Sustainable Cities and Society 70 (2021) 102924

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

Prediction and evaluation of greenhouse gas emissions for sustainable road transport within Europe

Yigit Kazancoglu *, Melisa Ozbiltekin-Pala, Yesim Deniz Ozkan-Ozen

Yasar University, 35100, İzmir, Department of Logistics Management, Turkey

ARTICLE INFO

Keywords:
Road transportation
Sustainable development
Greenhouse gas emissions
Grey prediction

ABSTRACT

Environmental pollution leads a rise in sustainable development problems. Greenhouse gases(GHG) are one of the most important barriers against to sustainable development and greener cities. When the causes of GHG are investigated, human activities appeared as one of the main reasons. As one of the human activities, transportation has the highest impact on the increase in GHG emissions in green cities. Of the different transportation modes such as air, railways, and road, this study focused on road transportation due to its greater impact when compared to others in terms of GHG emissions. GHG emission estimation should be the initial step to evaluate current status of countries. Therefore, this study aims to make detailed analysis of GHG emissions in four European countries, due to different types of road transport vehicles. Grey prediction is used to estimate the amount of GHG emissions for each road transport vehicle for each country. In conclusion, implications are presented in order to reduce the GHG emissions and to meet sustainable development conditions according to the numerical results of the estimation and it is aimed to prepare a base for new studies about GHG emissions in road transportation.

1. Introduction

A dramatic increase in world population, higher technological developments, and increase in purchasing power have caused a significant rise in production, and consequently, consumption (Wang, Mirza, Vasbieva, Abbas, & Xiong, 2020). This leads not only various types of environmental pollution but also sustainable development and having greener cities status of countries (Shorfuzzaman, Hossain, & Alhamid, 2020). Green cities are cities where emissions are reduced, waste management is done effectively, the development of sustainable local businesses is encouraged and environmental impacts are tried to be reduced in line with these objectives (Mingaleva, Vukovic, Volkova, & Salimova, 2020). These cities are mainly affected by the high levels of carbon emissions (Kulińska and Dendera-Gruszka, 2019). However, almost all countries are faced with sustainable development problems and meeting green cities conditions. The protection of the environment has become important with sustainable development (Hannan et al., 2020) in green cities especially, which is expressed as planning today and the future in a way to meet the needs of next generations without excessive consumption of natural resources.

Global interest in global warming is increasing and changes in nature due to the global climate have recently become a focus of awareness (Replogle & Lewis, 2014). Global warming is increasing due to the types of gas generated by human activities, such as carbon dioxide, methane, nitrogen oxides (Azam, Zanjani, & Mood, 2016; Hooftman, Messagie, Mierlo, & Coosemans, 2018; IPCC, 2014a, 2014b; Ma, 1998). These gases, called GHG, are a significant global issue, and cause of global warming, since they allow a greater proportion of the sun's rays to reach the Earth's surface, but cause some of the outgoing thermal radiation to escape, and thus increase the energy of the surface heat (Kaushika, Reddy, & Kaushik, 2016; Ma, 1998).

Crucial increases in GHG in last 100 years have been mainly caused by human activities (Basha et al., 2017; IPCC, 2007; IPCC, 2014a, 2014b; PIEEE, 2015). Burning of fossil fuels for electricity, heat and transportation are presented as the main human activities that lead increase in GHG emissions (EPA, 2018; Perera, 2018). Globally, countries have to monitor GHG levels in order to create policies that will reduce future emissions (PPMC, 2016; Reznik, Kissinger, & Alfasi, 2018). When compared to the other areas, including agriculture, industry, commercial, and electricity generation, the highest impact on GHG emissions is

* Corresponding author.
E-mail addresses: yigit.kazancoglu@yasar.edu.tr (Y. Kazancoglu), melisa.ozbiltekin@yasar.edu.tr (M. Ozbiltekin-Pala), yesim.ozen@yasar.edu.tr (Y.D. Ozkan-Ozen).

https://doi.org/10.1016/j.scs.2021.102924
Received 26 November 2020; Received in revised form 8 March 2021; Accepted 6 April 2021
Available online 8 April 2021

made by transportation (European Commission, 2017). Different transportation modes are widely used widely, but road transport is the most common (Perera, Thompson, & Wu, 2020). In terms of wide range of land vehicle utilization, road transport is one of the biggest GHG emissions sources (Kijewska, Iwan, & Korczak, 2019). Additional problems are road damage, air pollution (Kapuku, Kho, Kim, & Cho, 2020), traffic congestion, and oil dependence (Santos, Behrendt, Maconi, Shirvani, & Teytelboym, 2010).

There are many different types of air pollution and GHG emissions from road vehicles. Some of are regulated by European Union (EU) regulation, but others are not under any regulation (EEA, 2016; Hooftman et al., 2018). Regulated pollutant materials are carbon dioxide, hydrocarbons, carbon monoxide, particulate matter, nitrogen oxide (Azam et al., 2016; EEA, 2016; Sharma, Jain, Khirwadkar, & Kulkarni, 2013). Road transport has many well-known hazardous impacts in terms of increasing GHG emissions, and there are obstacles to reducing these it (Global Commission on Environment & Economy, 2014). Santos (2017) stated that the high costs of clean technologies in transport and incomplete international agreements are the two main barriers reductions of GHG emissions. Moreover, various barriers can affect sustainable development in countries (Ma & Peng, 2020; Özgür, Elgin, & Elveren, 2020).

Along with rapidly increasing GHG emissions, many policies have been implemented across countries for years to reduce emissions. The Kyoto Protocol is an agreement adopted by the participating governments at the environmental meeting of the United Nations in Kyoto, Japan in 1997, to combat global climate change, by limiting the emissions of the six gases most likely to cause global warming (Davis, Ahiduzzaman, & Kumar, 2018; IPCC, 2014a, 2014b; Santis & Bortone, 2017). Carbon dioxide (CO_2), methane (CH_4) and nitrogen oxide (N_2O) are the most powerful of these according to Kyoto Protocol (Chlopek, Olecka, & Szczepanski, 2018; IPCC, 2014a, 2014b). The Kyoto Protocol highlights that transport is one of the major CO_2 emission sources. Moreover, it is noted that for the Kyoto Protocol, one of the most important targets is road transport, in terms of reducing global GHG emissions. In developed countries, which are highly dependent on sustainable development (Khan, 2020) and energy consumption, it is very important to organize a unified policy national help control climate change by regulating GHG emissions. For this reason, estimating GHG emissions is a key factor in setting relevant policies (Hamzacebi & Karakurt, 2015; Nanaki, Koreneos, Xydiss, & Rovas, 2014; Riberio et al., 2007; Yılmaz & Yılmaz, 2013).

Moreover, the Paris climate agreement is an agreement that includes measures to reduce GHG emissions within the framework of the United Nations climate change framework agreement (PPMC, 2016). Increasing adaptability and climate resilience to the adverse effects of climate change; The main objectives of the agreement are to ensure development with low GHG emissions and to ensure that food production is not harmed while these are achieved (OECD, 2020; PPMC, 2016). The long-term goal of the agreement is to keep the global average temperature increase 2 °C below the pre-industrial period; In addition, it refers to the continuation of global efforts to keep this increase below 1.5 °C (Allen, Babiker, Chen, de Coninck, & Conors, 2018). Finally, stabilizing the flow of finance is among the targets on the path to low emission and climate resilient development (UNFCCC, 2020). Although the emission is expected to decrease with this agreement, it is necessary to know the increase or decrease in the period until the effects of the agreement are seen.

However, it is extremely important to be able to predict present and future values in order to be able to follow the course of the process for these long-term policies that will show their effects after many years. In real life, what policies will be implemented in the future, what will be the technological and economic effects, the effects of important chaotic situations (such as COVID-19) parameters cause uncertain situations. Although these mentioned parameters were not determined as variables and accepted as constant in this study, the results obtained are expected to be a base for new policies and new practices with scenario analysis.

In the globalizing world, it becomes extremely important to have information about these uncertain situations and to make new inferences by expanding the studies. From this point of view, in order to deal with road transport GHG emissions, it is essential to make a deeper analysis with an appropriate prediction method. Since economic conditions, level of industrial development, and daily lifestyle may vary according to country, the deeper analysis should separately consider for each country and each road vehicle type (Hensher, 2008).

Among studies that predict GHG emissions (i.e. Hamzacebi & Karakurt, 2015; Nanaki et al., 2014; Yılmaz & Yılmaz, 2013), to the best of our knowledge, none of analyze countries individually for the different road transportation vehicles. This current study focuses especially on developed countries which are members of EU and have the highest rates of GHG caused by road transportation. The aim of this study is to fulfil the literature gap by initially using Grey Prediction for the GHG emissions caused by different types of road transportation vehicles for overall EU, and four EU countries separately, and secondly, proposing different policies to reduce road transportation GHG for both country wise and overall EU. From the sustainable development perspective, it is very critical to give importance to the global CO_2 emission in transportation sector as soon as possible (Zhang et al., 2020). Therefore, it is aimed to show that how countries affected the negative GHG situations based on sustainable development perspective.

In the following sections, firstly literature review related to GHG emissions, GHG emissions in road transportation and GHG emissions prediction for road transportation are discussed. The methodology of the study is explained and then, implementation of the study and discussions related to the numerical results are presented.

2. Literature review

Literature review in this study is divided into two sub sections: firstly, literature related to the GHG emissions in road transportation, and secondly, GHG prediction in road transportation.

2.1. GHG emissions in road transport

Primary sources of GHG Emissions include transportation, electricity production, industry, commercial and residential, agriculture, land use and forestry (Calderon et al., 2016; EEA, 2016). Although all sectors cause for GHG Emissions to some extent, GHG Emissions from the transport sector have increased in recent years (EEA, 2016; Wang, Xie, & Yang, 2017).

The transportation is the sector that most affects a range of environmental externalities, namely GHG emissions, air pollution and traffic congestion (Thompson, Nassir, & Frauenfelder, 2020) and also has biggest impact on green cities (IEA (International Energy Agency), 2009; Goldmann & Sieg, 2020; Janic, 2017). The world's largest air pollutant sector is road transportation in terms of carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NOx), and volatile organic compounds (VOC). Emissions from vehicles cause more than 50 percent of entire air pollution problems (Ghose, 2002). According to the Statistical Pocket 2017 Report of European Commission, the transport sector is the most common cause of GHG emissions. The distribution of the sectors causing GHG emission is shown in the Fig. 1.

