primary supply of petroleum products

6 http://noc.org.np/import

3.4 GHG emissions from the transport sector

The deteriorating air quality of Nepal is mainly due to the unmanaged transport sector. The total GHG emission from the transport sector was 2.74 million metric tons in 2015, which accounted for 26% of the total energy-related GHG emissions in the country. Since petroleum fuels are the only fuel sources in the transport sector, emission from the transport sector is higher compared to its energy consumption share, which is only 7% of total energy consumed in the country. At the current rate of vehicular registration, the GHG emission from transport in 2050 is projected to be 18.98 million metric tons, that will be 35% of the total emissions. Gasoline is the primary fuel in road passenger-private transport and diesel is the primary fuel in road passenger-public and freight transport. Emission from gasoline vehicles accounted for 19%, whereas diesel vehicle accounted for 68% in the transport sector. It is due to high emission from freight vehicles, which accounted for almost 40% of the total emission. GHGs, CO_2, CO, NOx, HC, $PM_{2.5}$ are major air pollutants from the transport sector. In 2015, road transport emitted 2513 kt of CO_2 117 kt of CO, 4 kt of SO_2, and 17 kt $PM_{2.5}$ and 6kt BC in the country (ICIMOD, 2017). Moreover, Kathmandu valley alone emitted 9.6kt of $PM_{2.5}$ and 1.6kt of BC (Ghimire & Shrestha, 2014). Vehicular emission accounts for 38% of total air pollution (JICA, 2017).

Due to concentrated economic activities in Kathmandu valley, the capital city of Nepal, energy consumption and emission is considerably higher in the valley and plays a significant role in overall energy consumption and emission levels of Nepal. A Study on emission in Kathmandu valley shows that small vehicles (LDVs and motorcycles) emit 58% of total CO_2, 84% of total CO, 92% of total HC, 32% of total NOx and 65% of total PM_{10} emissions (Bajracharya & Bhattarai, 2016). They emphasized on improving fuel efficiency and penetration of new technology in the transport sector to reduce emission. The average national $PM_{2.5}$ concentration from the study was found to be 47 µg/m3 in the year 2015, which is the way above the WHO standard of 10 µg/m^3 (WHO, 2006). Most of the emission is due to transboundary emission and natural emission, and 30% emission is due to nationally anthropogenic emission and is increasing at an annual rate of 2.3% (ICIMOD, 2017). It has lead Nepal into a higher risk of premature mortality rate.

Nepal Transport Policy, 2001 was formulated to develop sustainable, reliable, safer transport in the country with an emphasis on renewable energy sources and pollution-free transport system. In 2010, Nepal Oil Corporation, a state-owned trading enterprise that imports, stores and distributes various petroleum products started supplying EURO III standard fuel to reduce emission and improve fuel economy. It banned the import of vehicles emitting carbon dioxide beyond the given limit. In a bid to reduce emission from vehicles, the government also proposed ethanol mix fuel substitution, but so far it is not implemented. Environment-friendly Vehicle and Transport Policy, 2014, was formulated to promote environment-friendly vehicles in Nepal. It sets the target to achieve more than 20% of vehicle fleets to be environment-friendly vehicles by 2020, provided tax exemption to purchase electric vehicles. As a result, the use of the electric vehicle is gradually increasing in Nepal. Air quality management action plan for Kathmandu valley, 2017 was formulated to promote zero-emission vehicles from private as well as public transport. To further promote electric mobility in the country, the national action plan for electric mobility, 2018 was formulated. However, due to weak institutional capacity and absence of effective implementation and monitoring unit, the air quality of the country is degrading despite such policies.

3.5 Vehicle registration status in Nepal

Road Transport covers most of the transport in Nepal and passenger vehicles dominate the road transport. Vehicle registration status in Nepal in the fiscal year 2017/2018 shows that 78% of the total registered vehicles are motorcycles, 6% cars/jeeps/vans, 4% tractors and trucks, 3% pickups, 2% buses, and remaining others (tempo, rickshaw, heavy equipment minibus, and microbus) (Figure 7) (DOTM, 2017). At an annual growth rate of 14%, yearly vehicle registration in Nepal has increased dramatically from 0.48 million in 2005 to 3.22 million in 2018. The passenger vehicle registration in 2018 showed 3% public vehicles (bus, minibus, microbus, and tempo), 14% private vehicles (car, jeep, van) and 78% motorcycles as shown in Figure 7.

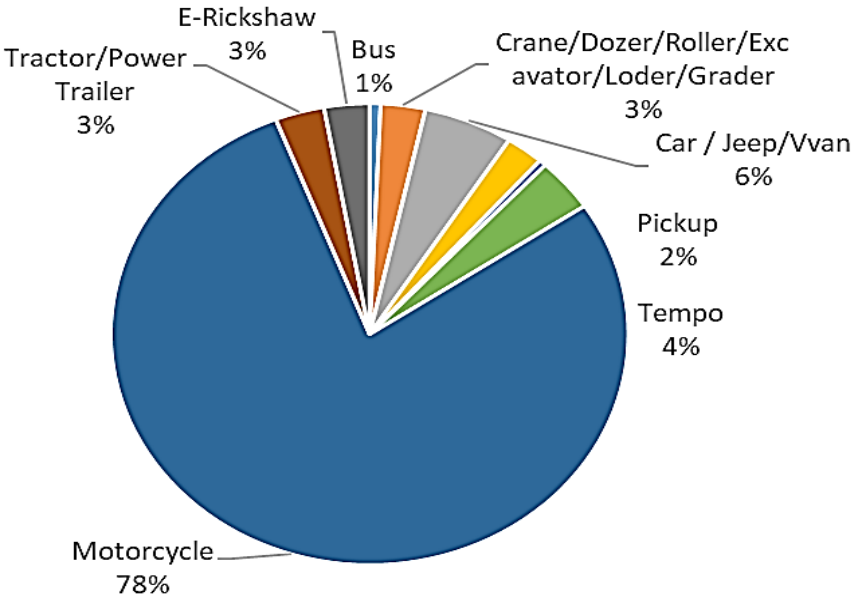


Figure 7 Vehicle registration status in Nepal in 2018

3.6 Registration status of Light-Duty Vehicles (LDV) in Nepal

LDVs mainly comprise of cars, jeeps, vans, pickups, and microbuses having gross vehicle weight less than 3,500 kg. The registration status of LDV (Figure 8) shows a tremendous increase in vehicles with an annual growth rate of 16% during the last decade. The average share of LDVs is 8% of total vehicle registration, and approximately 62% of the registered LDVs are cars followed by jeep 16%, pickup 14%, van 8%, and microbus 1% respectively. The annual car registration is increasing at the rate of 12% in Nepal, and almost 93% of them are petrol vehicles and the rest diesel vehicles. The registration status shows that the number of jeeps registration is increasing at an unprecedented rate of 31% from 2005 to 2016, followed by pick-up 26%, microbus 14%, and van 12%.

