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MOBILITY COST

A Case Study for Lebanon

2015 MINISTRY OF ENVIRONMENT

MOBILITY COST:
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Mobility Cost: A Case Study for Lebanon

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Foreword

Ministry of Environment

Through the publications of Lebanon's Initial and Second National Communications to the United Nations Framework Convention on Climate Change, and the Technology Needs Assessment for Climate Change, the Ministry of Environment drew the large climate change picture in the country. The picture shed the light on a number of climate change matters: Lebanon's contribution to global greenhouse gas emissions, the sectoral share of national emissions, the socio-economic and environmental risks that the country faces as a result of climate change, and the potential actions that could and should be undertaken to fight climate change both in terms of mitigation and adaptation.

Through these series of focused studies on various sectors (energy, forestry, waste, agriculture, industry, finance and transport), the Ministry of Environment is digging deeper into the analysis to identify strengths, weaknesses, threats and opportunities to climate friendly socio-economic development within each sector.

The technical findings presented in this report (Mobility Cost: A Case Study for Lebanon) will support policy makers in making informed decisions. The findings will also help academics in orienting their research towards bridging research gaps. Finally, they will increase public awareness on climate change and its relation to each sector. In addition, the present technical work complements the strategic work of the National Climate Change Coordination Unit. This unit has been bringing together representatives from public, private and non-governmental institutions to merge efforts and promote comprehensive planning approach to optimize climate action.

We are committed to be a part of the global fight against climate change. And one of the important tools to do so is improving our national knowledge on the matter and building our development and environmental policies on solid ground.

Mohammad Al Mashnouk

Minister of Environment

Foreword

United Nations Development Programme

Climate change is one of the greatest challenges of our time; it requires immediate attention as it is already having discernible and worsening effects on communities everywhere, including Lebanon. The poorest and most vulnerable populations of the world are most likely to face the harshest impact and suffer disproportionately from the negative effects of climate change.

The right mix of policies, skills, and incentives can influence behaviour and encourage investments in climate development-friendly activities. There are many things we can do now, with existing technologies and approaches, to address it.

To facilitate this, UNDP enhances the capacity of countries to formulate, finance and implement national and sub-national plans that align climate management efforts with development goals and that promote synergies between the two.

In Lebanon, projects on Climate Change were initiated in partnership with the Ministry of Environment from the early 2000s. UNDP has been a key partner in assisting Lebanon to assess its greenhouse gas emissions and duly reporting to the UN Framework Convention on Climate Change. With the generous support of numerous donors, projects have also analysed the impact of climate change on Lebanon's environment and economy in order to prioritise interventions and integrate climate action into the national agenda. UNDP has also implemented interventions on the ground not only to mitigate the effects of climate change but also to protect local communities from its impact.

This series of publications records the progress of several climate-related activities led by the Ministry of Environment which UNDP Lebanon has managed and supported during the past few years. These reports provide Lebanon with a technically sound solid basis for designing climate-related actions, and support the integration of climate change considerations into relevant social, economic and environmental policies.

Ross Mountain

UNDP Resident Representative

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Acronyms

AAA	American Automobile Association
BRT	Bus Rapid Transit
CAS	Central Administration of Statistics
DALY	Disability-Adjusted Life Year
EIA	Energy Information Administration (US)
GBA	Greater Beirut Area
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HEV	Hybrid Electric Vehicle
HP	Horsepower
IMF	International Monetary Fund
iRAP	International Road Assessment Programme
ISF	Internal Security Forces
MACRS	Modified Accelerated Cost Recovery System
MENA	Middle East and North Africa
MoEW	Ministry of Energy and Water
MoF	Ministry of Finance
MoIM	Ministry of Interior and Municipalities
MPM	Motorized Private Mode
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development
PM	Particulate Matter
PP	Purchase Price
PT	Public Transport
SCC	Social Cost of Carbon
SD	System Dynamics
SUV	Sport Utility Vehicles

TNA	Technology Needs Assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VAT	Value-Added Tax
VOCs	Volatile Organic Compounds
VoSL	Value of Statistical Life
VTT	Value of Time Travel
WDI	World Development Indicators
WEO	World Economic Outlook
WHO	World Health Organization
WTP	Willingness to Pay

Executive summary

It has been well established in numerous studies that the Lebanese passenger transport sector is unsustainable. This study provides an approach from the cost side of mobility to generate recommendations in order to move the Lebanese passenger transport sector towards sustainable ground.

It provides a particular methodology to calculate mobility cost in Lebanon, where data and information are scarce. One average conservative figure for mobility cost was yielded: one passenger travelling one kilometer in a passenger vehicle, including externality components of pollution, travel time, congestion, and accident costs around US¢ 48. Also, calculating mobility cost components in this study inspired the inception of important "sustainable mobility indicators" for Lebanon. It was found that the most critical indicators were not emissions or safety-related, but mostly pointed towards an excessive energy consumption by the passenger transport sector, mainly fossil fuels. Also, the number of vehicles in the passenger car fleet revealed to be excessively high with an ownership rate of one car for every four individuals, dominated by inefficient and old vehicles.

Hence, the indicators have facilitated comparing Lebanon's transport state to other countries and to establish a combination of measures and policies. The development of a public transportation system, and the renewal of the current passenger fleet, among other recommendations, would shift Lebanon's passenger transport towards more sustainable ground. With the right policies, this could lead to a decrease in the number of car usage and consequently that of car accidents, a reduction in the level of Greenhouse Gas (GHG) emissions as well as the intensity of congestion.

الملخص التنفيذي

لقد ثبت في العديد من الدراسات إلى أن قطاع نقل الركاب اللبناني غير مستدام. وتقدم هذه الدراسة مقاربةً في ما يتعلق بتكاليف التنقل بهدف التوصل إلى توصيات من أجل تحريك قطاع نقل الركاب اللبناني نحو أسسٍ مستدامة.

