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Impact of Fuel consumption in the transportation sector on people, animals, and plant life in Kabul city

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ABSTRACT

This research focused on fuel consumption and its dangerous emission and negative impact on people, animals, and plants' life in Kabul city. This research is evaluated and described total fuel consumed by all vehicles as2,306,481 m^3/year, in a separate form:911,542m^3/year petrol consumption and1,394,939 m^3/year diesel consumption. Also, the amount of pollution which is emitted from burning these fuel-based resources is 2,180,408ton/year CO_2, 46 ton/year NO_X, 529kg/year SO_X from the total amount of petrol consumption, and 3,431,550ton/year CO_2, 642 kg/year from diesel consumption. It is suggested to use applicable technologies and approaches to reduce fuel consumption and air pollution such as reducing trips, using public transportation, walking down and using bicycles, using biodiesel, preferring multiple occupant vehicles, electrical bus infrastructure develop, and expanding the use of clean fuel vehicles, Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG).

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1. Introduction

Kabul is the capital of the Islamic Republic of Afghanistan, with about 6 million population, located in the southeast of the country [1]. The transportation sector is like the ligature of a country. From one side, transportation activity support increased mobility demands for traveler and portage. On the other side, transport activities have resulted in growing levels of motorization and congestion. There are approximately 605,517 motorized vehicles (cars and motorcycles) in this city [2]. Fuel consumption by these vehicles has been causing multiple problems such as air pollution, water pollution, and noise. That is why Kabul is ranked the most polluted city in the world. As a result, the transportation sector is becoming increasingly linked to environmental problems. With a technology relying heavily on the combustion of hydrocarbons, notably with the internal combustion engine, the impacts of transportation over environmental systems has increased with motorization and fuel consumption.

Utilization of any kind of fuel in this city which is neither standard nor high quality generates a different kind of dangerous components such as Particulate Matter (PM), Carbon Dioxide (CO_2), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), Ozone (O_3), and other greenhouse gases. These components have caused the extremely high air pollution in this city, which resulted in asthma and respiratory system illnesses. Afghanistan depends on fossil fuels. Imports and usage of low-quality fuels (which has a higher amount of CO_2 and a component of greenhouse gases) by the transportation sector, including all cars and motorcycles, caused air pollution, dangerous problems, and various health risks like cancer, cardiovascular, respiratory and neurological diseases. Inhaling of Carbon Monoxide CO causes damage to the bloodstream. The lack of oxygen can be very harmful to human health. NO_2 emission reduces lung function, causing increased respiratory problems [3]. SO^2 and NO_X emissions create acidic rain when they mix with water Acidic rain explicitly affects the environment and causes forest decline and has adverse effects on agriculture crops. These fuels reduce natural availability and have an unfavorable impact on the life quality and attractiveness of touristic sites [4].

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2. Proposed Solution

In today's complex world, with hazardous chemicals gases from burning fossil fuel and gasoline-burning on the highway, the idea of being able to reduce air pollution is emerging. Like the rest of the world, large cities use technologies and fuel consumption reduction approaches, which lead to air pollution reduction. We can make sustainable transportation for Kabul city too by suggesting the below methods.

1- Reducing trips
2- Use of public transportation
3- Walking and bicycle use
4- Biodiesel
5- Multiple occupant vehicles
6- Electrical bus infrastructure
7- Expanding the use of clean fuel vehicles

2.1. Reducing trips

This option helps us to reduce the amount of fuel consumption and emissions, combining smaller loads into a single transport, which means finding alternatives for short distances. Households with multiple cars can drive one car at a time, which can be another method.

2.2. Use of public transportation

A single-vehicle can transport a large number of people. The usage of public transportation is another option that can help us to make sustainable transportation; for example, we can use a bus that carries 30 people on a given day instead of 15 small cars. Every bus consumes 33.3 liters of fuel per day, and every small car consumes 5.2 liters of fuel in one day, so 15 small cars fuel consumption can be equal to 78 liters of fuel. If we imagine 50 percent of this amount is diesel fuel, it can generate 93.327 kg/day CO_2, 0.00234 kg NO_X, and 0.00001794 kg SO_X emission and 95.94 kg/day CO_2, 0.00195 kg/day NO_X and 0.00002262 kg/ day SO_X emissions for an estimate of 15 small cars in each day[5].