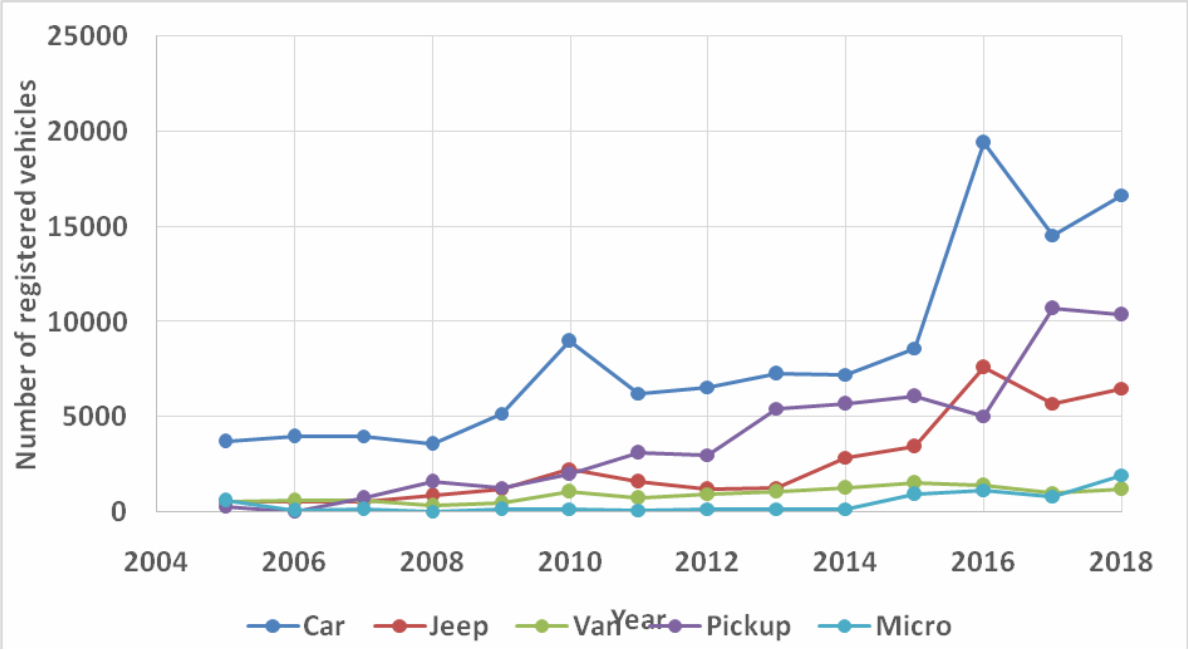


Figure 8: LDV registration status in Nepal in 2018

3.7 Vehicle Taxation

The transport sector in Nepal depends on vehicle imports. The cost of vehicles in the local market is thus dependent on the import taxes. The tax amount depends on transport modes and their engine capacity (cc). Every year all the vehicle owners must pay their vehicle tax to the Department of Transport Management. The vehicle tax system for LDVs for 2018 is as shown in Table 2. The vehicle tax is entirely based on engine capacity, and owners need to pay it annually. The tax rate varies from province to province for the same capacity of vehicles. The tax amount is lower for the LDVs operating on the fare for public service purpose[7].

Table 2 Annual Vehicle Tax System for car, jeep, van, and micro

S.N.	Engine Capacity (cc)	Amount in Rs.
1	upto-1000	19,000-21,000
2	1001-1500	21,000-26,000
3	1501-2000	23,000-25,000
4	2001-2500	32,000-38,000
5	2501-2900	37,000-45,000
6	2901 and above	53,000-65,000

In addition to vehicle tax, the government imposed import duty on import of vehicles. There is 80% import duty on cars, jeeps, and vans and 30% on microbuses and pickups[8] and for electric vehicles, import duty on cars, jeeps, and vans is 10% and on microbuses and pickups is 1%. For the promotion of electric vehicles in Nepal, such reduction on import duty on an electric vehicle is vital. The gradual shift is moving towards the electric vehicles in Nepal, with the

7 https://www.dotm.gov.np/en/tax-rate-circular-direction/
8 https://www.customs.gov.np/en/normal.html

arrival of the competitive electric vehicles in the market. The detail tax structure imposed on all imported vehicles is as shown in Table 3.

The government also imposed infrastructure tax on Rs. 5/ltr on import of petrol, diesel, and aviation fuel, road repair and improvement fees of Rs. 4/ltr in petrol and Rd. 2/ltr in diesel at the point of import. Also, there is a pollution control tax of Rs. 0.5/lts charged in petrol and diesel fuel9.

Table 3 Tax structure imposed on an imported vehicle in Nepal

Fuel category	CATEGORY	IMPORT DUTY	EXCISE DUTY	VAT	ROAD TAX
Petrol version	Up to 1,000 cc	80%	60%	13%	8%
	1001cc to 1,500 cc	80%	65%	13%	8%
	1501cc to 2,000 cc	80%	70%	13%	8%
	2001cc to 2,500 cc	80%	80%	13%	10%
	2501cc to 3,000 cc	80%	90%	13%	10%
	Above 3,001 cc	80%	100%	13%	10%
Diesel version	Up to 1,500 cc	80%	60%	13%	8%
	1501cc to 2,000 cc	80%	70%	13%	8%
	2001cc to 2,500 cc	80%	85%	13%	10%
	Above 2,501 cc	80%	100%	13%	10%
Electric Version	**Car, Jeep, Van**	**10%**	**0%**	**13%**	**4%**

3.8 Nepal's environmental issues, NDC and air pollution status and WHO report on mortality rates due to air pollution

Rapid urbanization and increasing economic activities in cities have dramatically increased vehicle demands in urban areas of Nepal. The current scenario of motorization adversely affects traffic congestion, air and noise pollution, and traffic accidents and injuries Table 4. The unsustainable trends in the transport sector observed worsen social equity, lower energy security, increase greenhouse gas (GHG) emissions, and destroy the environmental systems.

Table 4 Issues created from the different transport sector

Components	Trends and issues
Intercity Transport	• Low quality of fuel used in vehicles that produced more environmental problems. • Haphazard settlement along national highway routes • Increased landslide related problems due to roads construction in hilly areas
Urban Transport	• Rapid motorization by increasing incomes so, lifestyle improving day by day. • In the 2008-13, petrol consumption increased by 2.2 times. • A lot of urban problems created day by day due to the rapid population in Kathmandu city
Rural Transport	• Low cost, labor-intensive and non-engineered rural roads • Poor service and maintenance problems
GHG emissions and local pollution	• Low quality of fuels used in vehicles that produce large amounts of carbon dioxide in the air. • Burning of fossil fuels in large quantity

(MoPIT, 2015)

9 http://www.nbsm.com.np/assets/kcfinder/upload/files/Publication/Nepal%20Tax%20Guide%202016.pdf

i. Nationally Determined Contributions (NDCs)

The Paris Agreement aims to strengthen the global response to the threat of climate change , in the context of sustainable development and effort to eradicated poverty. It also aims to hold the increase in the global average temperature rise to well below 2°C above pre-industrial levels and persue the efforts to limit the temperature increase to 1.5°C. It entered into force on 4 November 2016, 30 days after 55 countries, representing 55% of global emissions, deposited their instruments of ratification, acceptance, or accession. NDCs are at heart of Paris agreements. It embodies efforts by each country to reduce the National emissions and adapt to the impacts of climate change. Nepal had signed the agreement on 22 April 2016 and deposited the instrument of ratification on 5th October 2016, the same day that the Paris Agreement fulfilled it's criteria to entry into force. Nepal, one among the Least Developed Countries (LDCs) with a negligible share of 0.027% of global greenhouse gas emission (MoSTE, 2014), is suffering from the increasing impacts of climate change. Nepal prepared National Adaptation Programme of Action (NAPA) in 2010 to address the most urgent and immediate adaptation needs of the country. Nepal formulated Climate Change Policy in 2011, which envisions for 80% of the total project fund to be spent at the community level. Similarly, in 2011, Nepal prepared National Framework for Local Adaptation Plans for Action (LAPA) to implement NAPA and localize the adaptation efforts. The Paris Agreement analyzes the implication for the energy sector, assesses the impact of nationally determined contributions (NDCs) on the energy sectors of developing member countries (DMCs) of the Asian Development Bank (ADB), and explains the challenges and opportunities faced by DMCs in the implementation of their NDCs.