GHG from transport is directly affecting carbon emissions, climate change and human health (Bain et al., 2016). Directly, GHG from transport is linked with sustainable development. The transportation sector has the largest share in GHG, and this is increasing (Lu, Ota, Dong, Yu, & Jin, 2017). Global GHG emissions continue to increase, therefore predicting future data is important to find a global solution for sustainable development. Transport includes domestic aviation, road transportation, rail transportation, domestic navigation, and other transportation (Ritchie & Roser, 2018), but road transportation causes more GHG emissions than railways or the other types (European

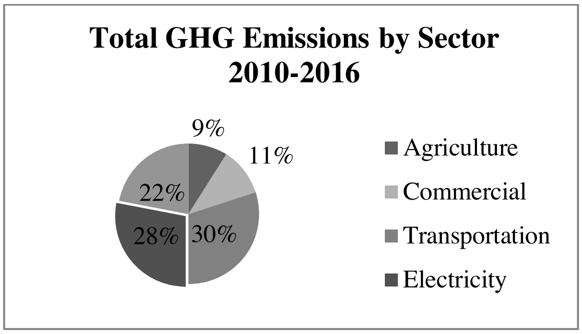

Fig. 1. Total GHG Emissions By sector 2010-2016 (European Commission Statistical Pocketbook, 2017).

Commission, 2017).

According to the European Commission Statistical Pocket 2017 Report, in 2015, road transport constitutes 73 percent of GHG emissions, as shown in Fig. 2.

As it is seen from Fig. 2, road transport has the highest affect in terms of GHG emissions, compared to other transportation modes. Due to this significant impact, this study focuses solely is on road transport.

Many studies focus on the importance of the GHG emissions in road transportation. Water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and ozone (O3) are naturally occurring GHG (OECD, 2002); however, emissions from transport make a significant contribution to the GHG levels in the atmosphere, and emissions are increasing worldwide. According to the European Commission Statistical Pocket Report (2017), the road transport sector has one of the highest emission levels with 73 %. Emissions are increasing rapidly as improvements in fuel efficiency in the transport sector is not sufficient to meet the increased demand (EEA, 2017; Mustapa & Bekhet, 2016).

Ajanovic and Haas (2017) analyzed the GHG emissions reduction policies in car transport in EU-15 using ALTER-MOTIVE method to reduce GHG emissions. Byars, Wei, and Handy (2017)) prepared a research report for reducing vehicle miles of travel with various state-level strategies. Fang and Volker (2017) searched the literature to explore the benefits of reducing vehicle miles of travelled based on examples from California. Morever, Böhler-Baedeker and Hueging (2012) studied on urban transport and energy efficiency and they focused on increasing energy efficiency with new strategies. Ou, Yan, and Zhang (2010) determined future impacts of energy demand (ED) and GHG (GHG) emissions in China's road transport sector. Similarly, Yan and Crookes (2009) predicted for the future impacts of energy demand and GHG emissions in China's road transport sector based on an analysis of energy demand in the period from 2000 to 2005.

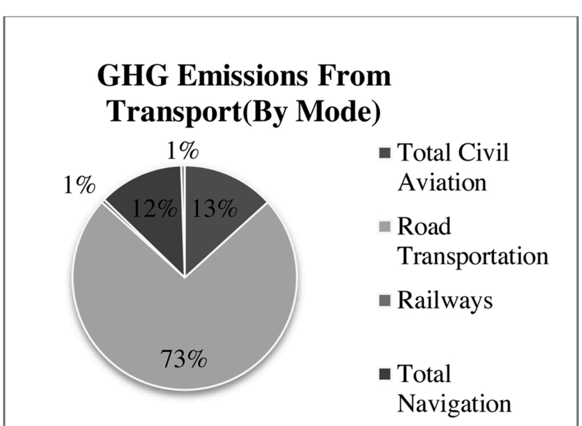

Fig. 2. GHG Emissions from Transport (By Mode) (European Commission Statistical Pocket, 2017).

Poudenx (2008) analysed the GHG emissions of vehicles, and aimed to reduce private vehicles in order to lower GHG emissions in 2008. Moreover, Singh et al. (2008) analysed the trends of energy consumption and GHG emissions in the Indian road transport sector for the period between 1980–2000. Furthermore, McKinnon and Piecyk (2009) researched factors affecting transport demand, truck fuel consumption and CO_2 emissions, by creating categories for stages of logistic decision-making process.

In addition, Apergis and Payne (2009) worked on explaining the relationship between CO_2 Emissions and energy usage in 6 Central America countries between 1971 and 2004, and Ang (2007), did the same for France. Furthermore, OECD published the roadmap report, "Strategies to Reduce GHG Emissions from Road Transport: Analytical Methods" in 2002. Lee, Choi, Hu, and Yoon (2018) used geometric design and Motor Vehicle Emission Simulator (MOVES) to estimate emissions in South Korea.

Ramachandra and Kashyap (2009) determined the road transport emissions for each type of vehicle, in comparison with railways, shipping and airways in India. Woodcock et al. (2009) used comparative risk assessments including GHG emissions to forecast alternative road transport situations, for London, UK, Delhi and India. Similarly, in 2011, Stanley and Hensher (2009) suggested two policies to reduce GHG in road transport in Australia, where transportation is the third largest source of GHG emissions.

Barth and Boriboonsomsin (2009) recommended on eco-driving policy to reduce GHG in transportation in UK. Schipper, Saenger, and Sudardshan (2011) developed a mathematical modelling to analyse transport and GHG Emissions in U.S, where transport the leading source of rapidly growing GHG emissions. Similarly, Yang, McCollum, McCarthy, and Leighty (2009) tried to answer the question of how California could decrease transportation GHG emissions to 80 % below 1990 levels by 2050, using the categorization of light-duty, heavy-duty, aviation, rail, marine, agriculture, and off-road vehicles.

Moreover, focusing on energy demand and electricity consumption in passenger transportation, Rentziou, Gkritza, and Souleyrette (2012) looked at the future impact of fuel tax policies and population density on energy consumption and GHG emissions using SURE Method.

In addition to the studies related to GHG in road transportation, some studies also forecast GHG emissions from road transport. In the following section, these studies are discussed briefly to highlight the literature gap in GHG forecasting in road transport, considering different road transportation vehicles from a macro perspective, involving in-depth country analysis, overall evaluation, and policy suggestions.

2.2. GHG emissions prediction in road transportation

It is crucial to obtain data for forecasting GHG emissions for road transportation for implementing applications, and creating roadmaps for reducing emissions in particular countries. For GHG emission from road transportation, in 2009, Lu et al. used Grey Modelling (1,1) (GM (1,1)) to predict of motor vehicle, energy demand and GHG emissions in Taiwan's rapidly growing road transportation sector. In 2007, Soylu used Copert 3 software to estimate road transport emissions in Turkey to indicate new strategies for decreasing emissions. According to Soylu (2007), strategies including fleet renewal and faster urban traffic speed etc. strategies which are necessary to decrease emissions in the country.

Soni applied the GM (1, 1) model to estimate GHG Emissions from Mumbai's transportation system based on diesel and fuel quantities. The transport sector was the largest producer of GHG emissions in Mumbai. As a result of the study, it is revealed that mitigation measures for Mumbai such as linking vehicle insurance, vehicle scrapping policy, tax on old vehicles etc. Hamzacebi and Karakurt (2015) used GM (1, 1) model to forecast energy related CO_2 emissions in Turkey, and highlights a need for new policy in the country. Similarly, Tirumalachetty and Kockelman (2010) worked on finding sustainable solution of GHG Emissions, and forecasting GHG emissions from urban regions by using micro simulation of land use model. These finding solutions are related to location and vehicle choices, vehicle miles travelled and GHG emissions, household energy demand and per capita emissions.

Using a mathematical model is another method for prediction GHG emissions in road transportation, for instance, in 2014, Choi et al. forecasted CO_2 emissions from the U.S. transportation sector. Özen (2013) used COPERT 4 emission model to estimate emissions based on the available truck freight data. The motivation for this study was the doubling of emissions from the transport sector in recent years, and the need for sustainable policies to reduce the emissions. Grant, Siwek, O'Rourke, Rose, and O'Connell (2013) prepared a report about performance-based approach to addressing greenhouse gas emissions through transportation planning.

Furthermore, Azeez, Pradhan, and Shafri (2018) studied prediction of vehicular emissions at specific locations and time in road transportation in Malaysia by using a GIS, support vector regression and correlation-based feature selection model, with the aim of decreasing GHG emissions in the country. With the study, it is stated that prediction maps are one of the important tools for finding sustainable solutions of traffic jams in toll plaza areas, highways, and road networks. Moreover, Peng, Ou, Yuan, Yan, and Zhang (2018) used a novel bottom up model to predict the GHG emissions and energy demand in Chinese road transportation. In addition, they analysed different scenarios for which are about decreasing GHG emissions by changing vehicles technical characteristics to reduce emissions. At the end of the study they made policy recommendations based on alternative fuels and vehicle technologies considering provincial differences, expansion of natural gas vehicle market etc.

In addition, Chang and Chung (2018) examined the possible policies to reduce GHG emissions by 2050 to below 2005 levels by using model predictive precision (MAPE) method for Taiwan's road transportation. They suggested decreasing emissions by greater use of public transportation. Moreover, Davis et al. (2018) analysed the future GHG emissions in Canada by using a novel bottom-up accounting-based energy model. In this study, source of GHG emissions and each sector related with GHG emissions were studied to obtain predictions. It is revealed that Canada's GHG emissions will continue to grow to 2050.