In this case, the usage of one bus can help to reduce these amounts of pollution in one day significantly. Assuming the price of one bus is $40,000.00 and one small car is $4,000.00, we need to reduce the pollution caused by 15 cars. The price of 15 cars is equal to $60,000.00. Consequently, we can save $20,000.00 by using public transportation and also increase the frequency of busses for better accessibility. They are less expensive and easily accessible. By taking these measures, we can help reduce fuel consumption and pollution. If the price of one litter diesel is 55 AFN and someone consumes 7.8 litter in one day, the total price is equal to 429 AFN. Also, if one small car consumes 5.2-liter diesel in one day, its fuel consumption price is equal to 286 AFN. The price of diesel for15 cars is equal to 6,435 AFN in one day, so we can save 6,149 AFN in one day from fuel consumption if we use public transportation.

Table 1: Public transportation improvement.

Vehicles	People	Fuel Consumption L/Day	Fuel Consumption L/Year	Price of Fuel (AFN)/day	Price of Fuels AFN/year	Vehicles price $
Bus	30	33.3	12,045	1,815	662,475	40,000
15 small cars	30	78	28,470	4,290	1,565,850	60,000
Saving		44.7	16,425	2,475	903,375	20,000

The amount of pollution generated from this comparison between 15 small cars and one bus if we estimate 50% of these cars consume diesel fuel or 39 liters and 50% consume petrol fuel or 39 litters is shown in Tables 2-3.

– 15 small cars (78L/day):

Table 2: Fuel consumption.

Fuels	CO_2 kg/day	NO_X kg/day	SO_X kg/day
Petrol	93.327	0.00,195	0.00002262
Diesel	95.94	0.00,234	0.00001794
Total	189.267	0.00429	0.00004056

– Bus (33.3/day):

Table 3: Amount of GHGs pollution.

Fuels	CO_2 kg/day	NO_X kg/day	SO_X kg/day
Total	81.918	0.001998	0.000015318

– Walking and bicycle use

Using this option for nearby places like schools is considered as a health benefit and reduces greenhouse gas emissions. For this adoption, the government must make bicycle lanes and implement bicycle policy usage. For example, if 100 people use bicycles in place of 50 cars and the price of one bicycle is 4000 AFN, and the price of one car is $4,000.00, so the price of 50 cars will be $200,000.00, and fuel consumption of one small car is 5.2L/day. Fifty cars' consumption is equal to 260 liters/day and 94,900 liters of fuel/year while, on the other hand, bicycles are pollution-free and have health benefits.

Table 4: Compare between a bicycle and motorized vehicles.

Vehicles	Number	Vehicle Price	Fuel Consumption/Day	Fuel Consumption/Year	CO_2 Emission kg/Day	CO_2 Emissions kg/Year
Bicycle	100	4,000AF	No fuel	Free	Free	Free
Cars	50	$200,000	260	94,900	621.92	227,000.8
Saving		11,400,000	260	94,900	621.92	227,000.8

2.3. Biodiesel

Using biodiesel cars is one of the major causes of reducing pollution option for Kabul city. Assuming the price of one biodiesel car is the same as usual private cars $4,000.00 and fuel price is $600.00-$800.00/barrel or one litter of this fuel is $0.7 approximately, it is also the same price of private cars. However, the amount of pollution which is generated by these cars is 95% less than real-world petrol and diesel cars. "The NGA also states that one litter of biodiesel reduces net emissions of CO_2 by over 95%, so one litter of biodiesel will save approximately 2.5kg of CO_2 [6].

Table 5: Comparison of usual and biodiesel cars.