According to the Second National Communication (2015), GHG emissions from the energy sector is the increasing trend, and this is almost negligible in the industry sector. Nepal believes that the cumulative impacts of Nationally Determined Contributions (NDCs) submitted to the UNFCCC would significantly contribute to limiting temperature rise to safe levels and making this planet livable. Nepal has prepared and submitted its first NDC in 5th October 2018 in the process of implementing the decisions of the Conference of the Parties (COPs) through a broad-based stakeholder consultation processes.

ii. Air pollution status in Nepal and WHO report on mortality rates due to air pollution

Air pollution is also called a silent killer that creates a variety of acute and chronic diseases. Globally, unhealthy environment causes a total of 12.6 million deaths (WHO, 2016). Nepal is among the bottom five countries on the Environmental Performance Index 2018, plummeting 27 points to 149 in 2016, according to a biennial report by Yale and Columbia Universities along with the World Economic Forum. Nepal's air quality was recently reported as the worst in the South Asia region. As of June 21, 2019, WHO says most of air pollution-related deaths are from non-communicable diseases, and in terms of global disease burden, air pollution is the cause of over one-third deaths from stroke, lung cancer, and chronic respiratory diseases. According to a WHO report, nearly 740 people died from an acute lower respiratory infection, 1,770 from chronic obstructive pulmonary disorder, 932 from lung cancer, 3,328 from ischemic heart disease and 3,183 from a stroke in Nepal in 2016. In Nepal, 9,944 deaths from Ischemic Heart Disease, 33.4% by stroke, 32% chronic obstructive pulmonary disease, 17.8% lung cancer, and 7.4% acute lower respiratory tract infection (Saud & Paudel, 2018). Around 7 million people die every year in the world primarily due to fine particles present in the air that lead to diseases such as stroke, heart disease, lung cancer, chronic obstructive pulmonary disease and respiratory infection, including pneumonia (WHO, 2018).

iii. Supporting transport policy documents

Over time, several plans, policies, and programs were formulated to improve the transport sector of Nepal. The key features of major transport policy, plans, and programs are tabulated in **Table 5** below.

Table 5 Plans, policies and programs related to the transport sector in Nepal

Key Plans, Policies, Programs	Features
Motor Vehicle and Transport Management Act, 1993	• Legal provision for vehicles to pass the roadworthiness test for registration and operation - the test includes pollution test and age of vehicles. • Provision of penalties for violating the regulations and on the spot check and fine for vehicles that are not roadworthy • Clear roles and responsibilities, and institutional setup of Department and Transport Management Committee • Appointment of transport inspector.
National Transport Policy, 2002	• Support policies and programs that address emission reductions from the transport sector. • Provisions to restrict polluting vehicles restrict the operation of vehicles in urban core areas and development of cycle tracks. • Provision to exempt custom duty and tax on non-polluting vehicles • Formation of Road Transport Authority for road transport management • Formation of National Transport Board to coordinate authorities relating to transport, including civil aviation
In-use Vehicle Emission Standard, 2002	• Euro 3 equivalent of the emission standard for new vehicles, and also separate emission standards for in-use vehicles.
Environment-friendly Vehicle and Transport Policy, 2014	• Promotion, development, and expansion of environment-friendly and electric vehicles and transportation. • Provision to allow conversion of technically feasible motor vehicles into electric vehicles. • Target to achieve more than 20% of vehicle fleets to be environmewnt-friendly vehicles by 2020. • Development of cycle tracks and charging stations for electric vehicles. • Preparation of LCEDS inclusive of environment-friendly vehicles and transport modes • Tax exemption and the provision of loans for private consumers to purchase environment-friendly vehicles • Establishment of separate division or section under the MOPIT, or its departments to oversee the registration, regulation, and monitoring of environment-friendly vehicles
Low Carbon Economic Development Strategy, 2015	• Development of strategies for low carbon green economic development • Promotion of clean energy, energy efficient technologies • Provision of modern energy access to all by 2030 • Development of hydropower and solar power for electrification and to shift to cleaner energy in all strategic sectors including residential, commercial, transportation, industry and agriculture and livestock
National Sustainable Transport Strategy, 2015-2040	• Development of efficient, reliable, affordable, inclusive and climate and disaster resilient transport system in Nepal • Integration of environmentally sustainable transport in overall policy • Efficiency improvement in investment and service operation • Improve accessibility • Promote Electric vehicles • Improve transport safety and security

14th three-year plan 2016/17 -2018/19	• Establishment of pollution monitoring systems in major urban areas • Revision of the standards for lifespan and emission level for vehicles • Sustainable management of waste • Establishment of waste processing centers in each municipality • Promote and develop clean, renewable energy • Priority for hydropower development including storage power plants, rural electrification, and smart grid and smart metering. • Generation of 2,300 MW hydropower, 11 MW mini, and micro-hydro, 16 MW solar, 1 MW wind • Study and development of railway including metro • Establishment of 7 Vehicle fitness testing center and old vehicle management
Air Quality Management Action Plan For Kathmandu Valley, 2017	• Promote zero emission and cleaner vehicles through minimum duties • Economic incentives for hybrid vehicles • Promote electric public transport • Develop bus terminals with charging station
National Action Plan for Electric Mobility, 2018	• Establish electric mobility • Launch national program for electric mobility

Despite all these policies and activities, the implementation aspects are very poor, and the transport sector is not moving forward in a positive direction toward a sustainable, fuel efficient, and low-emission pathway.

CHAPTER 4
DATA COLLECTION AND ANALYSIS

Based on the collected data from the Department of Transport Management (DOTM) for new vehicles registered in 2005, 2008 and continued till 2016 at a periodic difference of 2 years. A sample of vehicle information data sheet is provided in the Appendix 1.The fuel economy of LDVs are calculated, and the brief analysis is as follows.

The methodological guide on developing a national vehicle fuel economy database and baseline of GFEI is followed for the present analysis (UNEP, 2011). The primary aim of this study is to develop a baseline fuel economy of LDVs and assist the government in developing strategies for improving vehicle fuel economy and support the global tracking of fuel economy target set by GFEI.