In 2016, Chai et al. focused two steps to analyze the situation of GHG emissions in China. Firstly, after examining the historical background of road transportation in China, used ARIMA and ETS model to predict energy consumption and GHG emissions. It is shown that the road transportation energy consumption, GDP and urbanization increase depending on each other. Eder, Filimonova, Nemov, Komarova, and Salin (2019) studied economic development related to environmental aspects in Europe and Russia, analysing the current situation of GHG emissions in these countries and predicted GHG emissions to create policies for Europe and regions of Russia. In Table 1, literature summary of articles about forecasting GHG emission in road transportation are given.

With the implementation of various methods in these mentioned studies ae limited with the one or two road transport vehicles. These mentioned studies consist of simulation, COPERT 4 software, MAPE, GIS, ARIMA etc. These methods are more complex and requires detailed data information for prediction. Therefore, as understood from the literature review, prediction of GHG in road transport is limited in terms of number of studies in recent years. To the best of our knowledge, none used prediction methods for different road transport vehicles, or compared the impacts of different vehicles. The utilization rate of different vehicle types may vary according to the country's urban planning, industrial development level, geographical conditions, infrastructure, economic conditions, and local policies. Therefore, for deeper analysis, it is essential to make predictions for each vehicle type separately. Moreover, as mentioned, there is a lack of agreement in policy-making to reduce GHG emissions, therefore this study makes predictions not only for the selected countries, but also for the European Union as a whole.

Table 1
Literature Summary of GHG Emissions Prediction in Road Transportation.

Authors	Method	Focus Area
Soylu (2007)	Copert 3	Estimation of Turkish Road Transport Emissions
Lu, Lewis, and Lin (2009)	GM (1,1)	Forecasting Motor Vehicle, Energy Demand and CO_2 Emission
Tirumalachetty and Kockelman (2010)	Microsimulation Model	Forecasting GHG emissions from Urban Regions
Özen (2013)	COPERT 4 software	Annual Road Freight Emissions for 2000–2009 in Turkey.
Grant et al. (2013)	Desk Research – Report	GHG emissions through transportation planning
Choi, Roberts, and Lee (2014)	Mathematical Model	Forecasting of CO2 Emissions from U.S. Transportation Sector
Hamzacebi and Karakurt (2015)	GM(1,1)	Forecasting Energy Related CO2 Emissions of Turkey
Soni (2015)	GM (1,1)	Forecasting GHG Emissions in Mumba's transportation system
Azeez et al. (2018)	GIS, Support Vector Regression and Correlation Based Feature Selection Model	Forecasting of CO in road traffic
Chai, Lu, Wang, and Lai (2018)	ETS & ARIMA Model and Multiple Regression Models	Road transportation energy consumption
Chang and Chung (2018)	Model Predictive Precision (MAPE)	Policies and Forecasting GHG emissions in Taiwans
Davis et al. (2018)	Novel bottom-up accounting-based energy model.	Canada's future GHG emissions
Peng et al. (2018)	The China Provincial Road Transport Energy Demand and GHG Emissions Analysis (CPREG)	Forecasting energy demand and GHG emissions
Eder et al. (2019)	Methodological Approach	Forecasting GHG emissions in road transport in Europe and regions of Russia

In the following chapter, the prediction method that is used in this study is presented by including all the relevant equations and reasons to choose this method.

3. Methodology

Grey system theory was invented by Deng in 1982, in his article entitled "Control Problems of Grey System" in 1982 (Liu et al., 2015). Grey system includes grey numbers, where known information (called "white), unknown information (called "black") and partially known information (called "grey") (Papageorgiou & Salmeron, 2012). In the traditional prediction techniques for time series, impractical data makes forecasting difficult (Şen & Demiral, 2016). It is very important to use correct and reliable estimation values in decision making processes and to use appropriate estimation method to make accurate and reliable estimations. When there is an original data set, the grey prediction model can be established (Wang, Wei, Sun, & Li, 2016). Therefore, grey prediction method is more suitable for forecasting to overcome uncertainties (Lu, 2015).

GM (1,1) refers to a univariate estimation model of the first order, and is used for time series (Hamzacebi & Karakurt, 2015). GM (1, 1) model, and includes homogeneous exponential growth model includes the accumulation sequence and the least squares method. The growth rate of the original data indicates the accuracy of the estimate (Wang et al., 2016).

In the GM (1,1) model, prediction is made under the assumptions of insufficient and incomplete information, which is referred to as the main feature in real life problems, and these predictions guide the decision phase of new strategies (Yang, Zou, Kong, & Jiang, 2018). The model has been used in many disciplines to predict future data with small calculation efforts with only 4 data and successful results have been obtained (Chen and Huang, 2013; Şişman, 2016). When there is a need for practical solution, the GM (1, 1) model is better method for prediction data for time series forecasting (Chen & Huang, 2013). Therefore, to predict the amount of GHG emissions, GM (1, 1) model is used.

GM (1, 1) model includes actual data of series (x_1^0 , x_2^0 ,..)and aims to predict future data as $x_3^0, \dots, x_n^1$. In this study, totally 20 GM (1, 1) models are applied.

The necessary stages to apply GM (1, 1) model are summarized as below:

1st Step: While using initial data set, x_0 is found as original data set as in (1):

$$x^0 \; : \; (x_1^0 \; , \; x_2^0 , \ldots . x_n^1) \tag{1}$$

x^0: Non-negative sequence

n: sample size of the dataset and they are expressed as: $x_k^0 \geq 0k = 1, 2, \ldots, n$

After the representation of x_0, $x_1$is obtained with Accumulating Generation Operation (AGO). This means x_1 increases one by one (Kayacan, Ulutaş, & Kaynak, 2010).

2nd Step: x_0 data sets are transferred to x_1 data set with applying AGO. The formula is as shown below (2).

$$x_k^1 = \sum_{i=1}^{k} x^0 i \tag{2}$$

After finding the AGO formula, x_1 series are expressed as (3).

$$x_k^1 = \; x_1^1 , \; x_2^1 , \; \ldots , \; x_n^1 \tag{3}$$

3rd Step: z_k^1 is calculated after finding x_k^1 series. The generated mean sequence z_k^1 of x_k^1 is expressed as (4).

$$z_k^1 = 0.5 x_k^1 + \; 0.5 \; x_{(k-1)}^1 \tag{4}$$

k = 1, 2,…., n

With using the formula, z_k^1 is obtained as (5).

$$z_k^1 = \; (z_1^1 \; , \; z_2^1 , \ldots . z_n^1) \tag{5}$$

4th Step: A formula is applied using the parameters "a" and "b" to perform an analytical solution (Chen & Chang, 2000). The parameter "a" and the parameter "b" are found by using Eqs. (9) and (11). These parameters provide to create matrices to find predicted data. Chen and Chang (2000) suggested two different ways to find these parameters, Least Squares Method and the Parameter Method. In this study, least square method is used.

- **Least square method:**

To use Eq. (6), all values are substituted as in the Eq. (7).

$$b = \; x_{(k)}^0 \; + a z_k^1 \tag{6}$$

$$x_{(2)}^0 \; = \; a z_2^1 + b$$

$$x_{(3)}^0 \; = \; a z_3^1 + b$$

$$x_{(n)}^0 \; = \; a z_n^1 + b \tag{7}$$

Eq. (8) is used to find a and b values which are x and z series, and they are shown as "B" and "Y" in the matrix representation.

$$Y = \begin{matrix} x_2^0 \\ x_3^0 \\ x_n^0 \end{matrix} \quad B = \begin{matrix} -z_2^1 & 1 \\ -z_3^1 & 1 \\ -z_n^1 & 1 \end{matrix} \tag{8}$$

After using Eq. (8), the matrix method is prepared to find a and b parameters by Eq. (9).

$$\alpha = \; [a, b]^T = \left(B^T B\right)^{-1} (B^T . Y) \tag{9}$$

5th Step: Grey differential equation should be applied to gather estimated value of the initial data at time (k + 1) in the Eq. (10).

$$x_{(k+1)}^1 = \left[x_1^0 - \frac{b}{a} \right] e^{-ak} + \frac{b}{a} \tag{10}$$

In addition to finding the estimated value of the initial data, Inverse Accumulating Generation Operation should be applied with Eq. (11) (Kayacan et al., 2010).

If these steps give the same results, these are accepted as correct.

$$x_{(k+1)}^0 = \; x_{(k+1)}^1 \; - x_k^1 \tag{11}$$

$k = \; 1, 2, 3, \ldots, n$

Error analysis should be conducted in GM (1, 1) model for the closure. In the GM (1, 1) model, the obtained data set is used for estimation. Estimation can be made when k < n. to find error average of the model, equation 14 is used when $k = 1, \; 1 + 1, \; \ldots, \; n - 1$ (Yılmaz & Yılmaz, 2013).

$x_k^0 \; = \;$ true (initial) value

$$\hat{x}_k^0 \; = \; \text{predicted value of the dataset} e(k+1) = \left| x_{(k+1)}^0 - \frac{\hat{x}_{(k+1)}^0}{x_{(k+1)}^0} \right| x \; 100\% \tag{12}$$

The following path is followed in order to check the accuracy of the a and b parameters and the calculation obtained as a result of the implementation. The accuracy of GM (1, 1) model is *p∘* as shown in Eq. (13).

$$p_\circ \; = \; (1 \; - \; \varepsilon) \; \times \; 100\% \tag{13}$$

General requirement is *p∘* > 80 %.

In this paper, the Grey model (GM (1,1)) is used to forecast the values of GHG emissions from general road transportation, cars, light duty trucks (LDT) and heavy-duty trucks (HDT) in UK, Germany, France, Italy, and the EU generally. In the Fig. 3, the flowchart of the study is provided. According to the methodological approach, data are gathered from Eurostat Data Bank (2018) to implement GM (1,1) model. After gathering data, the actual data set is developed and the further steps are

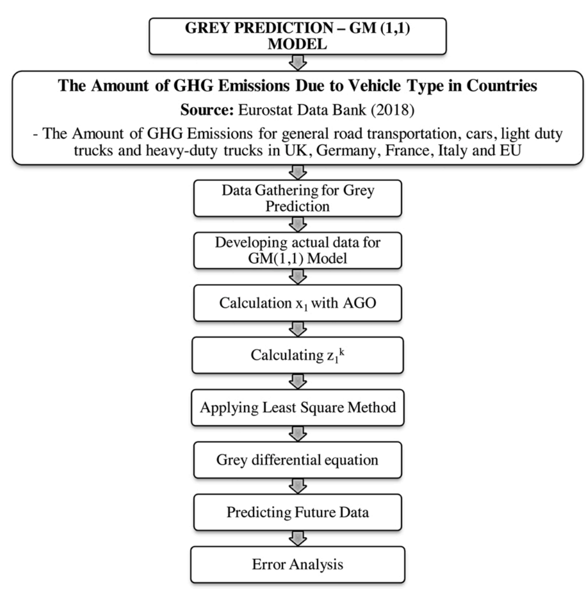

Fig. 3. Flowchart of the Methodology.

implemented to the data set.