Vehicles	Cars Price	Fuels price	Fuel consumption L/day	Fuel consumption L/year	CO_2 emission Kg/day	CO_2 emission Kg/ year
1 Usual cars	4,000$	55Afg	5.2	1,898	12.4384	4540.016
1 Biodiesel cars	4,000$	55Afg	5.2	1,898	0.62192	2270.008
Saving	0	0	0	-	11.81648	2270.008

2.4. Multiple occupant vehicles

Using multiple-occupancy vehicles, instead of single-occupancy vehicles going in the same direction, is another option. It involves every type of car people drive. For example, if five people work in the same company, and all 5 drive their own cars every day to work instead of car-pooling and each car consumes 5.2 litters of petrol fuel, they sum up to 26 liters of fuel. With that being said, multiple occupant cars can save 20.8 litters petrol in one day and 7,592 litters in one year. If the price of every litter of petrol is 57 AFN then the cost of fuel consumption for one car equals 269.4 AFN but the cost of fuel consumption of 5 cars equals 1,482 AFN so we can save 1185.6 AFN in one day and 432,744 AFN in one year. By using five cars or by consumption of 26 litter petrol, we generate 62.192kg/L CO_2 emission and 22,700.08kg/year from one car. If only one car is used in place of five cars, 5.2 litter petrol will generate 12.4382kg/L CO_2 emission in one day and 4,539.943kg/year CO_2 emissions.

Table 6: Single and more private cars competence.

Vehicles	Fuel consumption L/day	Fuel consumption/year	Fuel price (AFN)/day	Fuel price AFN/year	CO_2 emission Kg/day	CO_2 Emission Kg/year
5 private cars	26	9,490	1,482	540,930	62.192	22,700.08
1 private car	5.2	1,898	269.4	98,331	12.4382	4,539.943
Saving	20.8	7,592	1,185.6	432,744	49.7538	18,160.137

2.5. Electrical bus infrastructure

Using electric vehicles is a great alternative to reduce pollution and make the transportation system more sustainable–one electrical bus costs between $4,000.00-$189,000.00. As per average consumption, we assume the cost of one car is $60,000.00. If we assume approximately ten cars for one unit of an area, then the price of ten cars is 600,000$. If we assume using 15 small cars where the price of one car is $4,000.00, then the price of 15 cars is $60,000.00. Then using a bus instead of 5 cars has a significant difference; one charging bus has no consumption of fuel while the consumption of small cars if they are running on petrol fuel, is equal to 78 L petrol in one day. This results in saving 78 L fuel in one day and 28,470 L in one year, and the amount of pollution charging bus produces is no pollution but 15 small cars which combust 78 litter petrol/day generate 186.576 kg/day CO_2 emission and in one year which is 68,100.24kg/year.

Moreover, another benefit is cost-saving as the fuel consumption of every litter of petrol costs 57 AFN and the cost of 78 liters petrol is 4,446 AFN/day while charging a bus does not need fuel and their batteries are designed to be charged by solar penal grid systems which creates zero pollution without exporting electricity from other countries and reduces energy dependency.

Table 7: Diesel and electric bus comparison.

Vehicles	Vehicle price $	Fuel consumption L/day	Fuel Consumption L/year	Fuel price AFN/day	Fuel price AFN/year	CO_2 Emission Kg /day	CO_2 Emission kg /year
Charging bus	60000	Free	Free	Free	Free	Free	Free
Diesel bus	60,000	33.3	12,154.5	1,898.1	692806.5	81.918	29,900.07
15 Small cars(petrol)	60,000	78	28,470	4,446	1,622,790	186.576	68,100.24

2.6. Expanding the use of clean fuel vehicles

The usage of clean fuel vehicles such as Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG) is one of the best ways for reducing air pollution and making sustainable transportation for Kabul city.

- LPG: Each private care consumes 5.2L/day of petrol fuel, which means that ten cars consume 52 L/day. The price of one liter of petrol is 57 AFN. For one car, it is 296.4 AFN, and for ten cars the price of petrol fuel is 2694 AFN/day, which is equal to 18,980 L/year, and its price is equal to 1,081,860 AFN/year. 18,980L/year generates 124.384 kg/day CO_2 emission and 45,400.16 kg/year CO_2 emission. Instead of this, 10 LPG fuel cars consume half the amount f fuel used by other private cars. If usual private cars consume 10 liters/100 km, LPG cars consume five liters/100 km, so 5.2 liters in one private car. LPG cars consume 2.6 litter, and the fuel consumption of 10 cars of this type is equal to 26 L/day, 9,490 L/year and the price of fuel is 1,482 AFN/day and 540,930 AFN/year. That is why converting ten private cars to LPG cars will save money significantly.
- CNG is a gaseous fuel (natural gas), stored under high pressure. Consequently, the consumption can be expressed in Nm^3/100km, but also in kg/100km. Nm^3 stands for a cubic meter under normal conditions (1 atm) pressure. Consumption of natural gas vehicles is, however, most often expressed in kg/100 km. Different types of natural gases are available, roughly divided into two categories: low and high calorific gas (L- and H-gas). CO_2 emissions differ between both categories and strongly depend on the composition and origin of the gas. The calculations below are therefore