وتقدّم الدراسة منهجية معينة لاحتساب تكلفة التنقل في لبنان حيث البيانات والمعلومات شحيحة. لقد تمكّنا من الحصول على رقم واحد تحفظيّ لتكلفة التنقل: فتنقّل راكب واحد مساحة كيلومتر واحد في سيارة ركاب، بما في ذلك عناصر العوامل الخارجية من تلوّث وزمن السفر والازدحام والحوادث، يكلّف حوالي ٤٨ سنتًا أميركيًا. إضافة إلى ذلك، فقد بعثت عملية احتساب مكونات تكلفة التنقل في هذه الدراسة على إنشاء «مؤشرات التنقل المستدامة» المهمة للبنان. وقد تبين أن المؤشرات الأكثر أهمية لم تكن الانبعاثات أو تلك المتعلقة بالسلامة، فقد تمت الإشارة في معظم الأحيان إلى الاستهلاك المفرط للطاقة من قبل قطاع نقل الركاب، وللوقود الحفري بشكل رئيسي. كما تبيّن أن عدد المركبات في قافلة سيارات الركوب هو رقم عالٍ بشكل مفرط مع معدل ملكية سيارة واحدة لكل أربعة أفراد، مع سيطرة للمركبات غير الفعالة والقديمة.

بالتالي فقد سهّلت المؤشرات عملية مقارنة وضع النقل في لبنان مع بلدان أخرى وإنشاء مجموعة من التدابير والسياسات. وأما إنشاء وسائل نقل عام منظمة وتجديد أسطول نقل الركاب الحالي، من بين توصيات أخرى، فمن شأنه أن يحرّك قطاع نقل الركاب في لبنان نحو أسس أكثر استدامة. وأخيرًا، من المفترض أن يؤدي هذا التحرّك إلى انخفاض في عدد السيارات وبالتالي في عدد حوادث السيارات وانخفاض في مستوى انبعاثات الغازات الدفيئة فضلًا عن شدة الازدحام.

1. Introduction

It is uncontested that in Lebanon, a small developing Mediterranean country in the Middle East, the transportation sector is highly unsustainable from different perspectives. This paper treats the issue of the Lebanese passenger transportation sector in particular, which is highly polluting, heavily congested and greatly reliant on fossil fuels.

The car fleet is mainly composed of relatively old vehicles, with about 62% dating from the 1970s and 1980s, and mainly equipped with engines with a large displacement volume: more than 60% of the vehicles have an engine displacement of 2.0 liters and above (MoE/URC/GEF, 2012). This specific fleet composition, coupled with a high vehicle ownership, reaching 3.7 individuals per car, and a low vehicle occupancy, counting 1.2 passengers per car, renders the passenger fleet highly polluting (MoE/URC/GEF, 2012).

The latter fleet characteristics, high vehicle ownership and low occupancy rate, create heavy congestions during peak hours, especially on entries and exits of Beirut, the capital city. The Ministry of Interior and Municipalities (MoIM) reports a total ground fleet of around 1.3 million vehicles, out of which 1.07 million are private vehicles (MoIM, 2012).

The public transport service includes old buses and minibuses and is unreliable because it neither runs on a specific schedule nor on dedicated lanes. It also includes taxis, most of them old and dating back to the 1980s (MoE/URC/GEF, 2012).

In terms of energy and fossil fuel consumption, 60% of national oil consumption went to the transport sector in the year 2008, with gasoline consumption by the transport sector constituting more than 99% (IEA, 2008). In fact, this heavy consumption of fossil fuels has led to high levels of Greenhouse Gas (GHG) emissions, notably carbon dioxide (CO_2): the passenger transport sector was responsible for 25% of CO_2 emissions in the year 2000, and has since witnessed an increase of 114% (MoE/URC/GEF, 2012; MoE/UNDP/GEF, 2014).

Hence, for the case of Lebanon, three key aspects of unsustainable mobility have been identified, and it has been established that a shift towards a more sustainable passenger transport sector is crucial. This paper only focuses on cars and Sport Utility Vehicles (SUV), and does not include motorcycles and freight vehicles in the analysis. Moreover, the paper adopts the concept of mobility cost as a benchmark and a medium for this shift. Mobility is by definition the movement of passengers (and goods) from an origin to a destination, and therefore, mobility cost is the cost borne by society at large due to this movement. This cost includes ownership and vehicle operating costs, borne by the driver (also assumed to be the car owner), in addition to the cost of externalities, including but not limited to the costs of pollution, climate change, accidents, congestion and travel time. The cost of externalities is borne by society as a whole. The final figure of mobility cost is expressed in United States Dollars (USD) per passenger kilometer (USD/pass.km) and thus would give an indication of how much it would cost one passenger to travel a distance of one kilometer on the roads in Lebanon. The calculation is performed for four separate vehicle categories, divided depending on the engine displacement.

Following the calculation of mobility cost, cost components are benchmarked against neighboring countries in the Middle East and North Africa (MENA) region and within the Gulf Cooperation Council (GCC) area, as well as other developed Mediterranean countries, such as Greece and Cyprus.

Furthermore, several "sustainable transportation" indicators are analyzed in order to benchmark Lebanon's "sustainability status" against the aforementioned countries. In fact, the environmental, social, car ownership and energy efficiency indicators discussed here will form concrete and standard indicators for sustainable transportation in Lebanon.

In this study, "sustainable transportation" and "sustainable mobility" are used interchangeably, as per the European convention (Black, 2010). Doing so will allow for a specific comparison of mobility cost components and sub-components, and will draw recommendations that will assist in shaping policies to shift Lebanon's passenger transport sector towards sustainability.

Finally, having identified specific mobility indicators, devising measures and policies with an ultimate aim to improve the Lebanese passenger transport sector, facilitates monitoring Lebanon's progressive shift (Black, 2010).

2. Background

2.1. Lebanon's case

To this day, several papers and projects tackled the transportation sector in Lebanon and have stressed the fact that there is an urgent need for new, innovative and feasible solutions for the Lebanese transport sector to shift towards sustainability. The current state suffers from high congestion, high pollution and a dependence on fossil fuels for mobility.