In the following section, implementation of the study is conducted and explained using above equations.

4. Implementation of the study

GHG emissions have become a major problem in most developed countries, including the EU. The aim of this study is to predict the future values of GHG emissions for United Kingdom, Germany, France, Italy and EU, for general road transportation, cars, light trucks and heavy-duty trucks between 2017 and 2025. The countries considered in this study were selected on the basis of their rapid and potentially dangerous increase in greenhouse gas emissions among the EU countries, sustainable development status and the completeness of their dataset for the considered time duration, and for each vehicle type. Moreover, it is assumed that the current situation described in this study remains constant and it is aimed to prepare the basis for the studies that can be done by considering the changes that occur in the future.

The actual data of the study, from 2013 to 2016 were obtained from the Eurostat Data Bank (Eurostat Data Bank, 2018), and is revealed that the amount of GHG emissions depend on the distribution of road vehicle types in these countries. Fig. 4 presents the percentage of greenhouse gas emissions from different vehicles.

According to the Fig. 4, 99 % of GHG emissions in road transportation are caused by cars and light duty and heavy-duty trucks. Therefore, this study analyses these four vehicle types in the implementation.

The data set from "Eurostat Data Bank (2018)" for UK, Germany, France, Italy and EU countries includes general road transportation, cars, light duty trucks and heavy-duty trucks. In Fig. 5, all data for EU, and for each vehicle type are given for 2013–2016 and in Fig. 6, all data for UK, France, Germany, Italy and for each vehicle type are given for 2013–2016. To start with, as seen in Fig. 5, the increase in GHG emissions in EU between 2013–2016, was caused not only by cars, but also light and heavy-duty trucks. Similarly, the amount of GHG emissions increased for UK between 2013–2016 as seen in Fig. 6. As seen in the Fig. 6, according to actual data set, cars are the most common mode of GHG releasing vehicles in UK. Cars are also the type of vehicles that release the most GHG in Germany between 2013 and 2016. In addition, GHG emissions caused by heavy duty trucks rapidly increased from 2013 to 2016. Therefore, there is dramatic increase in the amount of GHG emissions from road transportation general. Furthermore, the amount of GHG emissions in France, according to actual values, increases yearly. The biggest increase is in cars, the crucial vehicle type for France for GHG emission. A slight decrease in the amount of GHG emissions from heavy duty trucks could not prevent an overall increase in France. In Italy, the amount of GHG emissions in general road transportation had dramatic increase with a fall in GHG emissions caused by cars and light duty trucks being offset by an increase from heavy duty trucks.

As explained in the methodology section, there are 11 steps in Grey prediction method. All equations were followed for each selected country, based on each individual vehicle types. As an example, the

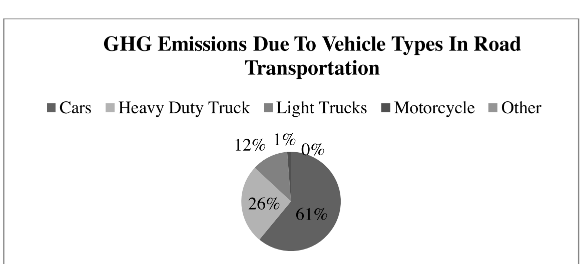

Fig. 4. GHG Emissions According to Vehicle Types in Road Transportation (European Commission Statistical Pocket 2017).

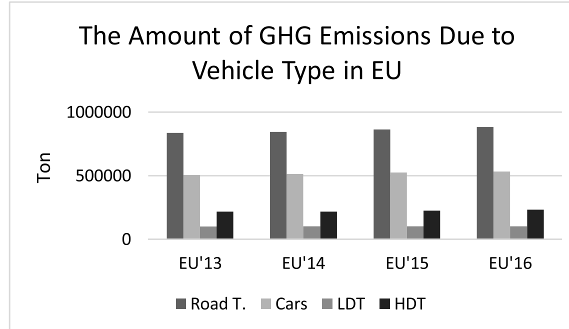

Fig. 5. The Data Set of the Amount of GHG Emissions Due to Vehicle Type in EU.

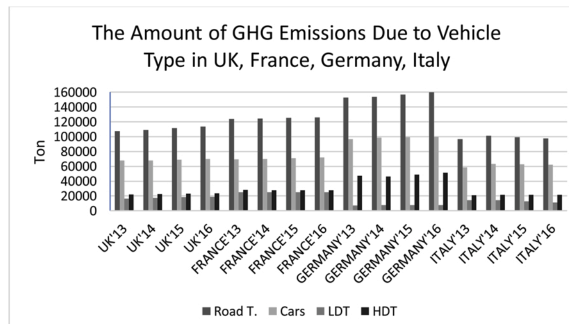

Fig. 6. The Data Set of the Amount of GHG Emissions Due to Vehicle Type in UK, France, Germany, and Italy.

prediction for GHG emissions from cars in EU was calculated by using Grey prediction method, as shown below. This example is based on predicting the amount of GHG emissions generated by cars in EU countries. Similarly, various calculations are made for UK, Germany, France, Italy and EU countries based on the amount of GHG caused by general road transportation, cars, light duty trucks and heavy-duty trucks. Predictions for other vehicle types and other countries, the same steps are applied. For example, $X^{(0)}$ refers to actual data set of the amount of GHG emissions caused by cars in EU. These data are gathered from Eurostat Data Bank.

Moreover, the data set is suitable for the implementation of GM (1,1) model. As mentioned before, GM (1,1) model is appropriate to use when there is less and limited data, only 4 data, and it is a time series prediction model containing a group of differentials and it is adapted for parameter variance as well as first order differential equation (Ozcan, 2017; Xia & Wong, 2014).

The following steps have been taken to assess the amount of GHG emissions from cars in EU.

The actual non-negative data series called as "$X_{(0)}$" shows as;

$$X^{(0)}{}_{=} (506807, 516158, 523964, 535738)$$

After determination of $X^{(0)}$, the new $X_{(1)}$ series is calculated from the cumulative sum of the series $^{(0)}$ which is AGO.

$$X_{(1)} = (506807, 1022965, 1546929, 2082667)$$

$Z^1{}_k$of $X^1{}_k$is found in the following sequence;

$$Z^{(1)}{}_{(k)} = (764886, 1284947, 1814798)$$

After applying Eq. (6), with using Eq. (7) "a" and "b" values are found, and the calculation is called as "The Least Square Method". After determination of "a" and "b", Y and B matrices are calculated by using Eq. (8).

$$Y = \begin{matrix} 516158 \\ 523964 \\ 535738 \end{matrix} \quad B = \begin{matrix} -764886 & 1 \\ -1284947 & 1 \\ -1814798 & 1 \end{matrix}$$

Before using Eq. (9), $(B^T.B)^{-1}$ is calculated.

$$B^T = \begin{matrix} -764886 & -1284947 & -1814798 \\ 1 & 1 & 1 \end{matrix}$$

$$\left(B^T.B\right) = \begin{matrix} 5,52963E+12 & -3864631 \\ -3864631 & 3 \end{matrix}$$

$$\left(B^T.B\right) = \begin{matrix} 1,81431E-12 & 2,33721E-06 \\ 2,33721E-06 & 3,34415593 \end{matrix}$$

After applying Eq. (9) which is $\alpha = [a,b]^T = \left(B^TB\right)^{-1}\left(B^T.Y\right)$

The results are shown in the below;

a = −0,0186

b = 501247,93

e = 2,7183

Moreover, the accuracy of GM (1,1) model for the implementation, which is GHG emissions in EU caused by cars, is calculated as 0,99, which means $p_\circ > 80$ %. In addition, all these calculations are made for other types of vehicles and other countries in the study and all of them had an accuracy rate greater than 80 percent.

The predicted values from the equation of Grey prediction method are shown in the Figs. 7 and 8. The Fig. 7 shows predicted values for GHG emissions from each vehicle type in EU between 2017 and 2025 and similarly, Fig. 8 shows predicted values for GHG emissions from each vehicle type in UK, Germany, France and Italy between 2017 and 2025.

As shown in Fig. 7, according to the results, for the predicted amount of GHG emissions, it can be seen that the greatest increase in GHG emissions in EU is from heavy duty trucks and cars.

According to obtained values for UK, the largest increase in emissions is expected to be from light duty trucks during this period. It is expected that in the UK GHG emissions will increase from 116433 metric tons per capita in 2017–138818 in 2025.

Furthermore, according to predicted values, it is expected that GHG emissions will continue to increase in Germany. It is expected that GHG from general road transportation will increase from 163429 metric tons per capita in 2017–192552 in 2025. Especially, this increase will be from heavy duty trucks, with a difference between initial year and final year of 28423 metric tons per capita for these vehicles.

Moreover, the predicted amount of GHG emissions for France between 2017 and 2025 are shown in the Fig. 8. Although there is a minor decrease in the amount of GHG emissions from cars and heavy-duty trucks, there is an increase from light duty trucks from 2017 to 2025. Lastly, according to predicted values for GHG emissions in Italy between 2017 and 2025, it is expected that GHG emissions from cars and light duty trucks will decrease yearly, but emissions from heavy duty truck will increase.When these prediction results are analysed separately, general increase is seen in the amount of GHG emissions caused by cars, light duty trucks and heavy-duty trucks. The specific results are reflected in the Figs. 7 and 8 and explained below.