merely indicative. The public CNG stations in Belgium mainly offer low calorific gas. It can be seen that the CO_2 emissions per kg of H-gas are higher than those of L-gas. H-gas. However, it contains more energy, so it will need less kg of gas per 100 km, which ensures that, at least in theory, the average CO_2 emissions from CNG vehicles are independent of the gas type used. Consumption of these types of cars is half the consumption of other cars. For example, if a new usual small or private car consumes 10 kg petrol or diesel in every 100 km (10 kg/100 km) in CNG cars, it reduces to 5 kg fuel (5 kg/100 km), which is the most significant difference of fuel consumption between 2 cars of these type. By saving fuel can save the fuel price. It also reduces pollution because CNG fuels generate less CO_2 emission than petrol and diesel fuels [7].

3. Methodology and survey

This topic focuses on Kabul city fuel consumption, vehicles, vehicle suppliers, and machinery. The methodology of this research is as follows: data were collected through data and figures provided by the ministry and also through the interviews and questionnaires, which were conducted in National Environment Protection Agency (NEPA) and Kabul municipality. It is worth mentioning that public surveys were conducted for the determination of the average consumption of both diesel and petrol. Then we calculated emissions like CO_2, NO_X, SO_X, which were caused by the consumption of fuels and finally suggested technology and approaches to reduce fuel consumption and air pollution.We surveyed different fuels used in Kabul city such as petrol, gas, and diesel and took the average of fuel consumption. Table 8 shows the number of cars and vehicles of Kabul's transportation system.

Table 8: Number of vehicles in Kabul city.

Kind of Cars	Number of Cars	Petrol	Diesel	Annual Growth
Private	370,577	80%	20%	0.80%
Truck	82,986	5%	95%	1.83%
Bus	34,501	5%	95%	2.96%
Taxi	28,488	70%	30%	0.53%
Motorcycle	39,029	100%	-	6.80%
GV	36,611	85%	15%	1.58%
T.V	13,325	95%	5%	0.21%

Figure 1 is a graph of diesel consumption/month, which shows 90% of large cars, 15% of small cars, and 10% of medium cars use this type of fuel in this city. Figure 2 is a graph of petrol consumption/month which shows 100% of motorcycle use petrol fuel, 90% of medium cars, 85% of small cars, and 10% of large cars use this type of fuel in this city.

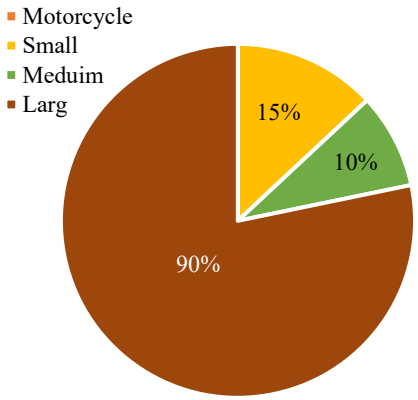

Figure 1. Diesel fuel consumption.

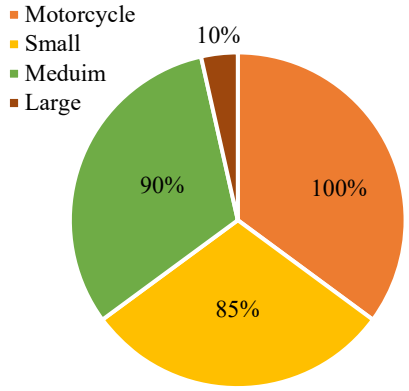

Figure 2. Petrol fuel consumption.

4. Pollution analysis

According to the survey, the vehicles were categorized into four types, and the fuel consumption of these vehicles per day, per year, and month was found. This consumption was as follows: 27877.85714 L/day from the motorcycle as the first category, 2075138 L/day for small cars as the second category, 389500.8 L/day for the medium cars as the third category, and 3916233.333 L/day for the large cars as the last category Fuel consumption per month and year is also shown in Table 9.

