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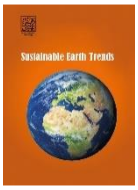

Green Commute: Reducing Carbon footprint in commuting scenarios in Karaj

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ABSTRACT

This study addresses the substantial contribution of mobile sources in commuting to greenhouse gas (GHG) emissions in megacities and underscores strategies for carbon footprint emission reduction. Field interviews and questionnaires facilitate data collection, enabling the classification of the studied vehicle fleet based on various parameters. The scenarios aim to minimize GHG_s from the commute, utilizing the International Vehicle Emission (IVE) model to establish a primary carbon footprint emission inventory for commuting in Karaj. The base scenario reveals that commuting in Karaj produces 1579423 grams of $CO2_e$, with CO_2, N_2O, and CH_4 emissions at 1389039 grams, 43.74 grams, and 6385.38 grams, respectively. Three carbon footprint reduction scenarios, involving removing diesel vehicles, adopting natural gas-fueled vehicles, and replacing Euro 4 and 5 with older vehicles, demonstrate that the removal of diesel vehicles (S1) and adopting natural gas-fueled vehicles, and replacing Euro 4 and 5 with older vehicles (S3) are the most effective strategies, achieving a 99% efficiency rate in reducing CO_2e. This study highlights the substantial impact of curbing carbon emissions from GHG_s. S1 and S3 show significant reductions in carbon footprint emissions, emphasizing the crucial role of strategic planning and greenhouse gas minimization in controlling emissions from commuting. These findings underscore the critical importance of reducing carbon footprints and commuting to effectively mitigate GHG_s in congested urban areas.

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1. Introduction

The World Health Organization (WHO) in 2016 recognized climate change as a significant environmental concern, and it is increasingly becoming a pressing issue in developing nations due to their rapid industrialization (WHO, 2016). To mitigate the consequences of climate change, decreasing greenhouse gas (GHG) emissions is imperative. Different types of carbon (CO_2 and CH_4), nitrous oxide (N_2O), and CFC_s play a vital part in causing global warming and climate change by increasing their concentrations in the atmosphere (Ramachandra, 2015). Numerous sources of pollutants, including burning fossil fuels and industrial processes, often simultaneously release air pollutants and CO_2 into the atmosphere. Consequently, cooperatively decreasing the emissions of air pollutants and CO_2 yields mutual advantages, effectively enhancing air quality and mitigating climate change (Xue, 2023). These reductions can be tracked by maintaining records of both emissions and the absorption of these gases (Bun et al., 2019). Road transportation ranks as the second most substantial contributor to GHG emissions like carbon and stands as the foremost oil consumer, responsible for 26% of total GHG emissions and consuming 45% of the world's total oil supply (Hassani & Maleki, 2021). Commuting as a form of road transport impacts daily life, as this type of travel significantly contributes to high CO_2 emissions.