Data collection is a major part of this study that includes all the new vehicles imported and registered in the respective periods in Nepal. All the registered vehicles are assumed as a new one. Only new vehicles are allowed to be imported in the country. Since fuel economy varies based on different vehicle categories, the vital information of the vehicles is collected from primary data survey, which includes:

- Vehicle make and model,
- Model production year,
- Year of first registration,
- Fuel type,
- Engine size,
- Rated fuel economy per model
- CO_2 emission factors

Fuel economy and CO_2 emission factor depend on the several technical factors and driving conditions and may deviate from the manufacturer's label. It thus requires the performance testing of the vehicles for the more accurate database. However, for the present study, the rated fuel economy and CO_2 emission factors from the manufacturers are used for the analysis.

Department of Transport and Management under the Ministry of Physical Infrastructure and Transport, Government of Nepal, is a single organization that keeps all the records of vehicle registration. However, due to the weak data management system, retrieval of data was exhausting. Details of each light-duty vehicle registered in 2005, 2008, 2010, 2012, 2014 and 2016 were archived individually from its record book for over some time. Information on 66 thousand vehicles was retrieved out of 85 thousand registered vehicles. So the present analysis is based on the 39,432 cars, 12,453 jeeps, 4,467 vans, 9,146 pickups, and 418 microbuses.

The annual average fuel economy and CO_2 emission for the years 2005, 2008, 2010, 2012, 2014 and 2016 are estimated based on the weighted average of registered vehicles in the respective years using the following equations:

$$Average\ annual\ fuel\ economy = (Total\ vehicles\ of\ first\ registration\ during\ the\ year)/(\Sigma_i(i=1)^{\uparrow}n \equiv (Number\ of\ vehicles\ in\ Model\ i)/(Fuel\ economy\ of\ vehi$$

$$Average\ annual\ emissions = \frac{\sum_{i=1}^{n}(Number\ of\ vehicles\ in\ Model\ i\ x\ Emission\ of\ Model\ i)}{Total\ vehicles\ of\ first\ registration\ during\ the\ year}$$

4.1 Segregation of transport modes of LDV and their fuel economy

Based on the information of the registered vehicles, the vehicles are segregated into a different category. Vehicles segregation based on fuel type is as shown in Figure 9. The overall vehicle data show that petrol vehicles are popular in Nepal than diesel vehicles and petrol vehicle registration is almost two times more than diesel vehicles. The average share of diesel vehicles is 30%, and that of petrol vehicles is 70% in Nepal.

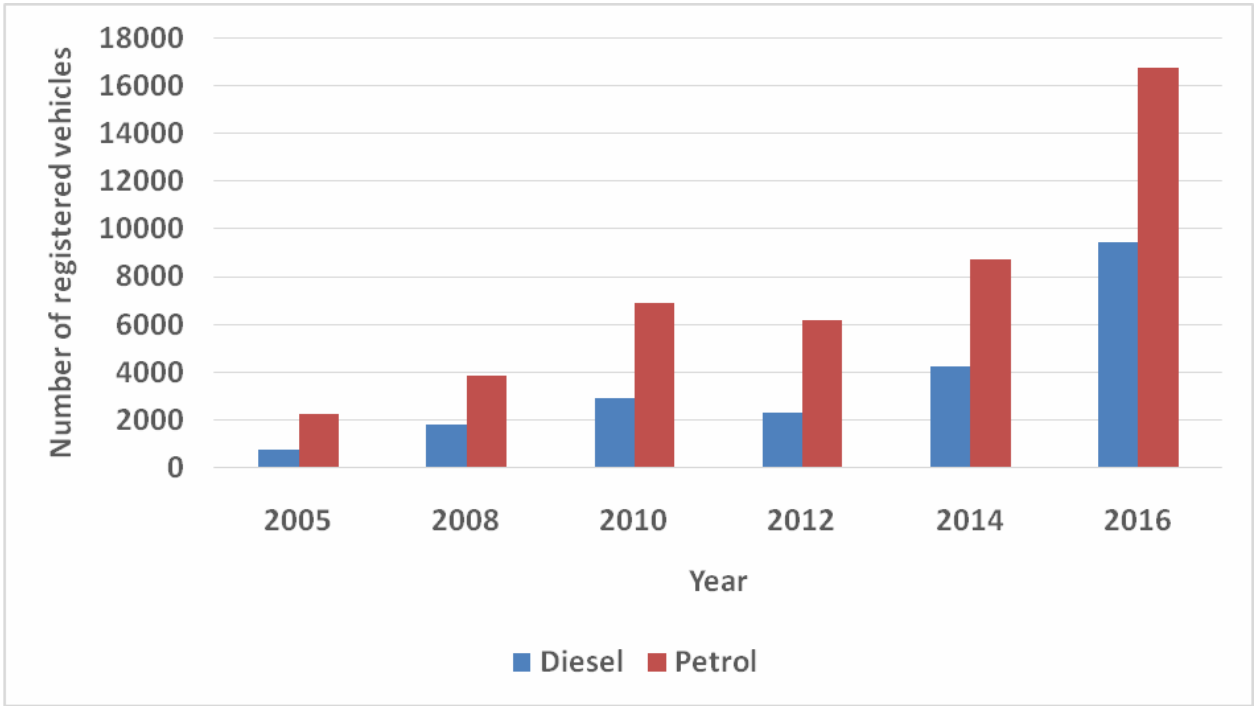


Figure 9 Vehicles segregation based on fuel type

The registered vehicles are segregated into its engine capacity (Table 6). It shows that most of the vehicles registered are of the small capacity engine. There is a considerable increase in vehicle registration from 2005 to 2016 in each vehicle category. A substantial number of vehicles with engine capacity higher than 1,500cc was registered in 2016 compared to 2005 fleet size.

Table 6 Engine capacity of registered vehicles in different years

Engine Capacity cc	2005	2008	2010	2012	2014	2016
upto-1000	820	1,484	1,786	2,434	3,526	7,870
1001-1500	1,350	2,242	5,157	3,586	6,155	10,681
1501-2000	300	796	1,313	1,096	786	2,816
2001-2500	109	388	581	571	1,192	3,144
2501-2900	177	416	587	428	817	2,302
2901 and above	233	423	535	375	633	875
Total	**2,989**	**5,749**	**9,959**	**8,490**	**13,109**	**27,688**

The average displacement ranges of LDVs registered in Nepal show that 69% of total vehicles fall below 1500 cc range (Figure 10). It clearly shows the import of smaller capacity vehicles in Nepal, which are mainly cars. The weighted average displacement range for LDVs is 1,415 cc, 1,499 cc, 1,537 cc, 1,493 cc, 1,501 cc, 1,591 cc in 2005, 2008, 2010, 2012, 2014, and 2016, respectively. The weighted average displacement range of LDVs in Nepal is estimated to be 1,538 cc attributed to the higher engine capacity of the jeep, pickup, and microbus.