Table 9: All cars fuel consumption.

Types of car	Number of cars	Fuel consumption L/day	Fuel consumption L/week	Fuel consumption L/ month	Fuel consumption L/year
Motorcycle	39,029	27,877.85714	195,145	780,580	9,366,960
Small	399,065	2,075,138	15,563,535	62,254,140	747,049,680
Medium	49,936	389,500.8	2,921,256	11,685,024	140,220,288
Large	117,487	3,916,233.333	29,371,750	117,487,000	1,409,844,000
Total					2,306,480,928

Table 10 shows the amount of petrol consumption and diesel consumption, which are indicated per year and per day. It is indicated as 911,542m^3/year petrol consumption and 1,394,939m^3 /year diesel consumption

Table 10: All cars fuel consumption.

Type of cars	number of cars	fuel consumption L/day	fuel consumption L/week	fuel consumption L/ month	fuel consumption L/year
motorcycle	39,029	27,877.85714	195,145	780,580	9,366,960
small	399,065	2,075,138	15,563,535	62,254,140	747,049,680
medium	49,936	389,500.8	2,921,256	11,685,024	140,220,288
Large	117,487	3,916,233.333	29,371,750	117,487,000	1,409,844,000
Total					2,306,480,928

By finding the fuel consumption of all cars and separating it from fuel consumption of diesel and petrol fuels, now we can calculate the amount of emission caused by these vehicles such as CO_2, NO_X, SO_X emissions and the amount of CO_2 emission by combustion of fuels from cars per day and per year. So, the total amount of petrol consumption generates 2,180,408.099 tons CO_2 each year and the total amount of diesel consumption generate 3,431,550.139 tons CO_2 emission every day in Kabul city.

Table 11: Petrol and diesel consumption.

Fuel type	Fuel consumption m^3/year	CO_2 emission coefficient kg/m^3	CO_2 ton/ year
Petrol consumption	911,541.8472	2.392	2,180.408,099
Diesel consumption	1,394,939.081	2.460	3,431.550,139

If the amount of CO_2 in each m^3 of petrol is 2,392 kg and in each m^3 of diesel fuels 2,460 kg, then 1 metric ton = 1000 kg.

Table 12 shows the amount of NO_X emission by combustion of fuels from cars in one day and one year in Kabul city, which indicates 46tons/year NO_X emission from total petrol consumption and 84 tons/year NO_X emission from total diesel fuels consumption (if the amount of NO_X is 0.05 in each m^3 of petrol and 0.06 in each m^3 of diesel fuels).

Table 12: NO_X emissions.

Fuel types	Fuel consumption m^3/year	NO_X emission coefficient kg/m^3	NO_X Emission ton/ year
Petrol Consumption	911,541.8472	0.05	45.57709236
Diesel Consumption	1,394,939.081	0.06	83.69634485

Table 13 shows the amount of SO_X mission by the combustion of fuels from cars in one day and one year in Kabul city. They generate 529 kg SO_X from the total consumption of petrol and 642 kg SO_X from the total consumption of diesel fuels if the amount of SO_X emission is 0.00058 kg in each m^3 of petrol and 0.0046 kg in each m^3 of diesel.

Table 13: SO_X emissions.

Fuel types	Fuel consumption m^3/year	SO_X emission coefficient kg/m^3	SO_X emission kg/ year
PetrolConsumption	911,541.8472	0.00058	528.6942714
Diesel Consumption	1,394,939.081	0.00046	641.6719772

5. Conclusion

This research studied and described the fuel consumption in the transport sector, which has a negative effect on the environment by creating several pollution components.

The amount of pollution or dangerous components which are generated by fuel consumption in the transport sector such as CO_2, NO_X, SO_X is 561,195,824 kg, 1,292,734,372 kg, and 1,170,366,249 kg, respectively. The solutions to reduce these pollutions are proposed as reducing trips, improving public transport infrastructure, walking down and using the bicycle, using biodiesel cars, multiple occupants vehicles, approving electrical bus infrastructure, and using clean fuel vehicles. All possible approaches are analyzed and discussed in this study, which enables the policy and decision-makers to consider several solution mechanisms.

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