Policymakers must prioritize effective strategies to reduce emissions and promote environmental management, considering the disproportionate increase in an individual's daily exposure to urban air pollutants, including carbon (deSouza et al., 2021; Geng et al., 2013; Molina et al., 2020). The commute is due to its various purposes, including business, administrative services, education, shopping, medical visits, seeing relatives, and recreation, all contributing to significant traffic (Kissinger and Reznik, 2019; Moeinaddini et al., 2017). Green commuting, known as sustainable commuting (SC), involves environmentally friendly travel modes like public transport, walking, cycling, carpooling, and using vehicles with clean fuels. Research shows that green commuting aims to reduce reliance on fuel-based transportation methods can reduce greenhouse gas emissions also physical activities such as walking and cycling and upgrade old vehicle with new standards significantly reduce CO_2 emissions (Holian and Kahn, 2015; Molina et al., 2020). In this section, crucial element of environmentally conscious commuting comes to the forefront, centering on selecting the appropriate fuel of transportation for commute. This decision primarily involves opting for eco-friendly vehicle fuel options or considering alternative methods such as utilizing public transportation, electric vehicles, biking, or walking (Thøgersen et al., 2021). Hence, reducing of the fuel consumption of the vehicles and minimizing the adverse consequences of carbon footprint on climate change and air pollution are significant concerns. Governments across the globe have implemented various policies and measures to tackle these issues (Litman, 2013). These actions encompass enhancing the efficiency of new vehicles by imposing more stringent standards, promoting the adoption of alternative fuel vehicles (AFV), and updating vehicles by using Euro standards (Wang et al., 2007). These studies, such as those by Hamzacebi and Karakurt (2015), Nanaki et al. (2014), and Rouhi et al. (2023) have individually analyzed countries regarding GHG emissions from different road transportation vehicles. Subsequently, it aims to propose diverse policies for reducing GHG emissions from road transportation, both on a national level and for the EU. From the standpoint of sustainable development, prioritizing global CO_2 emissions in the transportation sector is extremely crucial (Hamzaçebi and Karakurt, 2015; Nanaki et al., 2014; Rouhi et al., 2023). Iran, with 83.9 million people, the most populous country in the Middle East, is among the top 10 global greenhouse gas and carbon emitters, with road transportation accounting for 85% of its total emissions (Hassani and Maleki, 2021). Growing concerns about the environmental consequences of GHG related to road transportation and development have prompted governments worldwide to assess the environmental effects of transportation projects before their execution (Crayton and Meier, 2017). This change is driven by various factors, such as improving fuel quality, reducing fuel consumption, and alleviating traffic congestion (Massar et al., 2021). In metropolitan areas, commuting plays a pivotal role in mitigating carbon footprints for various purposes. This study underscores the importance of reducing greenhouse gas emissions, fuel consumption, and pollution associated with commuting. The research highlights the significance of allocating resources to renewable energy projects and utilizing updated standard vehicles. Our study contributes to the understanding of the environmental impact of conventional energy sources such as diesel and petrol, emphasizing the need for sustainable transportation practices. By offering insights into reducing fuel consumption through commute reduction, our research provides valuable guidance for policymakers, industry stakeholders, and researchers.

2. Material and Methods

2.1. Study Area

Karaj serves as the capital of Alborz province, located in the eastern part of the province. As of 2015, it had a population of 2,512,737 residents. The city witnesses a substantial daily commuting activity, with an estimated volume of about 3,000,000 trips. Statistical data indicates that Karaj hosted approximately 364,000 passengers (excluding drivers) while the overall daily vehicular trips, encompassing the city and its suburbs, reached 1.6 million and 0.3 million, respectively, with passenger cars accounting for 37% of the fleet and taxis and buses making up 40% in Karaj city.

2.2. Data Collection

To conduct this research, data was obtained from the result of the field study in the form of a 500-questionnaire survey between February 2022 and May 2022, using traditional in-person methods and online questionnaires (due to the common epidemic conditions). This information was completed based on references to technical inspections of vehicles, urban traffic surveillance cameras, and the completion of questionnaires by people who commute for different purposes in Karaj. This questionnaire included questions about personal details, vehicle use, and suggestions for reducing people's commutes. Only 13% of respondents reported using public transportation for their daily commute, with 6.2% choosing buses and 6.4% choosing taxis. The average commute time for respondents was approximately 25 minutes. The survey findings provided participant recommendations that emphasized the need to prioritize city-wide public transportation, use clean fuels, implement smart service solutions, and create bike-friendly routes. These proposed actions are aligned with broader initiatives aimed at improving air quality and reducing pollution from traffic congestion.

2.3. Carbon footprint calculations

For this carbon footprint calculation, a case study utilizing commute data from Karaj was conducted. The data utilized pertains to calculating the carbon footprint associated with commuting in Karaj, including indirect emissions from fuel usage for commuting. The findings indicate that the total estimated CO_2 emissions from commuting in Karaj amount to 4897.559 grams of CO_2 equivalent. To calculate the CO_2 equivalent (CO_{2e}) for a greenhouse gas emission over a hundred-year timeframe, you need to consider the global warming potential (GWP) of the gas in question. The GWP is a measure of how much heat a greenhouse gas traps in the atmosphere relative to CO2 over a specific time period, usually 100 years (Marais et al., 2022)

In Eq. (1) is a general formula to calculate CO_{2e} for a given amount of greenhouse gas emission over a hundred years:

$$\mathrm{CO2e} = Emission\ amount \times GWP \quad (1)$$

Where:

CO_{2e} = CO_2 equivalent

Emission amount = The amount of greenhouse gas emitted (in units like kilograms or metric tons)

GWP = Global Warming Potential of the greenhouse gas for a hundred-year period (Lynch et al., 2020).