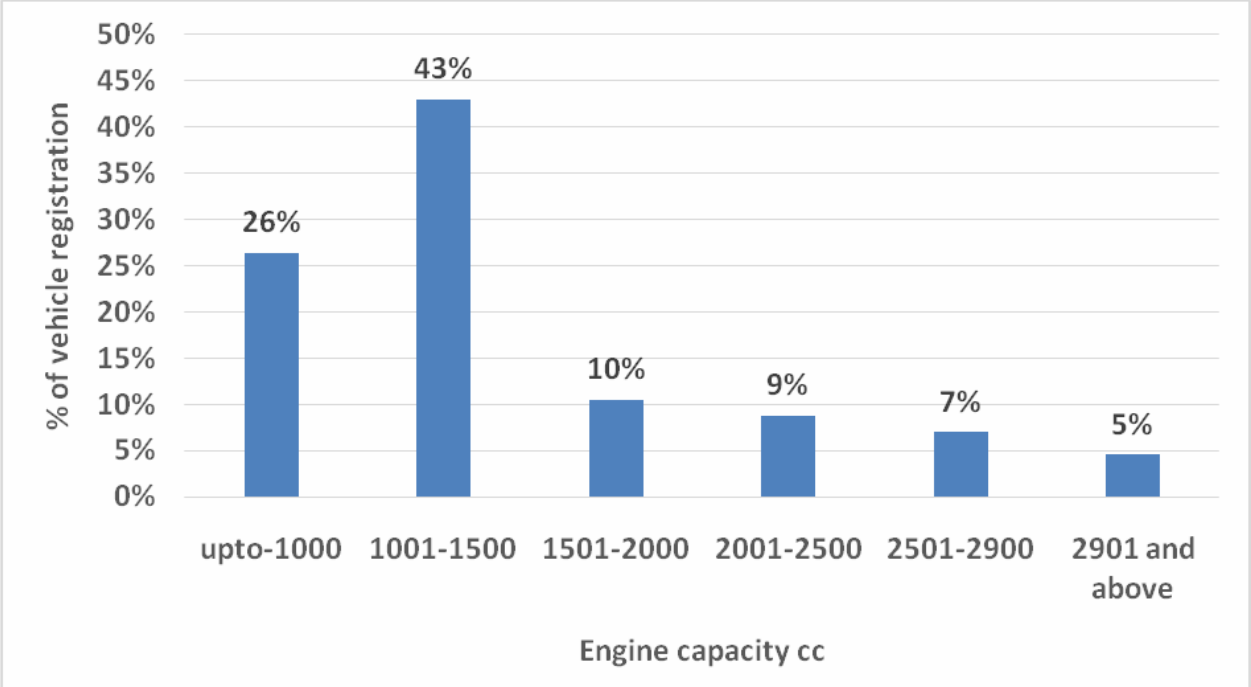


Figure 10: Distribution of registered LDVs under different engine capacity

Since the share of cars is higher in overall LDV registration in Nepal, the car fleet is further segregated into its fuel type to understand the vehicle category mostly imported in Nepal. It shows that 62% of total registered LDVs are a car and 93% of them use petrol fuel. The number of car fleet based on petrol and diesel use is as shown in Figure 11. Registration of a petrol car is increasing at an annual growth rate of 20%, and that of a diesel car is 16% during the same period. Such unprecedented growth in the import of vehicles directly affects the import of petroleum products. Since Nepal is 100% dependent on imported petroleum products, it is thus vital to know the fuel efficiency trend of car and overall fuel consumption.

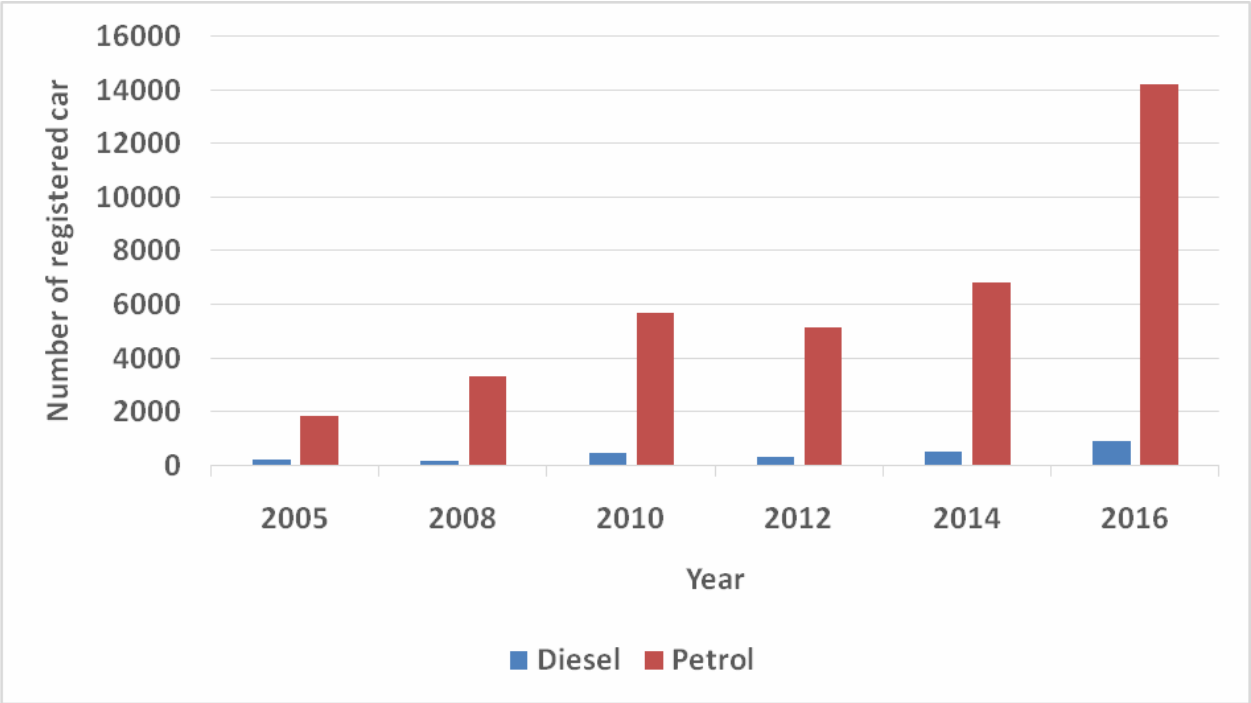


Figure 11: Car fleet by fuel type registered in Nepal

Furthermore, the registration trend of the car in Nepal shows a high share of smaller engine fleet. The distribution of car under different engine capacity range is as shown in Table 7. It clearly shows the dominance of smaller capacity fleets. Approximately 29% of registered car fleets are under 1,000 cc engine capacity range and almost 60% of fleet fall in between 1001-2,500 cc engine capacity range. Many smaller cars attribute to lower fuel consumption than other LDVs. The average displacement ranges of car plying in the country come to around 1,400 cc.

Table 7 Engine capacity of the registered car in different years

Engine Capacity	2005	2008	2010	2012	2014	2016
upto-1000	524	1,094	909	1,491	1,914	5,563
1001-1500	1,296	2,045	4,865	3,303	4,889	7,399
1501-2000	145	273	332	616	444	2,108
2001-2500	18	4	15	6	34	22
2501-2900	5	6	3	6	1	1
2901 and above	33	12	12	3	1	10
Total	**2,021**	**3,434**	**6,136**	**5,425**	**7,283**	**15,103**

In addition to this, overall year - wise vehicle distribution based on its engine capacity also shows 60% of the fleet under 1,000-1,500 cc. The yearly average engine capacity of a car imported in Nepal is 1,394 cc, 1,378 cc, 1,453 cc, 1,421 cc, 1,403 cc and 1,386 cc in 2005, 2008, 2010, 2012, 2014 and 2016 respectively (Figure 12). There is a gradual reduction in 2005 and 2008. However, the average engine capacity of the car increased in 2010 and then gradually decreased in the following years. The increase in average engine capacity in 2010 is attributed to the import of a large number of car fleet which is 78% higher than 2008 car fleet of which 80% falls in between 1001-1500 cc engine capacity.