Two mitigation strategies have been repeatedly suggested (MoE/UNDP/GEF, 2011; MoE/URC/GEF, 2012; MoE/UNDP/GEF, 2015):

- A car scrappage program that aims at decreasing the number of old, highly polluting cars and replacing them with newer, fuel-efficient models as well as Hybrid Electrical Vehicles (HEV). Fuel-efficient vehicles are a priority, as HEVs would require a more thorough study such as done by Buekers et al. (2014) to make them rechargeable with solar panels as the electricity generation in Lebanon remains fossil fuel-based (Fardoun et al., 2012).

- The revitalization of the Public Transport (PT) system through creating and operating a Bus Rapid Transit (BRT) system on dedicated lanes in the Greater Beirut Area (GBA), mainly in order to improve air quality and relieve congestion.

Currently, the scrappage program and the BRT system are in the feasibility study phase. However, none of the mentioned solutions or any other strategies would optimally work on their own, unless they were to be accompanied by a series of appropriate policies that would present incentives to the population and stakeholders, in order to approve of, support and contribute to the solutions.

In fact, the recommendations stemming from this study are a set of measures and policies that would allow transportation in Lebanon to shift from its current state to become more sustainable. The catalyst allowing this shift is the cost component of mobility, and the indicators would serve as progress checks for the shift towards sustainable mobility (Black, 2010).

2.2. Sustainable mobility and its indicators

Sustainable mobility is formally defined as a movement of goods and services which respects the ability to meet society's desires and needs to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values, today or in the future (WBCSD, 2009).

Sustainable mobility therefore has five pillars: accessibility, affordability, safety, efficiency and emissions. Accessibility is not within the scope of this study; however, the remaining four pillars are considered, and are the inspiration and motivation behind the inception of appropriate indicators. In fact, the mobility cost figure first captures the affordability of passenger transportation and is at the core of this study. Then, indicators to capture the degree of transport safety are generated, led by the number of fatalities in car accidents. Furthermore, efficiency in this context refers to the energy efficiency, while energy indicators examine energy consumption by the passenger transport sector. Also, emissions is a classic and principal criterion when it comes to sustainability. In Lebanon's case, GHGs and notably CO_2 emissions are investigated, and therefore the "emissions" indicators reflect the level of CO_2 emissions in Lebanon. A final indicator category related to car ownership is introduced, due to its relevance to the case study and its close ties to the other pillars of sustainable mobility. The indicators are incepted and compared to other different countries when data is available. The affordability of transport is also thoroughly examined.

3. Methodology

The computation of mobility cost in Lebanon is a challenging task to undertake due to the lack of data and detailed documentation, mainly in public organizations. Therefore, the proposed methodology consists of a number of assumptions and estimations, with an effort to avoid using proxies from international sources and yield original results for the case of Lebanon. The base year for the study is the year 2010, since it is the year with the most available and accurate data.

Mobility cost is calculated for four different car categories, as follows: cars equipped with an engine size smaller than 1.5 liters are referred to as "small", cars with an engine size varying between 1.5 liters and 2.0 liters as "medium", cars with an engine size between 2.0 liters and 3.0 liters as "large", and finally cars with engine displacements larger than 3.0 liters as "SUVs". It should be noted that the terms for vehicle categories are purely indicative of the engine size, rather than pointing to a model or a specific vehicle line (limousines with an engine size of 6.0 liters for example, still fall under the "SUV" category).

The total figure of mobility cost is the sum of the costs of the individual components, as indicated in equation 1 to equation 4 (Figure 1), and is expressed in USD/veh.km (USD per vehicle kilometer) and USD/pass.km (USD per passenger kilometer).

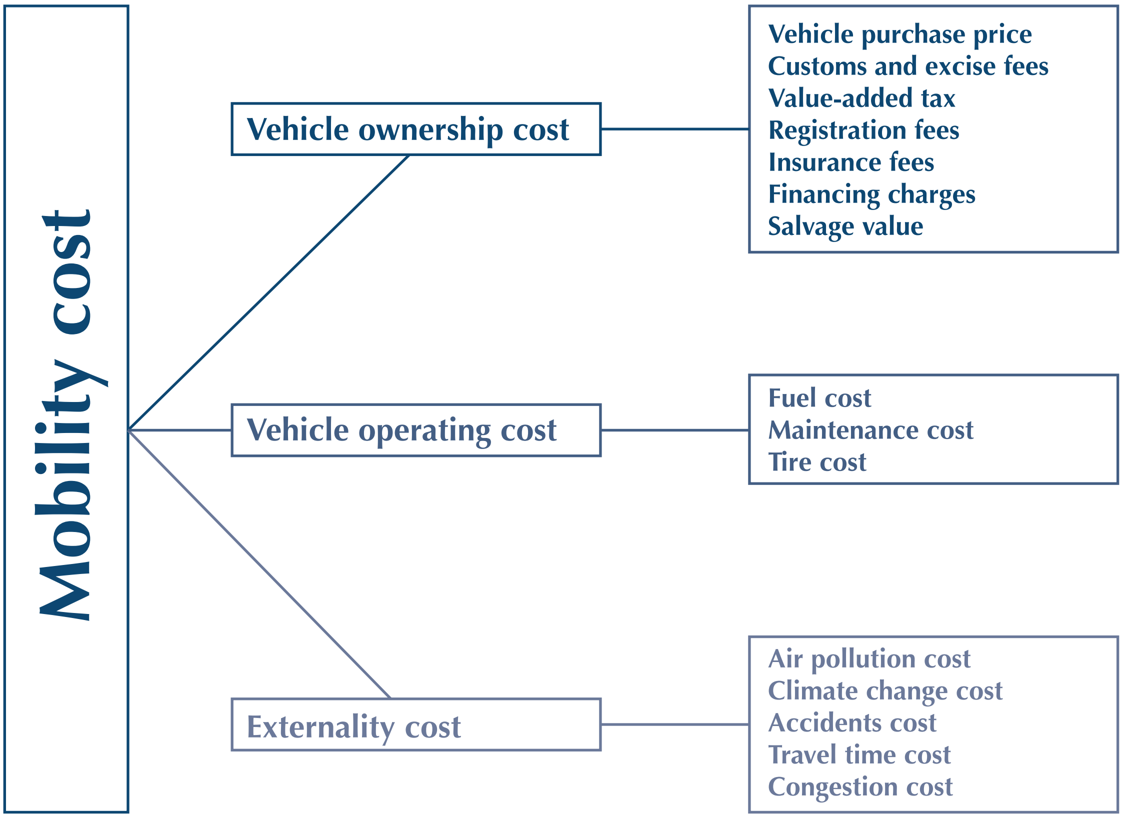

Figure 1: Mobility cost breakdown by components

$$C_M = C_{Own} + C_{Op} + E_C \qquad \text{(Equation 1)}$$

where

C_M	Mobility cost
C_{Own}	Ownership cost
C_{Op}	Operating cost
E_C	Externality cost