2.3.1. Vehicle Fleet Composition

The study of vehicle technologies is one of the most pivotal aspects of vehicle emissions analysis (Wang et al., 2008). Driving patterns can differ significantly between cities and across various road types due to factors like speed limits, vehicle types, traffic density, and the number of traffic signals. Typically, vehicles on highways maintain higher speeds with less frequent acceleration or deceleration, whereas those on urban arterial roads, characterized by heavier traffic, tend to have lower speeds but experience more frequent acceleration, deceleration, and idling, which can lead to increased fuel consumption and greenhouse gases emissions (Zhang et al., 2021). Moreover, to perform power calculations based on GPS data and Google Maps, we gathered minute-by-minute speed, elevation, and distance data for various vehicle types on different types of roads and during different times of the day, with a particular focus on peak traffic hours to ensure a comprehensive and representative dataset (Viteri et al., 2023). The collected GPS data, which represents actual driving behaviors, was integrated into emission prediction models like IVE, along with local temperature and humidity data (Pathak et al., 2016). The driving style, encompassing factors like acceleration and vehicle speed, is influenced by local driving culture and traffic conditions. The IVE model utilizes a driving factor tied to the type of driving, particularly involving vehicle-specific power (VSP) and engine stress, which is calculated using Eq. (2) and is highly accurate for light vehicles (Shafabakhsh et al., 2018; Cuba et al., 2021).

$$VSP = V * [1.1a + 9.81(\mathrm{atan}(\sin(grade))) + 0.132] + 0.000302v^3 \quad (2)$$

where v is the vehicle velocity, a is the vehicle acceleration, and grade is the road slope. The following equation (3, 4, and 5) shows how to estimate engine stress(Hao et al., 2015; Shahbazi et al., 2016):

$$Engine\ Stress = RPM\ Index + \left(0.08\ \frac{ton}{KW}\right) * Preave\ Power \qquad (3)$$

$$Preave\ Power = Average\ (VSP) \left(\frac{KW}{ton}\right) \qquad (4)$$

$$PRM\ Index = \frac{Velocity}{Speed\ Divider} \qquad (5)$$

In this study, the primary information was collected through completed surveys, in which the characteristics of the vehicles considered in the sample were investigated. A comprehensive analysis of the fleet composition was conducted through a field survey, encompassing diverse fuel types, various systems, production years, emission standards, and vehicle classes (engine volume or weight). Fleet emission rates were computed using the IVE database of the emission rates for each vehicle technology. Additionally, the investigation considered real-world driving behaviors influenced by drivers and distances traveled during commutes. Dynamic variables such as road length, obstacles, traffic timing, and average emission factors for CO_2, N_2O, and CH_4 emissions were calculated for Diesel, Petrol, Natural Gas, and Hybrid-fueled vehicles (Johnson, 2014; Shahbazi et al., 2016)

3. Results and discussion

3.1. Inventory Vehicle Emissions

Table 1 provides a representation of the vehicle fleet composition data provided by the IVE model. As described in the methodology section, Table 1 illustrates the input of fleet composition into the IVE model. The fleet composition is as follows: 77% of the vehicle fleet consisted of petrol vehicles, 5.2% for diesel, 3% for hybrid, and 15.4% for natural gas vehicles. Within the petrol-fueled vehicle category, 44.3% covered distances greater than 161 km, 23.4% traveled between 80-161 km, and 9.4% traveled less than 79 km. The entire diesel-fueled fleet covered distances exceeding 161 km. Regarding the natural gas fleet, 1% traveled less than 79 km, 4% between 80-161 km, and 10.4% traveled more than 161 km. It's worth noting that hybrid-fuel vehicles showed an even distribution across the three distance categories (1% each).