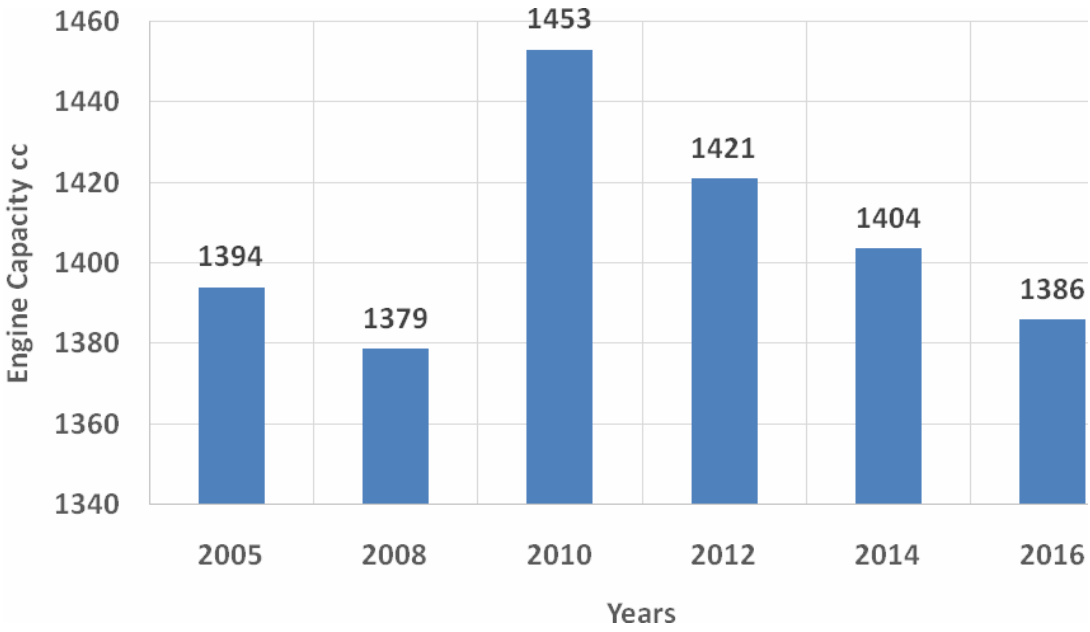


Figure 12: Average engine capacity of the car in the respective year

4.2 Estimation of the average fuel economy of Nepal

The weighted average fuel economy of light-duty vehicles shows the gradual improvement from 2005 to 2016. The average liter gasoline equivalent (Lge) per 100 km value reduces from 6.98 in 2005 to 5.89 in 2016 with a reduction of approximately 20% from 2005. The percentage of fuel economy improvement per year is observed at an annual rate of 1.9%. There is, however, a slight increase in average fuel economy in 2008, which is attributed to the import of large shares of less energy efficient vehicles like pickups and jeeps compared to those in 2005. The weighted annual average fuel economy for each fuel type and the national average is as shown in Figure 13

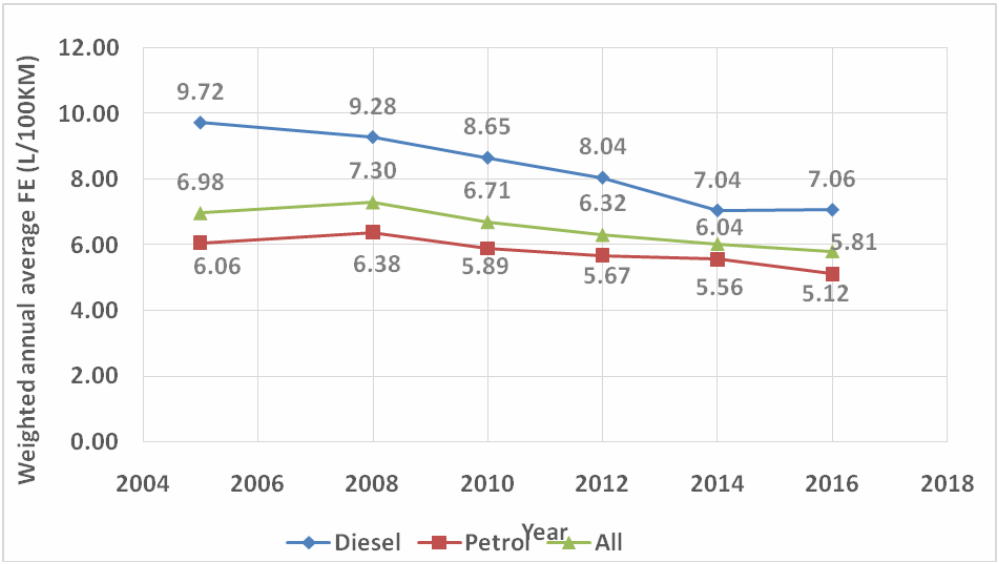


Figure 13: Weighted annual average fuel economy (Lge/100 km) by fuel type in the respective years

Weighted average liter gasoline equivalent (Lge) per 100 km based on vehicle type in several years is as shown in Table 8. It indicates car as highly fuel-efficient vehicle compared to other LDVs due to its lower engine capacity. The trend analysis for car shows the improvement of fuel economy by 26% from 2005. For jeep and van, the fuel economy improvement is 25% and 3% in 2016. However, the noticeable improvement of fuel economy is observed in the pickup, reducing more than half of its fuel that would be required in 2005. However, in the case of microbus, the Lge/100 km fuel consumption is 15% higher in 2016 than in 2005 attributed to the import of fleets with low fuel economy as the import of microbus shifted from Toyota to TATA. Comparing the passenger car and jeep fleet, the car is 48% fuel efficient than jeep in 2016.

Table 8 Weighted average liter gasoline equivalent (Lge) per 100 km based on vehicle type in respective years

	2005	2008	2010	2012	2014	2016
Car	6.19	6.34	5.85	5.57	5.36	4.92
Jeep	9.00	9.11	8.24	8.18	7.19	7.19
Van	6.29	6.29	6.03	6.27	6.10	6.09
Pickup	10.52	9.31	9.16	8.02	6.76	6.85
Microbus	9.19	10.71	10.79	10.99	10.72	10.78

4.3 Estimation of average CO_2 emission (g/km)

The annual average CO_2 emission of vehicles registered in 2005, 2008, 2010, 2012, 2014, and 2016 is as shown in Figure 14. It shows a decreasing trend of emission at an annual rate of 1.3% per year. The emission reduction is mostly attributed to the import of low CO_2 emitting cars in subsequent years. In average, CO_2 emission reduces by 14% from 159 g/km in 2005 to 137 g/km in 2016. The slight increase in 2008 is due to the import of substantial numbers of jeeps and pickups that attributed to higher emission compared to 2005 emission values. There is a decline in emission after 2008, indicating the import of latest vehicles with improved emission factor. The vehicular emission in Nepal is not just due to exhaust emission but also mainly attributed to suspended particles due to unpaved road and construction and maintenance of roads.