$$C_{Own} = PP + T + F_{Reg} + F_{Road} + F_{Ins} + F_{Fin} - SV \qquad \text{(Equation 2)}$$

where

PP	Purchase price
T	Taxes (customs and excise fees and VAT)
F_{Reg}	Registration fees
F_{Road}	Road usage fees
F_{Ins}	Insurance fees
F_{Fin}	Financing fees
SV	Salvage value

$$C_{Op} = C_{Fuel} + C_{Tire} + C_{Main} \quad \text{(Equation 3)}$$

where

C_{Fuel}	Fuel cost
C_{Main}	Maintenance cost
C_{Tire}	Tire cost

The limitation to the computation of mobility cost includes the omission of some sub-components, such as the disposal of waste and tires, the effect of dust on Particulate Matter (PM) emissions and the damage done to private and public properties in accidents.

The selection of externalities to be included in the calculation was performed through exploring the available literature. Delucchi and McCubbin (2010) present findings from a number of studies investigating external costs of mobility in developing and developed countries worldwide; it was concluded that accident costs and congestion costs constitute the largest portions of mobility cost, and can account for 15% to 38% and 10% to 20% of externality costs, respectively (Delucchi and McCubbin, 2010). Furthermore, Litman (2011) argues that travel time is also a significant component and should not be omitted from the calculations. The argument is further reinforced since the Lebanese passenger transport sector suffers from heavy traffic. Finally, pollution and climate change costs are included since this study aims at focusing on the policies to render the passenger transport a more environment-friendly sector.

$$E_C = C_P + C_{CC} + C_{Accident} + C_{TT} + C_G \quad \text{(Equation 4)}$$

where

C_P	Pollution cost
C_{CC}	Climate change cost
$C_{Accident}$	Accident cost
C_{TT}	Travel time cost
C_G	Congestion cost

Detailed explanations on the calculation methodology for each cost component and sub-component are included in the sections below.

3.1. Ownership cost

Recalling equation 2:

Ownership cost = purchase price + taxes + registration fees + road usage fees + insurance fees + financing charges – salvage value

3.1.1. The Purchase Price

The Purchase Price (PP) is the price of the vehicle at import. Data provided by Lebanese Customs and the Ministry of Finance (MoF) consist of records of monthly vehicle imports, by number of vehicles sold and by monetary value for the year 2010, distributed between used and new cars and into three categories: vehicles with an engine displacement less than 1.5 liters (small), vehicles with an engine displacement between 1.5 liters and 3.0 liters (medium and large consolidated), and finally those with an engine displacement larger than 3.0 liters (SUV). Since this segregation differs from the one adopted in this study, some refinements are undertaken to ensure consistency.

First, the middle consolidated category was segregated into the required "medium" and "large" categories. This is done through evenly averaging the costs throughout, for both old and new categories, as follows:

Let P_i denote the import price of category i:

$$P_{medium} = (P_{consolidated} + P_{small})/2$$

$$P_{large} = (P_{consolidated} + P_{SUV})/2$$

A second challenge is further segregating medium and large categories into used and new, because customs, excise and road-usage fees would be different for used and new vehicles (Annex I). The division of the consolidated category to the medium and large categories was therefore adopted.

Table 1: Numbers for PP computation

Car category	Small		Medium		Large		SUV	
Engine size	< 1.5 l		1.5 l < x < 2.0 l		2.0 l < x < 3.0 l		< 3.0 l	
Car state	Used	New	Used	New	Used	New	Used	New
Percentage	2.3%	97.7%	55.7%	44.3%	55.7%	44.3%	83.9%	16.1%

The PP is first expressed in USD per vehicle. Then, it is divided by the average vehicle life (assumed to be 10 years throughout the study, as considered in other studies such as the Technology Needs Assessment (TNA)) and by the average annual mileage of 15,000 km per year (as deduced from the car dealership surveys in Lebanon). This procedure is used throughout the computation of mobility cost components, to move to a figure in USD/veh, and USD/veh.km, respectively. Furthermore, to move from USD/veh.km to USD/pass.km, the occupancy rate of a vehicle is taken as 1.2 passengers per car (MoE/URC/GEF, 2012).

3.1.2. Taxes and fees

The following taxes are successively added to the import price of the car: first the customs and excise taxes, then a 10% VAT, and finally a 5.3% registration fee[1] are applied on the sum price. Lastly, the road-usage fee (mécanique) is applied, depending on whether the car is new or used, and on the Horsepower[2] (HP) of the vehicle. Due to the lack of detailed documentation, the model year of the vehicles are not recorded in each category. Therefore, the mécanique fee pricing adopted in this study is represented in the table below.

Table 2: Mécanique fees adopted in this study

		Mécanique fee (USD)	
HP	**Car category**	**Used vehicle[3]**	**New vehicle**
11 to 20	Small Medium	USD 93	USD 350
21 to 30	Large	USD 190	USD 700
31 to 40	SUV	USD 262	USD 1,017

Source | Adapted from MoF, 2011

In general, the Lebanese HP indicator follows the engine displacement (for example, a 2.0 car is assigned 20 HP). Hence the following assumptions are considered: small and medium cars fall under 11-20 HP category, large cars under 21-30 HP and SUVs under 31- 40 HP.

