

Original Research Paper

# Carbon Footprint of the Kuwaiti Public Road Transport Industry

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**Abstract:** Throughout the last fifty years, Kuwait's population has grown and its oil exploration has produced massive economic changes. That has led to high vehicle demand. As a result, air pollution is increasing in urban areas in particular. The objective of the paper was to estimate carbon emissions from road travel following IPCC guidelines and using national fuel price and sales data of the State of Kuwait road travel between 2001 and 2015. With vehicle numbers rising at an annual rate of about 9% and no mitigation plan in place, this study looks into the contribution of road transport to CO<sub>2</sub> emissions. The findings highlight the urgent need for policies that promote sustainable transport and reduce the carbon footprint of highway transport.

**Keywords:** Air Pollution, Carbon Footprint, Transport Emissions, Kuwait, Urban Area

## Introduction

A carbon footprint is the cumulative sum of greenhouse gas emissions generated by an organization, occurrence, substance or individual directly as well as indirectly and usually is measured in tons of carbon dioxide equivalent (or kilograms). Several studies have been carried out to track, quantify and assess carbon pollution strategies within the transportation industry. CO<sub>2</sub> emissions from transport represent the largest share of greenhouse gas (GHG) emissions from the sector. To limit global warming to below 2°C, net-zero annual CO<sub>2</sub> emissions must eventually be achieved (Pachauri *et al.*, 2014). Globally, the transport sector accounted for 23% of CO<sub>2</sub> emissions from fuel combustion, with road transport alone contributing roughly 20% of total emissions (International Energy Agency, 2016).

The IPCC 's fourth evaluation report indicates a significant tendency towards climate change (Solomon *et al.*, 2007). The IPCC has made the developing countries most likely to have effects on climate change (Protocol, 1997). Kuwait is a member of the Gulf Cooperation Council (GCC). Since the discovery and export of oil in 1946, Kuwait has

undergone profound economic and social changes. It holds approximately 8% of the world's proven oil reserves (OPEC, 2015). Kuwait lies in a subtropical desert region with an average annual precipitation of only about 100 mm. Due to its harsh environment and the effects of climate change, Kuwait faces challenges such as dwindling groundwater resources and rising sea levels, which threaten socio-economic and industrial development (Nachmany *et al.*, 2015).

Also, studies have been conducted in Kuwait on power stations and stationary sources (Hamoda, 2001; Darwish and Al-Naijem, 2005; Darwish and Darwish, 2008; Darwish *et al.*, 2008a; 2008b; Alotaibi, 2011). There are several studies of the emissions of power stations and stationary sources. The carbon footprint for road transport was explored by (Alsabbagh *et al.*, 2013) and was one of the first research in the GCC Area. Despite consumption of fuel and average pre-vehicle distance, research was conducted. Kuwait's carbon footprint (91.03 million tons), based on data from the local fossil fuel consumption, has been estimated as a metric indicator of energy emissions in the World Bank Data report (World Development Indicators, 2006). In 2017 the Kuwait carbon footprint was 89 million tons from fuel consumption (IEA, 2018). In urban areas the

air pollutants of road transport are caused by air pollution by emissions of CO gases, NO<sub>x</sub>s, (VOC) and O<sub>3</sub> (Al-Mutairi and Kouchki, 2009; D'Angiola *et al.*, 2010). Furthermore, the increase in vehicle ownership led to congestion and injury and traffic accident killings (UNDP and General Directorate of Traffic Project 2009-2013, 2009) and noise pollution (Albassam *et al.*, 2009) as a consequence of transport accidents.

The main greenhouse gas emission source in Kuwait is road transport, with 19% of the production of fuel being used by users of road traffic in Kuwait (Ministry of Oil, 2011). According to recent studies, (Chapman, 2007) estimated that the transport industry made up 26% of global emissions of carbon dioxide. Al-Mutairi and Koushki (2009) reported that the transport industry accounted for 80% of greenhouse gas pollution in many metropolitan areas. The IEA reported, however, that 22% of global CO<sub>2</sub> emissions in 2008 (IPC) served the transportation industry (IEA, 2010). The principal causes in Kuwait's urban areas of greenhouse gas pollution are the shipping, manufacturing and plant sectors (Aldaihani and Alenezi, 2017).