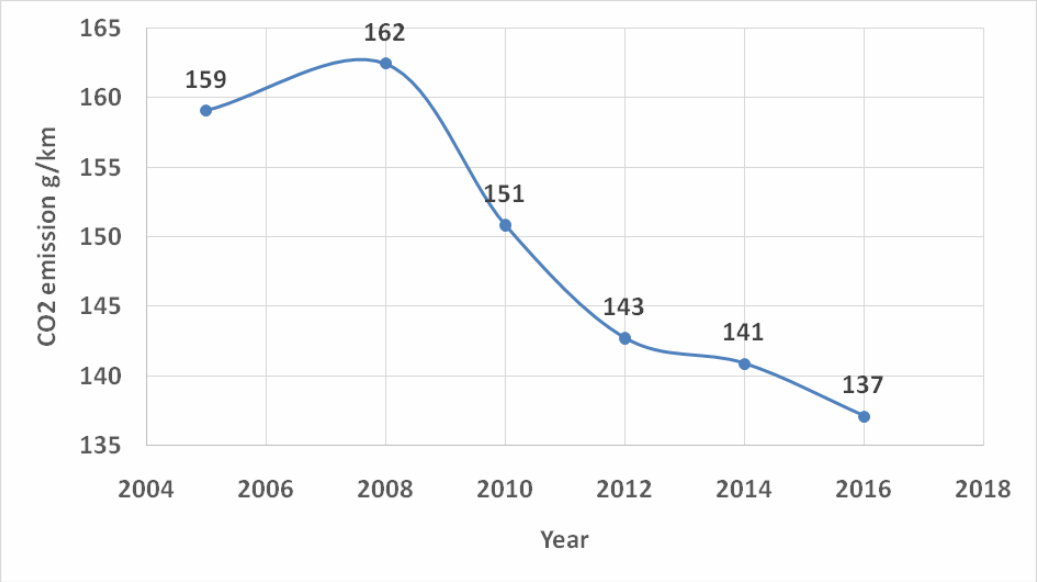


Figure 14: Annual average CO_2 emission of vehicles in the respective years

Since cars dominate most of LDVs, the analysis of car based on its fuel types is carried out for a clear picture of the fuel economy of the country. The total number of cars registered in Nepal in 2005, 2008, 2010, 2012, 2014 and 2016 is 39,423, which is almost 60% of total LDVs. The standard displacement range for the car is 1,001-1,500 cc. The fuel economy and CO_2 emission of the car is further segregated, as shown in Table 9. At an annual growth rate of 20% petrol car registration, the percentage of fuel economy improvement is 1.8%, and the reduction in CO_2 emission is 1.6% per year from 2005 to 2016.

Similarly, for diesel vehicles, the annual registration rate is 15.8%, fuel economy and CO_2 emission improvement is 3.3% and 0.53% respectively. The overall improvement of fuel economy and CO_2 emission of the car is 2% and 1.56% per year respectively. The overall fuel economy of the car in 2016 is 4.92, which is 18% lower compared to weighted average liter gasoline equivalent of LDV in Nepal. It indicates that car imported in the country are energy efficient and environmentally friendly than other LDVs like jeeps, vans, pickups, and microbuses, which are mainly diesel fuel type and of higher engine capacity.

Table 9 Average fuel economy and CO_2 emission of car by fuel type

Year	No. of vehicles	Weighted annual average FE (Lge/100 km)	Annual average CO_2 emission (g/km)
		Petrol car	
2005	1846	6.01	143.05
2008	3311	6.29	145.51
2010	5677	5.77	135.23
2012	5140	5.54	133.49
2014	6803	5.36	127.32
2016	14222	4.88	119.51
		Diesel car	
2005	175	8.07	150.37
2008	139	7.56	165.53
2010	464	6.80	147.74
2012	291	6.09	153.91
2014	480	5.28	136.33
2016	884	5.54	141.85
		All cars	
2005	2021	6.19	143.68
2008	3450	6.34	146.32
2010	6141	5.85	136.18
2012	5431	5.57	134.59
2014	7283	5.36	127.91
2016	15106	4.92	120.82

4.4 Discussions

The present analysis shows that fuel economy of Nepal is lower than the world average fuel economy. The average fuel economy of light-duty vehicles in emerging countries falls in between 6.5 to 8.5 Lge/100km, and India has the lowest fuel consumption of 5.6 Lge/100km (IEA, 2019) and an average CO_2 emission of 121 g/km (ICCT, 2018). Since Nepal imports most of the vehicles from India and most of them are of small capacity, the average fuel economy of Nepal is also comparatively lower than the world average.

The estimated average fuel economy of Nepal is 5.89 Lge/100km, and CO_2 emission 137 g/km in 2016. The lower fuel economy value is primarily due to the use of lower capacity vehicles. Most of the vehicles imported in Nepal falls under 1,500 cc category with the average engine capacity of 1,400 cc.

Sri Lanka has the fuel economy of 6.6 Lge/100km, which is 12% higher than that of Nepal. Also, the fuel economy of Nepal is better than Bangladesh's 6.6 Lge/100 km by 17%. Moreover, compared to other South East Asian countries that have a fuel economy of 7.2 Lge/100 km, the fuel efficiency of LDVs in Nepal improved by 22%. The lower fuel economy of Nepal is due to less number of vehicles compared to those countries and also the lower engine size of the vehicles. Besides, most of the vehicles are imported from India, where fuel economy has substantially improved in recent years.

The world average fuel economy in 2005 was 8.8 Lge/100km and has improved to 7.2 Lge/100km in 2017 at an annual improvement rate of 1.7%. However, the required improvement rate is 2.8% to achieve the GFEI target. GFEI has set the target to improve the fuel efficiency of light-duty vehicles fuel economy by 50% for all the new vehicles by 2030 from 2005 baseline (GFEI, 2019b). It sets the target of 4.4 Lge/100 km by 2030. The fuel economy of emerging countries was 8.6 in 2005 and enhanced to 7.5 in 2017 at an improvement rate of 1.2% per annum. However, the fuel economy of Nepal was 6.89 Lge/100km in 2005 and enhanced to 5.89 Lge/100km in 2016 at the improvement rate of 1.9% per annum. At this rate, the fuel economy of Nepal will be 4.45 Lge/100km by 2030, which almost meets the GFEI standard.

Since the automobile market in Nepal depends upon the international markets, mainly the Indian market, the fuel economy is prone to fluctuate based on imported vehicles. The fuel economy estimated in the present analysis is exclusively based on manufactures' labeling. However, it also depends upon engine size, driving conditions, test cycles, and other technical parameters. The estimated value is thus the theoretical fuel economy of LDVs registered in Nepal in the respective years. A more realistic fuel economy of LDVs could be ascertained, had the sample tests be done in the emission -test laboratory. This can be taken as a limitation in the current baseline study.

CHAPTER 5
CONCLUSIONS

Road transport dominates all forms of transport in Nepal. The rapid growth of vehicle registration trend in Nepal shows an unprecedented growth of 20% per annum. There are 3.22 million registered vehicles in Nepal, and 90% of them are passenger vehicles, and only 10% are freight vehicles. Private vehicles take over most of the passenger vehicles, with 96% of passenger vehicles registered as private vehicles and only 4% as public. It raises the concern of sustainability in the transport sector in Nepal along with growing high demands for imported petroleum products each year. Baseline study of fuel economy is a step towards improving fuel efficiency and emission in the transport sector. However, LDVs account only 8% of total vehicle registration in Nepal and 78% of them are motorcycles. The automobile market of Nepal is primarily dominated by IC engines fueled by petrol and diesel. The hybrid and electric vehicle technology are still new in Nepal even though the import has started some years in the past. The total dependence on imported petroleum fuel creates a substantial economic burden on the country and raises questions on sustainable energy development and energy security.