3.1.3. Insurance fees

Since there is no single and official figure for car insurance premiums in Lebanon, a brief market survey was undertaken. Insurance premiums exclude old cars since there is no access to the model year. These are presented in Table 3 below:

Table 3: Insurance premium costs

	Small vehicle	Medium vehicle	Large vehicle	SUV
Insurance premium (USD/year)	620	730	1,102	1,168

[1] The registration fee consists in a 4% fee to the MoF, a 1% fee to municipalities and a 0.3% stamps fee.

[2] It is important to note that the HP unit adopted by the Lebanese government concerning the mécanique fee differs from the horsepower unit used internationally.

[3] Average mécanique fee for old cars.

3.1.4. Financing charges

In order to determine the financing charges, down payment, interest rates and loan period, 11 banks in Lebanon are considered[4]. The extracted information is averaged and established as follows, assuming that all vehicles purchased are part of a financing plan (the number of cars purchased by cash on site is not available).

Table 4: Financing charges

	Interest rate (%)	Period (years)	Down payment (% of vehicle price)
Used vehicles	6.1%	5.125 (taken as 5 years)	20%
New vehicles	3.96%	5.44 (taken as 5 years)	15.63%

3.1.5. Salvage value

Since there are no standards to calculate vehicle depreciation in Lebanon, and prices of used cars are randomly assigned, the American standard was adopted to calculate depreciation over five years, as a Modified Accelerated Cost Recovery System (MACRS) (Park, 2011), as follows:

Table 5: MACRS depreciation for automobiles

Year	1	2	3	4	5
MACRS %	20%	32%	19.2%	11%	11%

Source | Park, 2011

The salvage value is the difference between the initial vehicle price and the depreciation value after five years.

3.2. Operating cost

Recalling equation 3:

Operating cost = fuel cost + tire cost + maintenance cost

It is important to note that the safe disposal of tire and engine oil is not included in the operating cost calculation.

[4] The banks are Al-Ahli, Al-Mawarid, Arab Bank, Bank Audi, Bank of Beirut, Banque Libano-Française, Bank Misr Liban, BBAC, BLT, BLOM, Byblos Bank, Crédit Libanais, FNB, Fransabank and Libano Swiss. The data is sourced from the bnooki.com website.

3.2.1. Fuel cost

Weekly figures for fuel prices for the year 2010 are extracted from the Ministry of Energy and Water (MoEW) website and averaged over the year. In Lebanon, two types of gasoline fuels are traded: 95 Octane fuel and 98 Octane fuel. The lack of documentation does not allow identifying the share of cars running on either type of fuels, therefore a 50/50 split is assumed, and the fuel price is the average of 95 and 98 Octane fuels: 1.09 USD/liter.

In this study, a linear relationship is assumed between CO_2 emissions and fuel consumption, which is extracted and adapted from Mansour, Zgheib and Saba (2011). It is important to mention that the same data is used in the calculation of externalities.

The United States Energy Information Administration (EIA)[5] states that 19.64 pounds of CO_2 are the product of burning one gallon of gasoline, or 3.78 liters of gasoline emit ~8.91 kilograms of CO_2. Therefore, fuel consumption is equal to CO_2 emissions divided by (8,905.5/3.78). Finally, fuel cost is the product of fuel consumption and the price of fuel.

Table 6: Lebanese fleet CO_2 emissions and fuel consumption

Car category	CO_2 emissions (g/km)	Fuel consumption (l/100 km)
Small	185	7.95
Medium	200	8.48
Large	218	9.24
SUV	228	9.66

Source | Adapted from Mansour, Zgheib and Saba, 2011

3.2.2. Tire cost

The three largest tire dealerships in the country were surveyed, from which the tire prices for the four car categories were acquired. Furthermore, for increased accuracy, regular tires are differentiated from premium tires and the respective market shares were obtained, yielding in a weighted average cost of tires.

3.2.3. Maintenance cost

As opposed to the United States where the American Automobile Association (AAA) provides final figures for maintenance cost, a survey was necessary in order to obtain the required figures. To that end, after-sales managers at two official car dealerships and two local mechanics and garage owners were interviewed.

[5] http://www.eia.gov/tools/faqs/faq.cfm?id=307andt=11

3.3. Externality cost

Recalling equation 4, the cost of externalities is the sum of the cost of air pollution, cost of climate change, cost of accidents, cost of travel time and cost of congestion.

3.3.1. Cost of air pollution

Air pollution caused by the transport sector is majorly responsible for human health degradation, and is therefore considered as the main cost of pollution (Delucchi and McCubbin, 2010). In fact, non-health impacts (impacts on visibility, agriculture and forestry) account for 6% of the value of human health impact (Muller and Mendelsohn, 2007). Also, estimates for water pollution caused by the road transport sector are still scarce and unreliable (Delucchi and McCubbin, 2010).

Different sources in the literature state that the effect of particulate matter (PM_{10}) is preferably computed independently, and that the monetary figure would serve as a lower bound for pollution cost (Department of Environment and Conservation NSW, 2005; Ricardo-AEA, 2014). Other major pollutants that have significant health damage are nitrogen oxides (NO_x) sulphur dioxide (SO_2) and Volatile Organic Compounds (VOCs)[6] (Muller and Mendelsohn, 2007). The effects of the pollutants are evaluated following Muller and Mendelsohn's comprehensive analysis in the US, due to the scarcity of case studies on transportation air pollution cost (2007).

The effect of PM_{10} is quantified following a methodology developed by the World Health Organization (WHO) and the World Bank, which takes into account four cases of negative human health effects: morbidity, adult mortality, child mortality and discomfort due to urban pollution. The results are adapted to data for the year 2010, using a population of 4.3 million extracted from the World Development Indicators (WDI) (World Bank, 2014e), and an average PM_{10} level of 63 $\mu g/m^3$ (Massoud et al., 2011).

In order to obtain a figure in USD/veh.km, the aggregate number of pollution cost is divided by the number of vehicles in circulation as of the year 2010, which is estimated from a list provided by the MoIM dating back to the 1940s. The number of motorcycles, private and public freight is subtracted and the final number of passenger cars in circulation is estimated at 1,108,328 vehicles (MoIM, 2012).