Pollutant emissions may vary greatly depending on the location. Zhang and Batterman (2013) stated that road transportation, especially vehicles, has become the key cause of air pollution in metropolitan areas in USA. The road traffic congestion duration and severity had increased pollutant emissions and lower air quality, especially near large highways. In Kuwait, power plants, desalination plants, refineries and petrochemical plants and road transport is responsible for the concentration of air pollutants. The population and automobiles are increasing gradually 3.4 and 9% respectively (TWBG, 2020; Ministry of Interior Kuwait, 2019). Al-Temeemi (1995) stated that air quality is affected by road transport emissions and increasing of fuel consumption.

Cariou (2011) tried to study the elimination of fuel usage and pollution by improving road speed. For example, the Pollution Routing issue (PRP) posed by (Bektaş and Laporte, 2011) accounted for not only travel distance, but also greenhouse gas emits, power, travel time and expense. In addition, in a time-dependent vehicle travel climate, (Jabali *et al.*, 2012) introduced a system to model CO<sub>2</sub> emissions and solved the problem using a tabu search technique.

This study examines the road sector emissions from fuel consumption in Kuwait. A complicating aspect in the analysis of outsourced transport pollution is emissions' control. The transport industry is considered entirely responsible for the pollution. This presumption is justified since transport demand is significantly increasing. In fact, it is in the government best interests to ensure that using transportation is carried out as effectively as possible, because pollutants are associated with fuel prices.

Abaza *et al.* (2011) stated that global warming effects the Gulf region. Nasrallah *et al.* (2004) stated that the intensity of heat waves is increasing. In the Arab countries, the transport sector is consuming about 32% of fossil fuel (Tolba and Saab, 2009). European Environment Agency (2009) stated that transport sector is major greenhouse emissions and the transport emission increased up to 28% during 1990-2005. The air quality and the climate change were affected by road transport emission (Uherek *et al.*, 2010). As a consequence of this growth, the number of road users has risen and air pollution levels have decreased.

## Methodology

This study has been used for the estimation of the production of carbon dioxide from road traffic in Kuwait. The input details used in Equation (1) was from Kuwait National Petroleum Company (KNPC) transport fuel supplier (Ministry of Oil, 2015) and Table 1.

The data of fuel sale in the country through the statistics of the National Petroleum Company is shown in Fig. 1 in the local market from first of April 2001 to the end of March 2015. The data was transferred into the Microsoft Excel format and were analyzed using Excel to carry out descriptive analysis. The calculation based on each type of fuel as shown in Fig. 1 and the following assumption:

1. One barrel is equal to 159 liters
2. One ton of gasoline and diesel are equal to 8.53 and 7.46 barrels respectively
3. 1000 tons of gasoline and diesel are equal to 44.3 and 43 tera Joule respectively which is the Net Calorific Value (NCV) a unit of energy (Solomon *et al.*, 2007):

$$Emission = \sum_a (Fuel_a \times Ef_a) \quad (1)$$

$$\begin{aligned} Emission &= \text{Emissions of CO}_2 \text{ (kg)} \\ Fuel_a &= \text{Fuel sold (TJ)} \\ Ef_a &= \text{Emission factor for fuel type (kg/TJ)} \\ a &= \text{Fuel type (gasoline/diesel)} \end{aligned}$$