Table 1. Vehicle fleet categories of study area

Fuel Category		Vehicle Mileage (%)			Euro emission standard (%)					
	Vehicle population (%)	<79km	80-161 km	>161 km	EuroI	EuroII	EuroIII	EuroIV	EuroV	EuroVI
		11.4	28.4	60.93	3	21.8	3.8	10.2	52.6	8.3
Petrol	77	9.4	23.4	44.3	2	23.3	4	17	54	0
Diesel	5.2	0	0	5.2	16	61	22.5	0	0	0
Natural Gas	15.4	1	4	10.43	4.5	33	1	13.5	48	0
Hybrid	3	1	1	1	0	0	0	0	60	30

As depicted in Table 2, the calculations concern commuting within distinct fuel classifications, including petrol, natural gas, hybrid, and diesel. These calculations are linked to the service and emission inventory associated with commuting. They were derived from the IVE model and are categorized based on different fleet groups according to the Euro emission standards. Table 2 illustrates emission inventory projections for heavy morning traffic, sorted into different vehicle categories based on their Euro emission standards. This categorization is achieved using the IVE model. These projections are then multiplied by traffic activity data to comprehensively evaluate pollutant emissions. The results in Table 2 show the distribution of vehicles with different Euro emission standards across various fuel types. The findings indicate that approximately half of the petrol-fueled fleet in this study complies with EuroV standards. In contrast, EuroI, and EuroIII standards constitute a smaller proportion. Among the Natural Gas-fueled vehicles, a significant portion adheres to EuroV and EuroII standards, while EuroI and EuroIII standards represent a minor share. Diesel-fueled vehicles are divided into three categories: EuroI, EuroII, and EuroIII, with EuroII standards comprising the most significant portion. Hybrid-fueled vehicles are solely categorized under EuroV and EuroVI standards, with EuroVI being the prevailing standard within the Hybrid fuel fleet. Also, EuroVI emission standard has been exclusively observed in hybrid vehicles, while its presence in other vehicles is negligible. Consequently, IVE model's calculations yield emissions of

1,389,039 grams per service for CO_2, 43.74 grams per service for N_2O, and 6,385.38 grams per service for CH_4. The research highlights that, in terms of emissions by weight, CO_2 emerges as the dominant contributor.

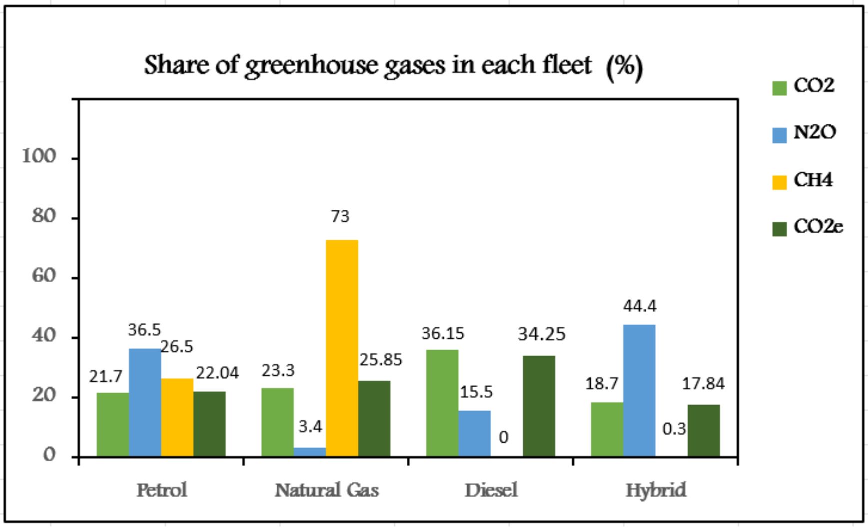

Fig.1. The emission inventory by fuel category for Fleet related to administrative service.