3.3.2. Cost of climate change

The cost of climate change is based on the evaluation of the effects of GHGs on the global climate, where CO_2 was selected as the major GHG since it dominates with 97.33% of total emissions (MoE/UNDP/GEF, 2015). The Social Cost of Carbon (SCC) is a good measure of the societal cost of current and future damages that comes with emitting an additional tonne of CO_2 (Van Den Bergh and Botzen, 2014).

Many models to evaluate the SCC exist with more than 300 different values (Van Den Bergh and Botzen, 2014). Due to the high significance of the cost of climate change, a lower bound and an

[6] NH_3 ammonia was excluded due to data unavailability in Lebanon.

upper bound of SCC are considered: first, the value of 41 USD/t CO_2 was adopted (Van Den Bergh and Botzen, 2014). The second scenario adopts the value of 125 USD/t CO_2, recommended by Van Den Bergh and Botzen (2014).

Then, SCC is the product of the average price of a tonne of CO_2 and the vehicle's CO_2 emissions.

3.3.3. Cost of accidents

The cost of accidents is the sum of a car accident's serious consequences, including the medical costs incurred by severe injuries, the loss of productivity due to hospitalization and the cost of a fatality, or cost of death.

Hence:

$C_{Accident}$ = cost of severe injury + foregone earnings + cost of fatality

Data on the number of accidents and fatalities stems from the Internal Security Forces (ISF) and is accessed through the Kunhadi association (Non-Governmental Organization (NGO)) website[7].

Cost of severe injury: The medical cost of injury includes the cost of hospitalization, ambulance and medication fees for car accidents resulting in injuries. The International Road Assessment Programme (iRAP) suggests a model for the number of serious injuries for developing countries, as well as the cost incurred per serious injury (iRAP, 2010). The numbers show 4,392 serious injuries, with a cost of USD 114,000 per injury.

Foregone earnings: The foregone earnings figure represents the present value of lost wages, had the individual not been in an accident; therefore, this component would depend on the intensity of the injury. Following iRAP's definition, a serious injury is one that leads to at least one night of hospital stay, which is the type of injury that is most suitable for estimating the foregone earnings (iRAP, 2010). The average number of days spent in the hospital in the year 2010 is assumed to be at 1.76 days by Choueiri et al., (2010).

Cost of fatality: The cost of a fatality is the Value of Statistical Life (VoSL): an economic value used in order to capture the Willingness to Pay (WTP) to reduce the risk of premature mortality which is based on Organization for Economic Cooperation and Development (OECD, 2014). Since a WTP survey is time-consuming, a "rule of thumb" for calculating VoSL for developing countries suggested by iRAP presents a valid estimation for a VoSL in Lebanon (iRAP, 2010). Following their regression model, an average figure of USD 647,608 is calculated.

Finally, every vehicle category would have its own accident cost value, because the latter partly represents the significance of the damage done to the car itself and to the passengers (Litman, 2011). In fact, small cars impose a lower risk on occupants of other cars, but are exposed to a higher risk in case of collision with larger cars.

[7] www.kunhadi.org/en/In-Numbers

The average accident cost calculated from VoSL and injury cost data is considered as the value for the "medium" vehicle category. "Small" and "large" cars will have a 10% incremental value from the average, while the "SUV" category will incur an additional 20% cost.

It is also worth noting that "active mobility" or "active transportation", such as walking or riding bicycles to reach one's destination, is accompanied with health benefits (reduction in obesity, reduction of cardio-vascular diseases, etc.) as well as health risks (cyclist and pedestrian injury risk). Thus, active transportation can increase or decrease the cost of accidents (Litman, 2011). However, a cost/benefit analysis for active transportation is not included in this study, due to the unavailability of data regarding active transportation in Lebanon.

3.3.4. Cost of travel time

The calculation of travel time, or Value of Time Travel (VTT), has been linked to three key parameters and follows Litman's methodology (2011).

First, VTT is evaluated on an opportunity cost basis: in fact, instead of commuting for an hour, the driver can spend an hour being productive. Hence, VTT is linked to wages.

Second, VTT naturally varies with the congestion level, which depends on the speed of the car. Therefore, VTT depends on the average speed of the vehicle. The data on average vehicle speed is extracted from a paper by Mansour and Zgheib (2012), whereas the share of travel time between urban peak and off-peak and rural is extracted from the Lebanon Technology Needs Assessment (TNA) for climate change (MoE/URC/GEF, 2012).

Table 7: Vehicle average speed and share of total trip for urban peak, urban off-peak and rural travel

	Average vehicle speed (km/hr)	Share of total trip (%)
Urban peak	17.6	51%
Urban off-peak	39.1	31%
Rural	51.3	18%

Source | Mansour and Zgheib, 2012; MoE/URC/GEF, 2012

Finally, VTT depends on the goal of the trip: the more serious the purpose of the trip, the higher the VTT. The methodology for VTT is summarized in the following table:

Table 8: VTT calculation

Category	Description/ circumstances of travel	Corresponding cost value	Portion of travel time/ travel goal
Paid	Travel by employees when being paid, traveling to meetings or between job sites	150% wage rate	5% commercial travel
Personal, high cost	Personal travel when discomfort and frustration is experienced	50% wage rate	20% urban peak travel/ congestion
Personal, medium cost	Personal travel when no discomfort is experienced	25% wage rate	50% no congestion
Zero-cost	Personal travel (enjoyable)	No cost	25% recreation travel

Source | Based on Litman, 2011

Therefore, VTT is calculated using the formula $VTT = (W \times n_w \times s_t)/S_a$

With: n_w Corresponding cost value (percentage wage rate)

S_a Vehicle average speed

s_t Share of travel

W Average hourly wage rate, which is estimated as follows:

Since the most recent reported figure for the Lebanese average wage dates from 2007 in a Central Administration of Statistics (CAS) publication, the following methodology has been adopted in order to obtain a proxy for the year 2010:

For the year 2007, the average monthly wage of LBP 702,000 is stated (CAS, 2011); following the International Monetary Fund (IMF) World Economic Outlook (WEO) database, the Gross Domestic Product (GDP) per capita for the year 2007 is USD 5,937 (IMF, 2014) equivalent to LBP 742,096 per month, yielding a 5.7% difference in values. The adjusted 2010 GDP/capita of USD 8,756 (IMF, 2014) is used as the average wage: USD 688 per month.[8]

Assuming five working days per week, with eight working hours per day, the average hourly rate is USD 4.30 per hour.