After predicting the results and finding the specific number of predictions, it is aimed to indicate the range of increases and decreases with the help of percentage calculation under the assumption that the current situation will remain constant and uncertainty situations will continue in these countries. In line with this purpose, the percentage change between the first predicted year (2017) and the last predicted year (2025) is found for each country and each vehicle type. After finding the average error rate for each calculation, which is found 16 %, a range is created the first predicted year (2017) and the last predicted year (2025).

To start with the EU, an increase is seen in the amount of GHG from cars and heavy-duty truck in the whole EU; 27 % increase, the range of 27 %–43 %, in GHG emissions from heavy duty truck is expected, and 16 % increase, the range of 16 %–32 % from cars. It can be seen in the data set, in France, cars and light duty trucks play an important role in increasing of GHG emissions; it is expected that this increase will be caused by cars with respective increase of 10 % and the expected range is between 10 %–26 %. Furthermore, the amount of GHG emissions is increasing because of heavy duty trucks and light duty trucks in UK. Based on the forecasting calculations, increases are 20 % in a range of 20 %–36 % and 50 % in a range of 50 %–66 % for heavy duty trucks and light duty trucks respectively. In Germany, the biggest increase in emissions are from heavy duty trucks 50 %; the expected range is between 50 %–66 %. In Italy, heavy duty trucks are the major cause of increasing emissions and expected range of changes is 8 %–24 %.

In addition, to be more understandable the average annual change of GHG emissions in the UK, France, Germany and Italy are calculated. Average annual change has been found by taking the average of the annual changes between 2021–2025 in the predicted range. It is expected to that in road transportation, there will be 2 % increase in GHG emissions in the UK and Germany and 1 % increase in France every year. On the contrary, there will be 2 % decrease in GHG emissions in Italy. On the other hand, it is forecasted that there will be 2 % increase in the UK and 1 % increase in 1 % increase in France and Germany in GHG emissions caused by cars every year until 2025. Furthermore, about the GHG emissions caused by heavy duty trucks, it is expected to 5 % increase in Germany, 2 % increase in the UK and 1 % increase in France and Italy until 2025. For light duty trucks, there will be 5 % increase in the UK and 1 % increase in France and Germany for GHG emissions. However, the GHG emissions caused by light duty trucks in Italy is predicted that there will be 11 % decrease until 2025.

5. Discussions

The rapid increase in the amount of GHG emissions caused by road

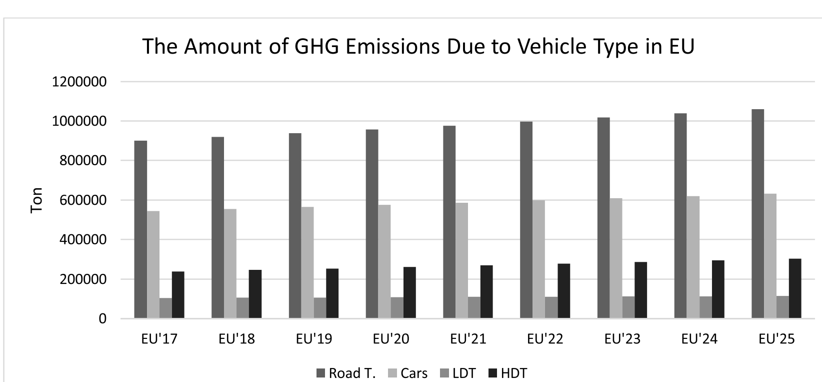

Fig. 7. Predicted Values of the Amount of GHG Emissions due to Each Vehicle Type in EU between 2017–2025.

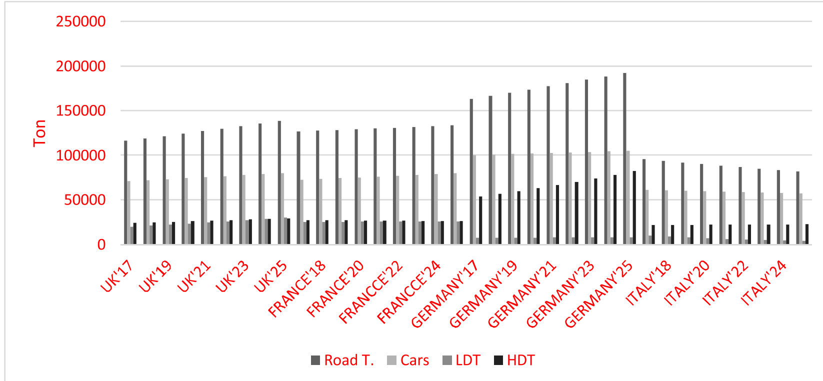

Fig. 8. Predicted Values of the Amount of GHG Emissions due to Each Vehicle Type in UK, France, Germany and Italy between 2017–2025.

transport can have severe global consequences, which is the most important one is impacts on sustainable development and green cities (Ahad, Paiva, Tripathi, & Feroz, 2020). As mentioned before, there are various policies to reduce GHG emissions in countries such as Kyoto Protocol, Paris Agreement, promoting electric vehicles instead of use of diesel vehicles etc. (European Commission, 2016). Moreover, partially implemented policies are fuel efficiency, traffic management, digital technologies, investments for low-emission mobility, and efficient pricing in road transport. These policies are key to reducing GHG emissions caused by road transport worldwide. The regulations and policies are aimed to reduce GHG emissions and it is essential to implement new and beneficial policies, either unique or common, according to vehicle type to reach green cities level in the countries (Byars et al., 2017; Climate Works, 2014; Dutzik, 2016; Pernestål, Engholm, Kristoffersson, & Hammes, 2020). Since the analysis in the study is conducted for EU, UK, France, Germany and Italy, policy suggestions for different vehicle types apply specifically to these countries and it is crucial to meet Sustainable Development Goals. As mentioned before some of these policies are partially implemented in the countries, but some of them are not implemented yet. Before moving to the explanations, in Table 2 summary of the policies for GHG emission reduction are presented.

To start with a general discussion, results of the GHG emissions estimation showed an increase in the GHG emissions for different vehicle types in the EU, and therefore its ability to reduce emissions in the coming years is important in terms of climate friendliness. This means, implementing green environment-sensitive tools that consume less energy.

As one of the main contributions of this study, policies to reduce GHG emissions should address different vehicle types with the consideration of countries sustainable development status. From this point of view, according to the prediction results, the greatest increases in the GHG emissions will be caused by cars in the general EU. Moreover, heavy duty trucks are expected to be the main reason for GHG emissions increase in Germany, while in France and in UK, GHG emissions from both cars and heavy-duty trucks are increasing rapidly, and in UK, light duty trucks are the main cause of increase in GHG emissions. Furthermore, in Italy to suffer higher GHG emissions for the next years, will be caused by cars and light duty trucks in particular. These results indicate the importance of different policies in terms of vehicle types to reduce GHG emissions caused by road transport.

Table 2
Summary of the Policies to Reduce GHG for Different Vehicle Types and Countries.

	EU	UK	France		Germany	Italy	
	CAR	LDT	CAR	HDT	HDT	CAR	LDT
Fuel Efficiency	✓	✓	✓	✓	✓	✓	✓
Modal Shift		✓		✓	✓		✓
Vehicle Efficiency		✓		✓	✓		✓
Taxation System	✓	✓	✓	✓	✓	✓	✓
City Traffic Management	✓	✓	✓			✓	✓
Low-Carbon Society	✓		✓			✓	
Renewable Energy	✓		✓			✓	
Labelling	✓	✓	✓	✓	✓	✓	✓
Fuel Quality	✓	✓	✓	✓	✓	✓	✓
Electric Vehicles Initiatives	✓	✓	✓	✓	✓	✓	✓
Distance-Based Taxes	✓	✓	✓	✓	✓	✓	✓
Vehicle Age Regulations	✓	✓	✓	✓	✓	✓	✓

Since the cars are the main source of GHG emissions in the EU, and in France, and Italy, there is a need to focus on common policies, such as modal shift, fuel efficiency, using alternative fuels, city traffic management, low carbon society, taxation system, and new car types with renewable energy. These are all directly or indirectly linked. For instance, using alternative fuel such as biofuels provides fuel efficiency, therefore, research on alternative fuel technology should be supported by governments (Greenberg & Evans, 2017). These new technologies can be extended in terms of using alternative energy sources instead of fossil fuel. Furthermore, as a growing trend, new implications under sharing economy can be presented, such as carpooling, which helps to reduce traffic congestion, and city traffic management and regulations should promote the low-carbon society, especially via public transportation (Floater & Rode, 2014; Mou et al., 2020), to reduce GHG emissions caused by cars.

The light duty truck is a vehicle type that causes significant amount of GHG emissions in the UK and Italy (Transport & Environment, 2019). To deal with this problem, fuel efficiency, taxation system changes, modal shift, city traffic management and vehicle efficiency can be suggested as policies. The modal shift may be applied to light duty trucks, commonly used for intra city light goods transportation, including parcel couriers (Drawdown, n.d; Feneri, Rasouli, & Timmermans, 2020). The modal shift for this type of vehicle can be achieved by bus or other public transit, or non-motorized transportation, such as cycling or walking (Cambridge Systematics, 2009). Moreover, for light duty trucks, fuel efficiency can be increased by using alternative fuels i.e. diesel, and gasoline. In addition, fuel efficiency can be provided by car sharing systems, nonmotorized transport, regulatory strategies etc. (Cambridge Systematics, 2009). Furthermore, vehicle utilization is an important parameter to improve vehicle efficiency. Light duty trucks are often not fully loaded, causing inefficiency due to excessive number of trips. Therefore, vehicle utilization can be controlled and improved by managing the capacity of vehicle, and volume and weight of load (Litman, 2007). In addition, fuel taxes are important to reduce light duty trucks emissions (Climate Works, 2014). Adjusting taxes (purchasing, registration) based on emission level is an effective way to reduce emissions for these vehicles in UK and Italy. Besides, crowd sourcing can be applied under city traffic management, for example, using the idle time of taxies for parcel courier.