Fig. 1 presents the percentage of greenhouse gas emissions for three major gases—CO_2, N_2O, CH_4, and CO_2e (equivalent)—across four fuel types: petrol, natural gas, diesel, and hybrid. Analyzing these data is essential for understanding the environmental impact of various fuels and carbon footprint as well as making informed decisions for a more sustainable future and the subject of greening commute. Fig.1 shows that CO_2e emissions vary significantly among fuel types. Diesel-fueled vehicles have the highest percentage of CO_2e emissions, with 34.25%, followed by natural gas-fueled vehicles, with 25.85%. Petrol-fueled vehicles emit 22.04% of CO_2e, while hybrid-fueled vehicles contribute the least at 17.84%. This shows that diesel, natural gas, and petrol vehicles are the primary sources of CO_2e emissions in this study. When it comes to N_2O emissions, hybrid vehicles stand out with the highest contribution, representing 44.43%. Petrol vehicles follow with 36.57%, while diesel vehicles contribute 15.60%. Natural gas vehicles emit a significantly lower percentage of N_2O, at 3.40%. This data highlights that hybrid vehicles are the major source of N_2O emissions, indicating potential areas for emission reduction strategies. Lastly, focusing on CH_4 emissions, the results are remarkable. Natural gas vehicles are the dominant source, contributing a staggering 96.45%. Petrol vehicles emit a moderate 3.50% of CH_4, while hybrid vehicles and diesel vehicles emit negligible amounts at 0.05% and 0.00%, respectively. In conclusion, this analysis underscores the varying environmental impacts of different fuel types. Natural gas, diesel, and petrol-fueled vehicles significantly contribute to CO_2 emissions, whereas hybrid vehicles are prominent in N_2O emissions. However, natural gas vehicles play the most substantial role in CH_4 emissions. Understanding these distinctions is crucial for developing targeted strategies to mitigate greenhouse gas emissions and work toward a more environmentally sustainable transportation sector. A study conducted by Graham et al. concerning vehicle emissions by Environment Canada supports these findings. It revealed that CO_2 emissions are predominantly attributed to diesel and petrol-fueled vehicles, as well as the emissions of N_2O originate from buses and heavy diesel trucks (Graham, 2008). The results align with the observations of this study.

3.2. Setting of vehicle emission reduction scenario

This research presents three scenarios aimed at reducing greenhouse gas emissions, with a particular focus on mitigating vehicle pollutants and strategies to minimize them while simultaneously decreasing fuel consumption. Specifically, this study provides data on the levels of certain air pollutants such as CO_2, N_2O, CH_4, and CO_{2e}. Table 2 outlines three distinct scenarios:

- The current situation (S0)

- The Removal of diesel fleet (S1): In this scenario, the focus is on phasing out diesel-fueled vehicles from the transportation fleet. This involves replacing existing diesel vehicles, which are known for emitting high levels of pollutants, with alternative, cleaner fuel options such as natural gas-fueled vehicles.
- The replacement of the fleet with natural gas-fueled vehicles (S2): Here, the emphasis is on transitioning the transportation fleet to natural gas-fueled vehicles. This involves replacing both diesel-fueled and potentially petrol-fueled vehicles with vehicles powered by natural gas. Natural gas is considered a cleaner alternative fuel, producing lower air pollution emissions than traditional fossil fuels.
- Along with upgrading Euro IV and V vehicles by replacing them with Euro I, II, III models (S3): This scenario involves upgrading existing Euro IV and V emission standard vehicles to earlier models, specifically Euro I, II, and III. The rationale behind this upgrade is to reduce emissions from the existing fleet by replacing them with vehicles that meet older, albeit less stringent, emission standards. This approach aims to address the environmental impact of vehicles currently in use by transitioning to models with lower emissions.