3.3.5. Cost of congestion

Congestion costs arise from the incremental damage (pollution, wasted productivity, etc.) caused by an additional vehicle entering traffic; estimating congestion costs involves studying the speed flow relationship of a road and its capacity (Litman, 2011).

[8] CAS has been contacted and recent data was not disclosed.

Therefore, the value already calculated in the TNA was adopted (MoE/URC/GEF, 2012).

3.4. Methodology summary

Table 9: Mobility cost methodology summary

Cost component	Cost sub-component	Methodology	Source
Vehicle ownership cost	Vehicle Purchase Price (PP)	Price at import	Customs (MoF)
	Customs and excise fees	Formula depending on PP	
	Value-Added Tax (VAT)	10% of PP + customs and excise fees	
	Mécanique fees	Formula depending on PP + customs and excise + VAT	
	Registration fees	5.3% depending on PP + customs and excise + VAT	
	Insurance fees	Survey	Insurance companies
	Financing charges	Website search	www.bnooki.com
	Salvage value	MACRS for automotive	Contemporary Engineering Economics, Park, 2011
Vehicle operating cost	Fuel cost	Website	MoEW
	Tire cost	Survey	Tire dealerships
	Maintenance cost	Survey	Car dealerships
Externalities	Air pollution cost	Disability-Adjusted Life Year (DALY) methodology and case study	World Bank/ WHO; Muller and Mendelsohn (2007)
	Climate change cost	Social cost of carbon	Van Den Bergh and Botzen (2014)
	Accident cost	VoSL and injuries	iRAP
	Travel time cost	VTT methodology by Litman	Litman (2011)
	Congestion cost	N/A	TNA

4. Indicators

As previously mentioned, specific indicators were established since no formal or standard sustainable transport indicators exist. Indicators are divided into four categories: safety, energy consumption, climate change and car ownership, and each result will be compared to that of neighboring countries and “sister cities”. Since specific data for cities is difficult to source, “sister cities” are considered as “sister countries”, which would further facilitate the comparison. The neighboring countries are Jordan, Syria, Cyprus, Egypt and Tunisia, whereas the sister countries (cities) are Athens (Greece), Dubai (UAE), and Yerevan (Armenia). Additionally, when data is available, Lebanon is also compared to the world average as well as the Arab world[9] average.

4.1. Safety indicators

Data on the number of car accidents, injuries and fatalities are extracted from the Global Status Report on Road Safety (WHO, 2009) and are solely available for the year 2007. Therefore, the 2007 data are adapted to the year 2010 using growth ratios for the number of accidents, injuries and fatalities (from the Lebanese accident data from 2007 through 2010).

Furthermore, population and GDP/capita data are sourced from the IMF WEO database.

Table 10: Population and GDP/capita data for the year 2010 (IMF, 2014) and the number of accidents

	Population	GDP/capita (USD)	Number of accidents in 2010 (calculated)[1]
Lebanon	43,419,092	5,937	549
Syria	19,928,516	2,016	19,658
Jordan	5,924,245	29,890	19,656
Tunisia	10,327,285	3,805	16,644
Armenia	3,002,271	2,853	3,204
Cyprus	854,671	28,039	2,289
Greece	11,146,918	27,448	23,150
UAE	4,380,439	41,472	12,658

[1]As stated in the methodology above

[9] The Arab world includes the following countries: Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, UAE and Yemen.

Ratio of fatalities per accident

The ratio of fatalities per accident shows how many accidents ended in fatalities. It is the simple ratio of accidents to fatalities: N_C/N_F, N_C being the number of accidents occurring in a country and N_F being the number of fatalities in the same country.

Number of fatalities per capita

The number of fatalities per capita indicates how many fatalities per individual occur. It is the result of dividing the number of fatalities by the population of the country: N_F/Population.

Number of fatalities per GDP/capita

The number of fatalities per GDP/capita is indicative of the number of fatalities while disregarding the productivity and the "wealth" of the country. It is the result of dividing the number of fatalities by the GDP/capita of the country: N_F/(GDP/capita).

4.2. Energy consumption indicators

There is no specific methodology for energy consumption indicators. Data are extracted from WDI and then analyzed and compared.

The "Road Sector Energy Consumption" indicator is the share of the road sector energy consumption (World Bank, 2014a). The "Gasoline Consumption" indicator represents the gasoline consumption per capita by the road sector (World Bank, 2014b). The "Fossil Fuel Consumption" indicator represents the percentage of fossil fuel consumption out of the total energy consumption (World Bank, 2014c).

4.3. Climate change indicators

CO_2 emissions percentage from road transport

CO_2 emissions resulting from fuel combustion from the transport sector are extracted from the WDI page, as a percentage of total fuel combustion in a country[10] (World Bank, 2014d).

CO_2 emissions per capita and per GDP/capita

Total emissions of CO_2 for the transport sector are extracted from the same source as the indicator above, and divided by the population to yield the tonnes of CO_2 emitted per capita for the transport sector. The same methodology follows for tonnes of CO_2 per GDP/capita by dividing total emissions by the country's GDP/capita figure.

[10] Numbers include domestic aviation, domestic navigation, rail, pipeline transport (which are assumed to be negligible and/or non-existent for the case of Lebanon) and road transport.

4.4. Car ownership indicators

Number of passenger cars/capita

For all countries considered in this study except for Lebanon (for which the number is calculated), the number of passenger cars per capita is extracted from the WDI (World Bank, 2014e).

Total number of passenger cars

Taking the number of passenger cars per capita and multiplying it with the country's population yields the total number of passenger cars in the fleet.