Moreover, for heavy duty trucks, fuel is an important factor in operating costs; hence, fuel efficiency is significant in terms the environment and economics in Germany and France. A suggestion for a new policy to deal with high GHG emissions caused by heavy duty trucks is the implementation of fuel- efficient driving programs, to encourage fuel-saving driving, and consequently, cost savings. Moreover, modal shift or intermodal transportation (SloCaT, 2014) are crucial in heavy duty trucks, since the potential for decreases in GHG emissions is significant compared to other vehicle types. For instance, increasing the volumes transported by railways and in-land waterways may bring lower cost environmentally-friendly transportation and reduce road congestion. Operation research methods can allow for route and network optimization to increase vehicle efficiency of heavy-duty trucks by reducing distances and transportation cost. Furthermore, by using new technologies such as block chain, the average load on laden trips can be increased, which will improve the vehicle utilization and efficiency respectively. As in other countries, in Germany and France, fuel taxes affect the amount of vehicle utilization. Therefore, fuel taxes can be implemented to reduce GHG emissions from heavy duty trucks.

Additionally, although the policies described so far have been partially implemented in countries, the policies described below include newly introduced policies that have not yet been implemented. One of the most recent policy is the European Parliament and the Council adopted Regulation (EU) 2019/631 setting GHG emission standards for heavy duty trucks and cars in 2019. According to the policy, one of new policies are car labelling, which aims to help drivers buy or rent cars that use less fuel and emit less GHG emissions. The "car labelling", which has not been fully implemented across countries, is a label showing the fuel efficiency and GHG emissions of a car (European Commission, 2016). However, it has not been fully implemented across countries. States should encourage this practice to be implemented.

Other newest policy, which is recommended to use in countries is fuel quality. Fuel quality is extremely important in reducing GHG emissions regardless of vehicle types. In this way, in order to keep the fuel quality at a certain level, companies should make the necessary controls and the government should encourage this. Moreover, distance-based taxes are other policy to reduce GHG emissions. A distance-based tax system should be adopted to reduce GHG emissions (Allen et al., 2018). Although this system has been mentioned before, it has not been fully implemented everywhere.

Between 1971 and 2014, greenhouse gas emissions resulting from fuel consumption increased by 57.9 % worldwide (IEA, 2020). For reducing GHG emissions caused by all type of vehicles, it is extremely important to encourage the production and purchase of electric vehicles (Iwan et al., 2019). Electric cars can be promoted to society as a more environmentally-friendly technology. Moreover, vehicles older than 20 years of age and with high energy consumption cause a significant increase in emissions (Serrenho, Norman, & Allwood, 2017). With the new policies to be revealed, the regulations to be introduced to vehicles 20 years old and over with high energy consumption will benefit the emission decrease.

6. Conclusion

Rapid increase in world population has triggered negative environmental impacts and sustainable development due to human activities and one of the most important problems faced with green cities. GHG emission is one of the most important environmental and sustainable development problems caused by human activities, and new policies are essential to reduce and prevent for their damage. Although there have been some policies on the subject, some of these policies have not good enough and some have not been able to show their effects because they have just started to be implemented. Initially, these policies need accurate estimations to understand and evaluate the potential conditions. Research shows that of all human activities, transportation has a greater impact on GHG emissions than agricultural activities, commercial activities, industrial activities, and electricity production.

In this study, to have a clearer understanding that will lead to more effective action plans to reduce GHG emissions and reach sustainable development and green city levels, the research area was narrowed to road transport, which has the highest impact of all transportation modes. After a detailed literature review, although many studies investigate different aspects of GHG emissions in road transportation, none of these studies analysed GHG emissions for different road transportation vehicles separately. From this point of view, originality of this paper is firstly, to address the literature gap by predicting the GHG emissions by different types of vehicles for the EU overall, and four EU countries individually, by using grey prediction, and secondly, explaining and proposing specific policies to reduce GHG and to reach sustainable development levels caused by road transportation at individual country and EU wide levels. With the prediction method applied, it has been aimed to prove the increase of the carbon emission amount in the countries according to the vehicle types. With the seriousness of the situation, it is aimed to accelerate the new strategies and regulations to be created.

Based on numerical results of the study, a range of policies are suggested including fuel efficiency policies, city traffic management, digital technologies, investments for low-emission mobility, and efficient pricing policies in transport.

One of the limitations of the study is that it is difficult to gather detailed data about GHG emissions in the countries. Moreover, in this study, it is accepted as an assumption that the current situation will remain constant. Although potential variables such as which policies to be implemented, technology, population and economy, and what the effects of COVID-19, which the whole world is fighting, are accepted as fixed, all proposed policies can be renewed according to the changes that occur and prepare the infrastructure for new policies. For future studies, similar prediction and investigation can be conducted for developing countries. Moreover, comparisons can be made between developing and developed countries to understand the potential value of common policies. In addition, since, GHG emissions is a global problem, other transportation modes can be similarly analysed to develop policies to reduce negative impacts of transportation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Ahad, M. A., Paiva, S., Tripathi, G., & Feroz, N. (2020). Enabling technologies and sustainable smart cities. *Sustainable Cities and Society, 61*, Article 102301.

Ajanovic, A., & Haas, R. (2017). The impact of energy policies in scenarios on GHG emission reduction in passenger car mobility in the EU-15. *Renewable and Sustainable Energy Reviews, 68*(2), 1088–1096.

Allen, M., Babiker, M., Chen, Y., de Coninck, H., & Conors, S. (2018). Global warming of 1.5 C. An IPCC Special Report on the impacts of global warming of 1.5 C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. *IPCC Special Report*.

Ang, J. B. (2007). CO_2 emissions, energy consumption, and output in France. *Energy Policy, 35*, 4772–4778.

Apergis, N., & Payne, J. E. (2009). CO_2 emissions, energy usage, and output in Central America. *Energy Policy, 37*, 3282–3286.

Azam, G. A., Zanjani, R. B., & Mood, B. M. (2016). Effects of air pollution on human health and practical measures for prevention in Iran. *Journal of Research in Medical Sciences, 21*, 65.

Azeez, O. S., Pradhan, B., & Shafri, H. Z. M. (2018). Vehicular CO emission prediction using support vector regression model and GIS. *Sustainability, 10*, 3434.

Bain, P. G., Milfont, T. L., Kashima, Y., Bilewicz, M., Doron, G., Garðarsdóttir, R. B., … Saviolidis, N. M. (2016). Co-benefits of addressing climate change can motivate action around the world. *Nature Climate Change, 6*, 154–157. https://doi.org/10.1038/nclimate2814