This research outlines three scenarios aimed at reducing greenhouse gas emissions, focusing on mitigating vehicle pollutants, and minimizing them while decreasing fuel consumption. Specifically, the study provides data on air pollutants such as CO_2, N_2O, CH_4, and CO_2e. Each scenario, including the Removal of the diesel fleet (S1), the replacement of the fleet with natural gas-fueled vehicles (S2), and the upgrading of Euro IV and V vehicles to earlier models (S3), aligns with broader environmental goals by emphasizing the exploration of environmentally friendly fuel options. These scenarios not only aim to reduce carbon emissions but also to improve air quality and public health. By transitioning to cleaner fuel options, significant reductions in greenhouse gas emissions are anticipated, contributing to the broader objectives of environmental sustainability and carbon footprint reduction. Evaluating different control measures is crucial for establishing the baseline emission scenario, especially when developing effective strategies for reducing vehicle emissions and promoting greener commuting. The baseline scenario (S0) results highlight those emissions from commuter vehicles, including CO_2, N_2O, CH_4, and CO_{2e}, stand at 1,389,039, 43.7, 6,385.3, and 1,579,423 grams, respectively. Further examination of emission reduction scenarios presents an opportunity to advance the environmental sustainability of the current fleet in Karaj, with a particular emphasis on reducing fuel consumption and carbon emissions (Moreira et al., 2022).

Table 2. Description of the Scenario Setting

Scenarios	Scenario Description	Scenario Objectives
S0	Current Situation	- Establish a baseline for commute emissions
S1	Removal of the diesel fleet	- Evaluate the impact of removing diesel-fueled vehicles on air quality
S2	Replacement of natural gas fleet	-Assess the benefits of using natural gas-fueled vehicles instead of petrol
S3	Euro IV &V upgrade	- Investigate the emission reductions associated with replacing older EuroI, II, and III vehicles

In Table 3, the efficiency percentages of emission reduction for CO_2, N_2O, CH_4, and CO_{2e} in various scenarios aimed at mitigating emissions during administrative commutes are discussed. These scenarios are denoted as S11, S1, S2, S3, and S4. Specifically, the emission levels of greenhouse gases such as CO_2, N_2O, CH_4, and CO_{2e} are reported in this study.

Table 3. The Results of the Scenario Development and their Efficiency

	unit	**CO_2**	**N_2O**	**CH_4**	**CO_{2e}**
S0	g/service	1389039	43.7475	6385.38	1579423
S1	g/service	5600.29	0.18	22.18	6269.03
	Efficiency (%)	-99.6	-99.59	-99.65	-99.6
S2	g/service	1340607	35.89	4430.903	1474183
	Efficiency (%)	-3.49	-17.96	-30.61	-6.66
S3	g/service	5488.5	0.17	39.2	6631.15
	Efficiency (%)	-99.6	-99.61	-99.39	-99.58