The present analysis shows that 32% of diesel vehicles and 68% of petrol vehicles ply on the roads of Nepal. Most of the diesel vehicles are jeeps, pickups, and microbuses besides freight and public buses which are not included in this analysis of LDVs. The weighted average engine displacement capacity of the LDVs that enters Nepal is 1,538 cc. In 2016 approx. 40% of LDVs imported falls under 1,001-1,500 cc category. In the case of a car, which shares almost 60% of total LDVs, the weighted engine capacity is 1 406 cc, and most of them are petrol-based vehicles.

The weighted average liter gasoline equivalent fuel economy was estimated for all LDVs registered in 2005, 2008, 2010, 2012, 2014, and 2016. Approximately 65 thousand vehicles were analyzed to estimate the weighted average based on vehicle type, fuel type, and engine capacity. The result shows a gradual improvement in fuel economy from 2005 to 2016 at the rate of 1.9% per annum. The improvement from 6.98 Lge/100 km in 2005 to 5.81Lge/100 km in 2016 indicates the import of fuel-efficient vehicles in Nepal. Since there are no automobile manufacturing companies in Nepal, the fuel economy depends solely on the type of vehicles imported and the policy imposed on the imports vehicles. As per the GFEI requirement, fuel consumption should reduce by 50% from the 2005 baseline. It requires the fuel economy of Nepal reduced to 3.48 Lge/100 km by 2030. However, as per the global average target for 2030, fuel economy should come down to 4.4 Lge/100 km. To achieve the target, it requires the strenuous effort to shift from conventional vehicles to electric and cleaner fuel vehicles. Since there is the abundant potential of hydropower in Nepal, shifting to electric vehicles will utilize electricity generated by clean energy sources – hydropower resources. Electrification in the transport sector, as well as other economic sectors, will positively impact on the national economy that helps in attaining SDGs and objectives of SE4ALL. Moreover, the vehicular emission that caused numerous health damage needs an effective control mechanism through regular monitoring and testing of vehicles. The average PM concentration in Nepal is way higher than the safe level indicated by WHO, causing an increase in respiratory diseases and other airborne diseases and even mortality due to air pollution.

In order to improve the fuel economy and to reduce the adverse impact of emission on economy and environment, it is crucial for the government to take necessary steps towards the implementation of the policies and institutionalize the mitigation and adaptation measures in the transport sector of Nepal. This study provides the baseline data of fuel economy, and emission factor of LDVs imported in Nepal that supplements the policy formulation to achieve fuel efficiency in Nepal. Since there are substantial numbers of two-wheelers and public and freight vehicles compared to LDVs, it is also crucial to shed light on the fuel economy of those vehicles as well to achieve significant improvement in fuel consumption in Nepal. These policy implementations must also be focused on sustainable development and energy security of the country.

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ANNEX 1: VEHICLE INFORMATION DATA SHEET – A SAMPLE

S.N.	Registration No.	Vehicle Type	Model	Year of Manufacture	Company	No. of Cylinder	Capacity (cc)	Seat	Fuel	Registration Date	Average FE (l/100km)	CO_2 (g/km)
1	Ba 14 Cha 48	Car	Aspire	2015	Ford	4	1196	5	Petrol	17/09/2072	5.49	130.9
2	Ba 14 Cha 111	Car	Vento 1.6	2015	Volkswagen	4	1598	5	Petrol	17/09/2072	6.5	154
3	Ba 14 Cha 114	Car	Eon D-Lite	2015	Hyundai	3	814	5	Petrol	19/09/2072	4.74	112.6
4	Ba 14 Cha 150	Car	i20 Active 1.2	2015	Hyundai	4	1197	5	Petrol	19/09/2072	5.38	127.3
5	Ba 14 Cha 228	Car	Datsun Go	2015	Nissan	3	1198	5	Petrol	22/09/2072	4.85	114.3
6	Ba 14 Cha 354	Car	Indica Xeta GLX	2015	TATA Motors	4	1193	5	Petrol	03/10/2072	8.4	150
7	Ba 14 Cha 366	Car	Alto 800	2015	Maruti Suzuki	3	796	5	Petrol	26/09/2072	4.05	96
8	Ba 14 Cha 450	Car	Rapid 1.6 Elegance+	2015	Skoda	4	1598	5	Petrol	29/09/2072	6.72	156.3
9	Ba 16 cha 9119	Car	Figo 1.5	2016	Ford	4	1498	5	Diesel	12/09/2073	4.1	108
10	BA 16 CHA 9278	Car	Swift VXI	2016	Maruti Suzuki	4	1197	5	Petrol	29/09/2073	4.9	116.2
11	Ba 14 Cha 42	Jeep	EcoSport	2015	Ford	4	1498	5	Petrol	17/09/2072	6.31	149
12	Ba 14 Cha 74	Jeep	Scorpio S10 2WD	2015	Mahindra & Mahindra	4	2179	8	Diesel	23/09/2072	6.49	172
13	Ba 14 Cha 126	Jeep	Pajero	2015	Mitsubishi	4	3200	7	Diesel	23/09/2072	12.2	245
14	BA 16 CHA 9252	Jeep	X-Trail	2016	Nissan	4	1997	5	Petrol	22/09/2073	7.94	180
15	Ba 14 Cha 1527	Jeep	Terios 1.5	2015	Daihatsu	4	1495	5	Petrol	16/12/2072	7.49	176
16	Ba 14 Cha 2875	Jeep	Safari Storme	2016	TATA Motors	4	2179	5	Diesel	05/11/2072	7.14	195.1
17	Bz 15 Cha 5901	Van	Omni	2016	Maruti Suzuki	3	796	8	Petrol	24/04/2073	5.95	141.2
18	Ba 14 Cha 36	Van	Ace Magic	2015	TATA Motors	2	702	8	Diesel	19/09/2072	4.9	129.5
19	Ba 14 Cha 41	Pickup	Hilux	2015	Toyota Motors	4	2755	5	Diesel	24/10/2072	7.58	178
20	Ba 16 cha 3807	Pickup	Scorpio Pickup DC 4WD	2016	Mahindra & Mahindra	4	2179	5	Diesel	08/07/2073	6.49	172
21	Ba 14 Cha 185	Pickup	Ace EX	2015	TATA Motors	2	702	2	Diesel	21/09/2072	4.52	119.6
22	Ba 14 Cha 295	Pickup	Bolero Camper DC 4WD	2015	Mahindra & Mahindra	4	2523	5	Diesel	26/09/2072	6.33	167.7
23	Ba 15 Cha 4280	Pickup	NAVARA	2015	Nissan	4	2488	5	Diesel	27/03/2073	9.19	245
24	Bz 15 Cha 4326	Pickup	Ranger 3.2	2016	Ford	5	3198	5	Diesel	26/03/2073	9.72	256

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