Barth, M., & Boriboonsomsin, K. (2009). Energy and emissions impacts of a freeway-based dynamic eco-driving system. *Transportation Research Part D: Transport and Environment, 14*, 400–410.
Basha, G., Kishore, P., Ratnam, V. M., Jayaraman, A., Kouchak, A. A., Ouarda, T. B. M. J., … Velicogna, I. (2017). Historical and projected surface temperature over India during the 20thand 21st century. *Scientific Reports, 7*, Article 2987.
Böhler-Baedeker, S., & Hueging, H. (2012). *Urban transport and energy efficiency: Module 5h; sustainable transport - a sourcebook for policy-makers in developing cities*.
Byars, M., Wei, Y., & Handy, S. (2017). *State-level strategies for reducing vehicle miles of travel*. University of California Institute of Transportation Studies.
Calderon, S., Alvarez, A. C., Loboguerrero, A. M., Arango, S., Calvin, K., Kober, T., … Vanden, F. K. (2016). Achieving CO_2 reductions in Colombia: Effects of carbon taxes and abatement targets. *Energy Economies, 56*, 575–586.
Cambridge Systematics. (2009). *Moving cooler: Transportation strategies to reduce greenhouse gas emissions*. Urban Land Institute and various cosponsers. at https://bit.ly/2ONAfkD. (Accessed: 01.08.2020).
Chai, J., Lu, Q. Y., Wang, S. Y., & Lai, K. K. (2018). Analysis of road transportation energy consumption demand in China. *Transportation Research Part D, 48*, 112–124.
Chang, C. C., & Chung, C. L. (2018). Greenhouse gas mitigation policies in Taiwan's road transportation sectors. *Energy Policy, 123*, 299–307.
Chen, H. W., & Chang, N. B. (2000). Prediction of solid waste generation via grey fuzzy dynamic modelling. *Resources Conservation and Recycling, 29*(1), 1–18.
Chen, C., & Huang, S. J. (2013). The necessary and sufficient condition for GM(1, 1) grey prediction model. *Applied Mathematics and Computation, 219*(11), 6152–6162.
Chlopek, Z., Olecka, A., & Szczepanski, K. (2018). Greenhouse gas emission from motor vehicles in Poland in 2015. *Environmental Protection and Natural Resources, 29*(76), 9–13, 2.
Choi, J., Roberts, D. C., & Lee, E. (2014). Forecast of CO_2 Emissions from the U.S. transportation sector: Estimation from a double exponential smoothing model. *Journal of the Transportation Research Forum, 53*(3), 63–81.
Climate Works. (2014). *Climate-smart development: Adding up the benefits of actions that help build prosperity, end poverty and combat climate change*. Climate Works Foundation (www.climateworks.org) and World Bank (www.worldbank.org); at http://tinyurl.com/lgr75hl. (Accessed: 07.08.2020).
Davis, M., Ahiduzzaman, M. D., & Kumar, A. (2018). How will Canada's greenhouse gas emissions change by 2050? A disaggregated analysis of past and future greenhouse gas emissions using bottom-up energy modelling and Sankey diagrams. *Applied Energy, 220*, 754–786.
Drawdown (n.d.). Sector Summary, Transportation. Retrieved from: https://drawdown.org/sectors/transportation. (Accessed: 01.08.2020).
Dutzik, T. (2016). *50 steps toward carbon-free transportation: Rethinking U.S. Transportation policy to fight global warming*. Frontier Group. Retrieved from: https://frontiergroup.org/reports/fg/50-steps-toward-carbon-free-transportation. (Accessed: 01.08.2020).
Eder, L., Filimonova, I., Nemov, V., Komarova, A., & Salin, K. (2019). Ecological aspects of economic development: Issues of forecast greenhouse gas emissions in road transport in Europe and regions of Russia. In *E3S Web of Conferences, 80* p. 03010).
EEA. (2016). *Explaining Road Transport Emissions, A Non-Technical Guide*. Retrieved From: (pp. 1–54) Copenhagen: EEA. https://doi.org/10.2800/71804 https://www.eea.europa.eu/publications/explaining-road-transport-emissions/file.
EEA. (2017). *Annual European Union greenhouse gas inventory 1990-2015 and inventory report 2017*. Retrieved From: (pp. 1–941) https://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2017.
EPA. (2018). *Sources of greenhouse gas emissions*. Retrieved From: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.
European Commission. (2016). *Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions. A European Strategy for Low-Emission Mobility*. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016DC0501&from=FI. (Accessed: 10.08.2020).
European Commission. (2017). *Statistical pocketbook*. ISBN 978-92-79-62312-7, 1-1464. Retrieved From: Mobility Transport https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017_en.
Eurostat Data Bank. (2018). *Data navigation tree, transport*. Retrieved From: https://ec.europa.eu/eurostat/data/database.
Fang, K., & Volker, J. (2017). *Cutting greenhouse gas emissions is only the beginning: A literature review of the Co-benefits of reducing vehicle miles travelled*. C Davis: National Center for Sustainable Transportation. Retrieved from: https://escholarship.org/uc/item/4h5494vr. (Accessed: 20.08.2020).
Feneri, A. M., Rasouli, S., & Timmermans, H. J. P. (2020). Modeling the effect of Mobility-as-a-service on mode choice decisions. *Transportation Letters*. https://doi.org/10.1080/19427867.2020.1730025
Floater, G., & Rode, R. (2014). *Cities and the new climate economy: The transformative role of global urban growth, NCE cities – Paper #1, supporting paper commissioned by the London school of economics' LSE cities program (www.lsecities.net), for the global commission on the economy and climate's new climate economy cities program*. Retrieved from: http://eprints.lse.ac.uk/60775/1/NCE%20Cities%20Paper01.pdf (Accessed: 15.08.2020).
Ghose, M. K. (2002). Controlling of motor vehicle emissions for a sustainable city. *TIDEE, 2*, 273–282.
Global Commission on Environment and Economy. (2014). *Better growth, better climate: The new climate economy report, global commission on the economy and climate*. Retrieved from: www.newclimateeconomy.report. (Accessed: 25.07.2020).
Goldmann, K., & Sieg, G. (2020). Economic implications of phantom traffic jams: Evidence from traffic experiments. *Transportation Letters, 12*(6), 386–390.
Grant, M., Siwek, S., O'Rourke, L., Rose, E., & O'Connell, J. (2013). *A performance-based approach to addressing greenhouse gas emissions through transportation planning*. ICF International, Inc.
Greenberg, A., & Evans, J. (2017). *Comparing greenhouse gas reductions and legal implementation possibilities for pay-to-save transportation price-shifting strategies and EPA's clean power plan*. Victoria Transport Policy Institute. Retrieved from: www.vtpi.org/G&E_GHG.pdf. (Accessed: 15.08.2020).
Hamzacebi, C., & Karakurt, I. (2015). Forecasting the energy-related CO_2 emissions of turkey using a grey prediction model. energy sources, part a: Recovery. *Utilization, and Environmental Effects, 37*(9), 1023–1031.
Hannan, M. A., Begum, R. A., Al-Shetwi, A. Q., Ker, P. J., Al Mamun, M. A., Hussain, A., … Mahlia, T. M. I. (2020). Waste collection route optimisation model for linking cost saving and emission reduction to achieve sustainable development goals. *Sustainable Cities and Society, 62*, Article 102393.
Hensher, D. A. (2008). Climate change, enhanced greenhouse gas emissions and passenger transport – What can we do to make a difference? *Transportation Research Part D: Transport and Environment, 13*(2), 95–111.
Hooftman, N., Messagie, M., Mierlo, J. M., & Coosemans, T. (2018). A review of the European passenger car regulations – Real driving emissions vs local air quality. *Renewable and Sustainable Energy Reviews, 86*, 1–21.
IEA. (2020). *Global EV outlook 2020*. Retrieved from: https://www.iea.org/reports/global-ev-outlook-2020#policies-continue-to-support-electric-vehicle-deployment-and-are-evolving-to-a-more-holistic-policy-portfolio. (Accessed: 15.08.2020).
IEA (International Energy Agency). (2009). *Energy prices and taxes quarterly statistics, first quarter*. ISSN 0256-2332. Retrieved From: (pp. 1–496) Paris: OECD https://klazar.files.wordpress.com/2011/12/energytax.pdf.
IPCC. (2007). *Summary for policymakers, climate change 2007, the physical science basis*. Retrieved From: Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press https://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4_wg1_full_report.pdf.
IPCC. (2014a). *Climate change 2014: Mitigation of climate change, intergovernmental panel on climate change*. ISBN 978-92-9169-142-145.
IPCC. (2014b). Summary for Policymakers. In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Retrieved From: http://www.ipcc.ch/report/ar5/syr/.
Iwan, S., Allesch, J., Celebi, D., Kijewska, K., Hoé, M., Klauenberg, J., … Zajicek, J. (2019). Electric mobility in European urban freight and logistics–status and attempts of improvement. *Transportation Research Procedia, 39*, 112–123.
Janic, M. (2017). *The sustainability of air transportation, a quantitative analysis and assessment*. London: Routledge. https://doi.org/10.4324/9781315236889
Kapuku, C., Kho, S. Y., Kim, D. K., & Cho, S. H. (2020). Modeling the competitiveness of a bike-sharing system using bicycle GPS and transit smartcard data. *Transportation Letters*. https://doi.org/10.1080/19427867.2020.1758389
Kaushika, N. D., Reddy, K. S., & Kaushik, K. (2016). Earth's planetary temperature. *Sustainable Energy and the Environment: A Clean Technology Approach*, 31–42.
Kayacan, E., Ulutaş, B., & Kaynak, O. (2010). Grey system theory-based models in time series prediction. *Expert Systems with Applications, 37*, 1784–1789.
Khan, M. (2020). CO_2 emissions and sustainable economic development: New evidence on the role of human capital. *Sustainable Development*. https://doi.org/10.1002/sd.2083
Kijewska, K., Iwan, S., & Korczak, J. (2019). Challenges to increase the sustainable urban freight transport in South Baltic Region–LCL project. *Transportation Research Procedia, 39*, 170–179.
Kulińska, E., & Dendera–Gruszka, M. (2019). Green cities–problems and solutions in Turkey. *Transportation Research Procedia, 39*, 242–251.
Lee, J., Choi, J. S., Hu, H., & Yoon, T. (2018). A method for the estimation of greenhouse gas emissions based on road geometric design and its application to South Korea. *International Journal of Sustainable Transportation*, 1–16. https://doi.org/10.1080/15568318.2018.1437487
Litman, T. (2007). *Win-win transportation emission reduction strategies smart transportation strategies can reduce pollution emissions and provide other important economic, social and environmental benefits*. Victoria Transport Policy Institute. Retrieved from: https://www.vtpi.org/wwclimate.pdf (Accessed: 15.08.2020).
Liu, Z., Guan, D., Wei, W., Davis, S. J., Ciais, P., Bai, J., & Andres, R. J. (2015). Reduced carbon emission estimates from fossil fuel combustion and cement production in China. *Nature, 524*(7565), 335–338.
Lu, M. (2015). Grey system: Theory, methods, applications and challenges. *Leverhulme Trust Workshop on Grey Systems and Applications*. Available at http://www.dmu.ac.uk/documents/technology-documents/research-faculties/cci/lu-grey-system-2015.pdf.
Lu, I. J., Lewis, C., & Lin, S. J. (2009). The forecast of motor vehicle, energy demand and CO_2 emission from Taiwan's road transportation sector. *Energy Policy, 37*(8), 2952–2961.
Lu, X., Ota, K., Dong, M., Yu, C., & Jin, H. (2017). Predicting transportation carbon emission with urban big data. *IEEE Transactions on Sustainable Computing, 2*(4), 333–344.
Ma, Q. (1998). *Greenhouse gases: Refining the role of Carbon Dioxide. March 1998*. Retrieved From: https://www.giss.nasa.gov/research/briefs/ma_01/.
Ma, C. X., & Peng, F. L. (2020). Monetary evaluation method of comprehensive benefits of complex underground roads for motor vehicles orienting urban sustainable development. *Sustainable Cities and Society*, 102569.fgree.
McKinnon, A. C., & Piecyk, M. I. (2009). Measurement of CO_2 emissions from road freight transport: A review of UK experience. *Energy Policy, 37*, 3733–3742.
Mingaleva, Z., Vukovic, N., Volkova, I., & Salimova, T. (2020). Waste management in green and smart cities: A case study of Russia. *Sustainability, 12*(1), 94.