3.3. Assessment of the emission reduction scenario findings

This study provides a detailed and comprehensive concept of applying the carbon footprint in the commute transportation sector in Karaj. The findings hold environmental significance in reducing CO_2 and other GHG emissions. It is evident that choosing a solution that addresses both greenhouse gas emissions and air pollutants while considering cost-effectiveness is crucial. To further facilitate decision-makers in making appropriate decisions to reduce greenhouse gases, a scenario analysis approach was used considering the current situation. Such an approach can quantitatively predict GHG emissions by examining different scenarios. In such a situation, the three scenarios are removing the diesel-burning fleet (i.e., diesel buses), using vehicles with natural gas fuel, and replacing older vehicles with Euro IV and V standards. As indicated in Table 3, in S1, the removal of diesel-fueled vehicles results in a substantial decrease in greenhouse gas emissions from commutes, with the potential to achieve a 96% reduction in greenhouse gas emissions from commuter vehicles. This finding aligns with studies by Mbandi et al., which highlight that using CNG is one of the most effective ways to reduce CO_2 emissions (Mbandi et al., 2023). Moreover, S1 shows a positive overall impact on diminishing various GHG_s, with an efficacy of around 96% in reducing CO_2, N_2O, CH_4, and CO_{2e} emissions. This underscores the substantial contribution of commute reduction in mitigating GHG_s and reducing carbon footprint. In S2, using natural gas-fueled vehicles instead of diesel and petrol vehicles results in a noticeable decrease in CH_4 emissions. However, the reduction efficiency for CO_2 is relatively lower than other gases, standing at only 3%. This scenario aligns with the outcomes of the research conducted by Shaarawi et al., where substituting fleet vehicles with natural gas fuel vehicles led to reduced GHG emissions (Shaarawi et al., 2023). Moreover, in S3 scenario, involving the replacement of the outdated EuroI, II, and III fleets with the Euro IV and V standard, demonstrates a substantial effect on the reduction of greenhouse gas emissions. In S3, by comparison, S2, demonstrates a higher efficiency in reducing emissions, with reduction rates for CO_2, N_2O, CH_4, and CO_{2e} amounting to 99.6%, 99.6%, 99.3%, and -99.5%, respectively. A similar study by Caetano et al. highlighted the importance of CO_{2e} in updated Euro vehicles (Caetano et al., 2023). According to the above analysis, it was found that the natural gas-fueled fleet has a better performance than the petrol-fueled vehicles. The natural gas fleet have the lowest CO_2 emissions, but with much higher N_2O, and CH_4 emissions, making it the best choice. (Geng et al., 2013). Generally, with the increasing urbanization process, the local government prioritize monitoring the carbon footprint resulting from transportation due to its higher CO_2 and air pollutants emissions (Geng et al., 2013). Overall, S1 and S3 are the most effective scenarios for reducing carbon footprint emissions, with an estimated reduction of 99%. The results show a significant reduction in CO_{2e} emissions, which has decreased by about 99% in both S1 and S3. The lowest reduction in carbon footprint emissions occurred in S2, where the carbon efficiency rate is only 6%. It is noteworthy that while S1 and S3 show significant efficiency in reducing carbon footprint emissions in commuting, S2 shows a significant reduction in CH_4 gas emissions. The scenario analysis yields valuable insights into strategies for mitigating carbon footprint emissions stemming from commutes. Primarily, removing diesel-fueled vehicles and then replacing updated fleets demonstrate its efficiency in decreasing overall GHG and significantly influencing the reduction of carbon emissions. Hence, decision-makers should prioritize these strategies in this domain to lessen commuting and curb carbon and other GHG_s.

4. Conclusion

In conclusion, utilizing the IVE model has facilitated the creation of one of the initial carbon footprint emission inventories for commuting in Karaj. This research reveals that commutes in Karaj produced 1579423 g CO_{2e}, the predominant GHG. The findings of the base scenario revealed that the emissions of other GHG_s in commute are 1389039 g for CO_2, 43.74 g for N_2O, and 6385.38 g for CH_4. Studying three carbon footprint emission reduction scenarios holds promise for addressing the current situation of vehicle emissions. These scenarios include removing diesel-fueled vehicles, using vehicles with natural gas fuel instead of diesel and petrol vehicles, and replacing Euro 4 and Euro 5 with older vehicles. After evaluating these scenarios, it becomes evident that S1 and S3 represent the most optimal strategies within the fleet. These scenarios are poised to yield the most effective reduction in carbon footprint. In these scenarios, the efficiency rate of CO_{2e} is 99% by removing and replacing diesel-fueled fleets. This substantial reduction underscores the significant impact of curbing carbon emissions from GHG_s. Considering that urban areas often witness vehicle fleets contributing significantly to carbon emissions, it is reasonable to conclude that S1 and S3 appear the most suitable scenarios for reducing emissions. In addition, both scenarios show a significant reduction in the carbon emissions associated with commuting. This analysis shows that reduced commuting in congested cities significantly reduces greenhouse gas emissions from mobile sources. The findings emphasize the importance of reducing carbon footprints and commuting, which should not be ignored when reducing air pollution. Strategic planning and developing strategies to minimize greenhouse gases caused by commuting play an essential role in reducing emissions and controlling carbon. Finally, this study also faced challenges in data collection due to the COVID-19 pandemic, impacting its efficiency. The reliance on standard scenarios introduces uncertainty in projecting future emissions. While recognizing these limitations, the study offers valuable insights, paving the way for future research to refine and enhance the accuracy of assessments.

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