**Table 1:** The emission factors of CO<sub>2</sub> from fuel type used in land transport (Solomon *et al.*, 2007)

Fuel type	Emission factor (kg/TJ)
Gasoline	69300
Diesel	74100

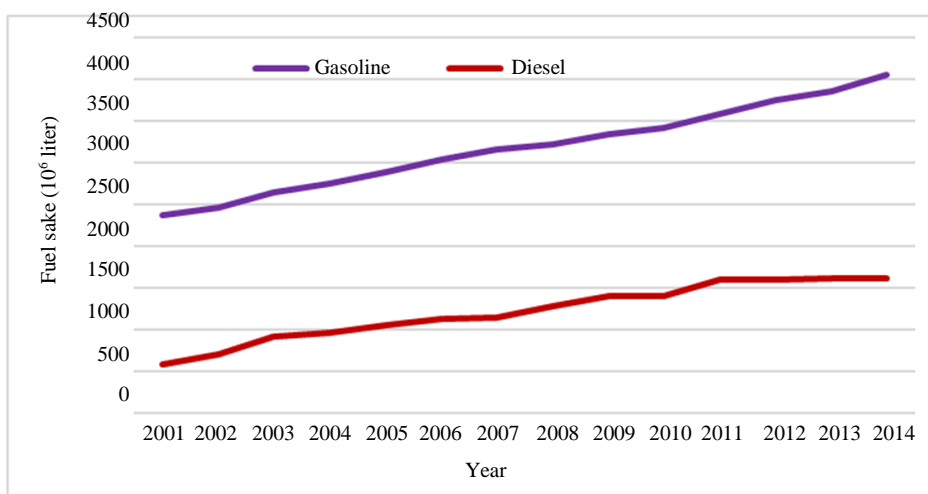
## Results and Discussion

The annual carbon dioxide emissions of transport by road in Kuwait is determined by the use of Equation (1) and by the use of the statistics by the Ministry of Oil

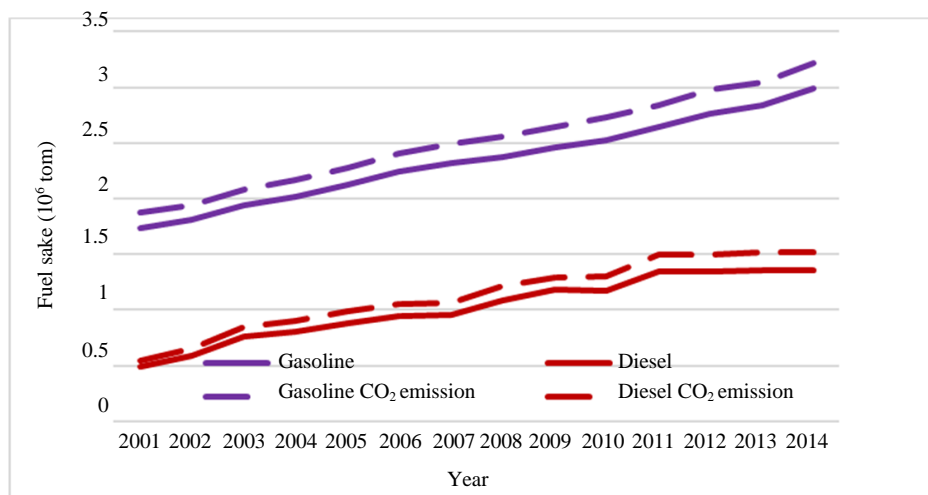
for 2001-2014. The cumulative annual fuel sales from 1 April to the end of March of the following year was estimated. To help appreciate the period variability of the carbon footprint of petrol and diesel as seen of Fig. 3. Firstly, the time series data was developed for carbon emissions throughout the years, it clearly shows a rise in pollution. As a result of increased demand for road transport fuel as shown in Fig. 2, CO<sub>2</sub> emissions have risen over time. Sales of 581×10<sup>6</sup> and 1613×10<sup>6</sup> liters (2360×10<sup>6</sup> and 4055×10<sup>6</sup>) respectively, for diesel (gasoline) in 2001 and 2014. The fuel sales for gasoline and diesel respectively increased by 172 and 277% between 2001 and 2014. Sales of diesel are more than nearly three times higher than gasoline sales. It is evident however, the annual steady rise in fuel consumption as illustrated in Fig. 1. Given a high

pollution factor and an annual rise in jet fuel over petrol, gasoline consumption emissions are higher than fossil fuel. The reason is that diesel vehicles in Kuwait were either trucks or buses.