Mou, Z., Liang, W., Chen, Y., Zhang, H., Yan, K., & Li, Z. (2020). The effects of carpooling on potential car Buyers' purchasing Intention: A case study of Jinan. *Case Studies on Transport Policy*. Available online 6 September 2020, In Press, Corrected Proof.
Mustapa, S. I., & Bekhet, H. A. (2016). Analysis of CO_2 emissions reduction in the Malaysian transportation sector: An optimisation approach. *Energy Policy, 89*(2), 171–183.
Nanaki, E. A., Koreneos, C. J., Xydiss, G. A., & Rovas, D. (2014). Comparative environmental assessment of Athens urban buses – Diesel, CNG and biofuel powered. *Transport Policy, 35*, 311–318.
OECD. (2002). *Strategies to reduce greenhouse gas emissions from road transport: Analytical methods. 1-67*. Retrieved From: https://www.itf-oecd.org/sites/default/files/docs/02greenhousee.pdf.
OECD. (2020). *Decarbonising urban mobility with land use and transport policies: The case of Auckland*. Paris: OECD Publishing. https://doi.org/10.1787/095848a3-en
Ou, X., Yan, X., & Zhang, X. (2010). Using coal for transportation in China: Life-cycle GHG of coal-based fuel and electric vehicle, and policy implications. *International Journal of Greenhouse Gas Control, 4*(4), 878–887.
Ozcan, T. (2017). Application of seasonal and multivariable grey prediction models for short-term load forecasting. *Alphanumeric Journal, 5*. https://doi.org/10.17093/alphanumeric.359942
Özen, M. (2013). *Estimation of road freight transportation emissions in Turkey*. Retrieved from: (pp. 1–241) Thesis in the Graduate School of Natural and Applied Sciences Middle East Technical University http://etd.lib.metu.edu.tr/upload/12616759/index.pdf.
Özgür, G., Elgin, C., & Elveren, A. Y. (2020). Is informality a barrier to sustainable development? *Sustainable Development*. https://doi.org/10.1002/sd.2130
Papageorgiou, E. I., & Salmeron, J. L. (2012). Learning fuzzy grey cognitive maps using nonlinear hebbian-based approach. *International Journal of Approximate Reasoning, 53*, 54–65.
Peng, T., Ou, X., Yuan, Z., Yan, X., & Zhang, X. (2018). Development and application of China provincial road transport energy demand and GHG emissions analysis model. *Applied Energy, 222*, 313–328.
Perera, F. (2018). Pollution from fossil-fuel combustion is the leading environmental threat to global pediatric health and equity: Solutions exist. *International Journal of Environmental Research and Public Health, 15*(1), 16.
Perera, L., Thompson, R. G., & Wu, W. (2020). A multi-class toll-based approach to reduce total emissions on roads for sustainable urban transportation. *Sustainable Cities and Society, 63*, Article 102435.
Pernestål, A., Engholm, A., Kristoffersson, I., & Hammes, J. J. (2020). The impacts of automated vehicles on the transport system and how to create policies that target sustainable development goals. In A. Paulsson, & C. H. Sørensen (Eds.), *Shaping smart mobility futures: Governance and policy instruments in times of sustainability transitions* (pp. 37–53). Emerald Publishing Limited.
PIEEE. (2015). *The sustainable communities and climate protection act (SB 375), achieving California's greenhouse gas goals: A focus on transportation: A report for next 10*. Policy Institute for Energy, Environment and the Economy of the University of California Davis. Retrieved from: https://bit.ly/1JKcd3D. (Accessed: 21.07.2020).
Poudenx, P. (2008). The effect of transportation policies on energy consumption and greenhouse gas emission from urban passenger transportation. *Transportation Research Part A: Policy and Practice, 42*(6), 901–909.
PPMC. (2016). *An actionable vision of transport decarbonization: Implementing the Paris agreement in a global roadmap aiming at Net-Zero Emissions Transport, Paris process on mobility and climate (PPMC) on behalf of the global climate action agenda transport team*. Retrieved from: https://bit.ly/2mBWtZm. (Accessed: 21.07.2020).
Ramachandra, T. V., & Kashyap, S. (2009). Emissions from India's transport sector: Statewise synthesis. *Atmospheric Environment*, 1–8.
Rentziou, A., Gkritza, K., & Souleyrette, R. (2012). VMT, energy consumption, and GHG emissions forecasting for passenger transportation. *Transportation Research Part A: Policy and Practice, 46*(3), 487–500.
Replogle, M. A., & Lewis, M. F. (2014). *A Global High Shift Scenario: Impacts and Potential for More Public Transport, Walking, and Cycling with Lower Car Use* (www.itdp.org); at. Institute for Transportation and Development Policy www.itdp.org/wp-content/uploads/2014/09/A-Global-High-Shift-Scenario_WEB.pdf.
Reznik, A., Kissinger, M., & Alfasi, N. (2018). Real-data-based high-resolution GHG emissions accounting of urban residents private transportation. *International Journal of Sustainable Transport*, 1–10. https://doi.org/10.1080/15568318.2018.1459971
Riberio, K. S., Kobayashi, S., Beuthe, M., Gasca, J., Greene, D., Lee, D. S., … Zhou, P. J. (2007). Transport and its infrastructure. *Climate change 2007: Mitigation*. Cambridge, United Kingdom: Cambridge University Press.
Ritchie, H., & Roser, M. (2018). *$CO_2$and other greenhouse gas emissions* [Електр. ресурс]–ДЖерело доступу. Retrieved From: OurWorldInData.org.
Santis, G. D., & Bortone, C. (2017). Climate change and air pollution. *International Conferences on Sustainable Development and Climate from Rio de Janerio to Paris*, 25–39.
Santos, G. (2017). Road transport and CO_2 emissions: What are the challenges? *Transport Policy, 59*, 71–74.
Santos, G., Behrendt, H., Maconi, L., Shirvani, T., & Teytelboym, A. (2010). Part I: Externalities and economic policies in road transport. *Research in Transportation Economics, 28*, 2–45.
Schipper, L., Saenger, C., & Sudardshan, A. (2011). Transport and carbon emissions in the United States: The long view. *Energies, 4*, 563–581.
Şen, H., & Demiral, M. F. (2016). Hospital location selection with grey system theory. *European Journal of Economics and Business Studies, 5*(1), 66–79.
Serrenho, A. C., Norman, J. B., & Allwood, J. M. (2017). The impact of reducing car weight on global emissions: The future fleet in Great Britain. *Philosophical transactions. Series A, Mathematical, Physical, and Engineering Sciences, 375*(2095), Article 20160364. https://doi.org/10.1098/rsta.2016.0364
Sharma, S. B., Jain, S., Khirwadkar, P., & Kulkarni, S. (2013). The effects of air pollution on the environment and human health. *Indian Journal of Research in Pharmacy and Biotechnology*, 391–396. ISSN: 2321-5674.
Shorfuzzaman, M., Hossain, M. S., & Alhamid, M. F. (2020). Towards the sustainable development of smart cities through mass video surveillance: A response to the COVID-19 pandemic. *Sustainable Cities and Society*, Article 102582.
Singh, A., Gangopadhyay, S., Nanda, P. K., Bhattacharya, S., Sharma, C., & Bhan, C. (2008). Trends of greenhouse gas emissions from the road transport sector in India. *The Science of the Total Environment, 390*(1), 124–131.
Şişman, B. (2016). A comparison of ARIMA and grey models for electricity consumption demand forecasting: The case of Turkey. *Kastamonu Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 13*(3), 234–245.
SloCaT. (2014). *Land transport's contribution to a 2°C target: Key messages on mitigation potential*. Institutions and Financing of Low-Carbon Land Transport, Sustainable, Low Carbon Transportation. Retrieved from: https://bit.ly/2BbWwV9. (Accessed: 23.07.2020).
Soni, A. R. (2015). Greenhouse gas emissions forecast for Mumbai's transportation system. In *8th Urban Mobility India Conference & Expo*.
Soylu, Ş. (2007). Estimation of Turkish road transport emissions. *Energy Policy, 35*, 4088–4094.
Stanley, J., & Hensher, D. (2009). *Urban transport in Australia: Has it reached breaking point? Working paper ITLS-WP-09-16*. Retrieved From: Institute of Transport and Logistics Studies, Australian Economic Review http://sydney.edu.au/business/_data/assets/pdf_file/0017/30635/itls-wp-09-16.pdf.
Thompson, R. G., Nassir, N., & Frauenfelder, P. (2020). Shared freight networks in metropolitan areas. *Transportation Research Procedia, 46*, 204–211.
Tirumalachetty, S., & Kockelman, K. M. (2010). Forecasting greenhouse gas emissions from urban regions: 2 microsimulation of Land use and transport patterns in Austin, Texas. *Presented at the 89th Annual Meeting of the Transportation Research Board, 20 January 2010, and Submitted for Publication in Transportation Research Record*. Retrieved From: http://www.caee.utexas.edu/prof/kockelman/public_html/trb10microsimulationco2.pdf.
Transport & Environment. (2019). *Emission reduction strategies for the transport sector in Italy*. Retrieved from https://www.transportenvironment.org/sites/te/files/publications/2019_01_EUKI_IT_report_FINAL_0.pdf.
UNFCCC. (2020). *What is the Paris agreement?*. Retrieved from: https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement. (Accessed: 15.08.2020).
Wang, R., Mirza, N., Vasbieva, D., Abbas, Q., & Xiong, D. (2020). The nexus of carbon emissions, financial development, renewable energy consumption, and technological innovation: What should be the priorities in light of COP 21 Agreements? *Journal of Environmental Management, 271*, 111027.
Wang, Y., Xie, T., & Yang, S. (2017). Carbon emission and its decoupling research of transportation in Jiangsu Province. *Journal of Cleaner Production, 142*(2), 907–914.
Wang, Y., Wei, F., Sun, C., & Li, Q. (2016). The research of improved grey GM (1, 1) model to predict the postprandial glucose in type 2 diabetes. *BioMed Research International, 2016*, 6, 6837052.
Woodcock, J., Edwards, P., Tonne, C., Armstrong, B. G., Ashiru, O., Banister, D., … Roberts, I. (2009). Public health benefits of strategies to reduce greenhouse-gas emissions: Urban land transport. *Lancet, 374*, 1930–1943.
Xia, M., & Wong, W. K. (2014). A seasonal discrete grey forecasting model for fashion retailing. *Knowledge-Based Systems, 57*, 119–126.
Yan, X., & Crookes, R. J. (2009). Reduction potentials of energy demand and GHG emissions in China's road transport sector. *Energy Policy, 37*(2), 658–668.
Yang, X., Zou, J., Kong, D., & Jiang, G. (2018). The analysis of GM (1, 1) grey model to predict the incidence trend of typhoid and paratyphoid fevers in Wuhan City, China. *Medicine (Baltimore), 97*(34), 2018.
Yang, C., McCollum, D., McCarthy, R., & Leighty, W. (2009). Meeting an 80% reduction in greenhouse gas emissions from transportation by 2050: A case study in California. *Transportation Research Part D: Transport and Environment, 14*(3), 147–156.
Yılmaz, H., & Yılmaz, M. (2013). Forecasting CO_2 emissions for Turkey by using the grey prediction method. *Sigma, 31*, 141–148.
Zhang, Y., Chen, X., Wu, Y., Shuai, C., Shen, L., & Ye, G. (2020). Peaks of transportation CO_2 emissions of 119 countries for sustainable development: Results from carbon Kuznets curve. *Sustainable Development, 28*(July (4)), 550–571. John Wiley & Sons, Ltd.