The annual CO<sub>2</sub> emissions from the highway sector in 2001-2014 are shown in Fig. 3 in Kuwait. It has been estimated by the (IEA, 2010) in 2014 that this document corresponds to 15.3 million tons of emissions of CO<sub>2</sub> from Kuwait state road haulage sectors. In 2015-2035 the market for fuel for road transport is expected to rise by 3% annually, says the Kuwait Institute of Science Research (KISR, 2019). It poses a challenge to curb emissions, such as promoting public transport and incentives for leaving petrol, with the introduction of new policies in Kuwait.



**Fig. 1:** Fuel purchases in Kuwait between 2001 and 2014



**Fig. 2:** CO<sub>2</sub> emissions (ton) during the period 2001-2014

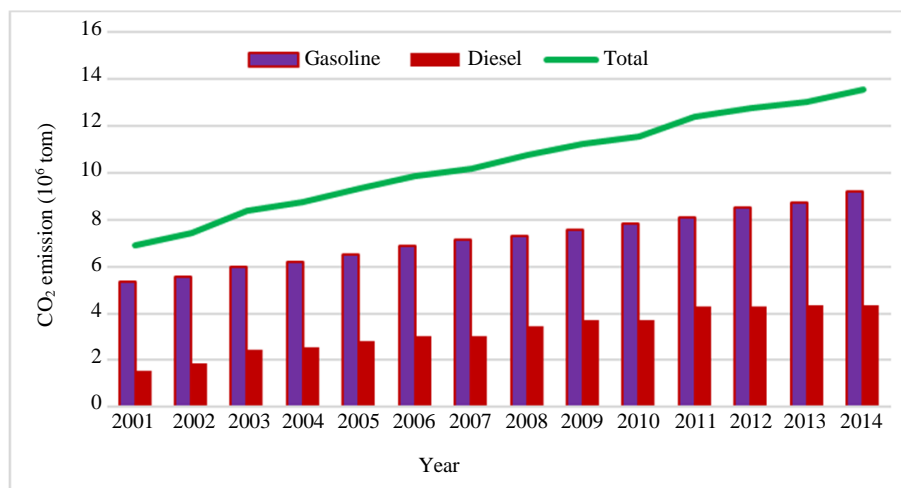


Fig. 3: CO<sub>2</sub> emissions for the period 2001-2014 in the road transport sector

Road users can generally be classified in Kuwait as private and commercial vehicles. Vehicles grew 162% between 2005 and 2014, private cars grew 61% from Ministry Of the Interior's (MOI) (Ministry of Interior Kuwait, 2019) statistics, with an average of 1 car for both residents of Kuwait. World Development Indicators (2006) suggested that for each three inhabitants, a single car is lower than in Kuwait on average in a developing nation. The quality of the fuel efficiency, vehicle form and carbon content of the petrol are important for CO<sub>2</sub> pollution in transport. The estimation of CO<sub>2</sub> emissions of road transport in Kuwait was based on data limitation, such as the fuel efficiency used and the average annual miles, close to United States EPA (Carlson *et al.*, 2013).

## Conclusion

The carbon footprint of road transport was evaluated. The study examines the carbon footprint of the Kuwait State Road between 2001 and 2014. The data were used to map the yearly profile to explain the CO<sub>2</sub> emission temperature variability. Owing to the large number of fuel cars, the carbon footprint of the use of diesel was greater. In addition, the Commission expected a rise in CO<sub>2</sub> emissions as fuel demand increases in the future. Future proposals to reduce the carbon footprint of road transport therefore need to be enforced.

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## Author's Contributions

**Nawaf H. Aldaihani:** Writing the paper and analysis.

**Hamad B. Matar:** Literature review, data collection and preparation.

**Khalefah A. Alhumaidah:** Edited and prepare for publication.

**Nayef Z. Al-Mutairi:** Preparing the paper for possible publication and responding to reviewers.

## Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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