Number of individuals per passenger car

This indicator is the inverse of the first indicator "number of passenger cars/capita".

Share of private motorized vehicles

Below is a chart extracted from "Towards a Green Economy" (2011) by the United Nations Environment Programme (UNEP), which shows the share of motorized private vehicles as a function of GDP/capita for several cities in the world, along with three patterns of sustainable transportation.

In order to locate Lebanon (or Beirut) on the map, GDP/capita for the years 2006 and 2010 have been extracted from the IMF World Economic Outlook database, and are of USD 5,343 and USD 8,756 per capita, respectively. Furthermore, the share of private motorized vehicles is approximately at 65% (MoE/UNDP/GEF, 2015).

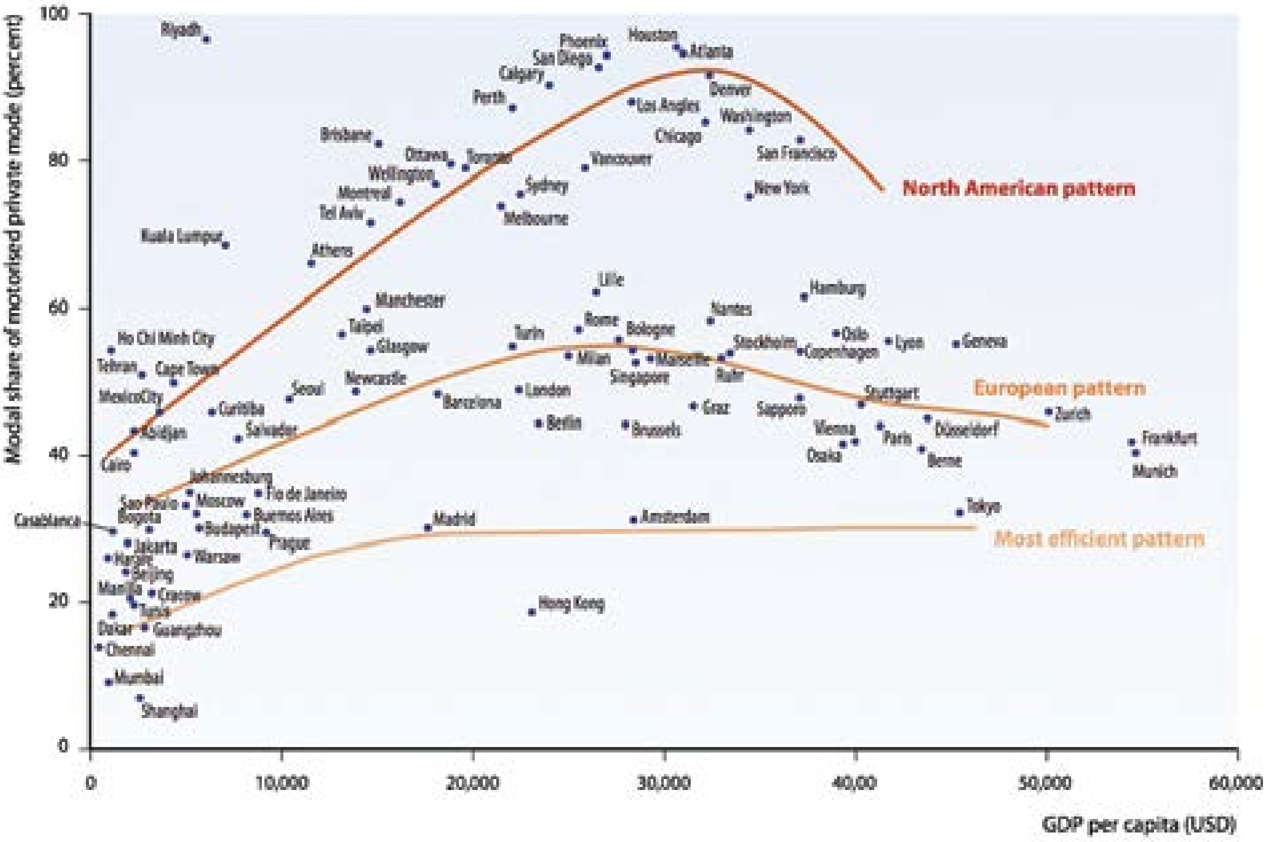

Figure 2: Modal share of motorized private mode vs. GDP/capita
Source | UNEP, 2011

5. Results and discussion

5.1. Mobility cost

After calculating mobility cost for the four vehicle categories, a weighted average figure is calculated following the fleet (in circulation) composition[11]. The resulting average figure is of approximately US¢ 50/veh.km and US¢ 42/pass.km. Table 11 and Figure 3 below illustrate the average results for mobility cost and its components and sub-components.

[11] Full results are found in Annex II.

Table 11: Average results of the four vehicle categories

Average results			
	Cost component	**US¢/veh.km**	**US¢/pass.km**
Ownership cost	Vehicle purchase	10.9	9.1
	Custom/excise tax	3.7	3.1
	VAT	1.5	1.2
	Registration	0.6	0.5
	Road-usage mécanique	2.1	1.8
	Insurance	0.6	0.5
	Salvage value	0.9	0.8
	Financing charges	0.7	0.6
	Total ownership cost	19.2	16.0
Operating cost	Fuel cost	9.6	8.0
	Tire cost	0.9	0.7
	Maintenance cost	2.1	1.8
	Total operating cost	12.7	10.6
Climate change cost[12]		0.9 (2.6)	0.7 (2.2)
Pollution cost		1.2	1.0
Travel time		5.2	4.4
Congestion cost		3.8	3.1
Accident cost		5.2	4.4
Total externality cost		16.3 (18)	13.6 (15.1)
Total cost		48.2 (49.9)	40.2 (41.7)

Note that the cost sub-components and the total ownership cost, total operating cost and total externality cost are the weighted averages of the costs from the four car categories depending on their respective percentage shares in the Lebanese private vehicle fleet.

[12] Upper bound for SCC results are between parentheses.

In Figure 3, the importance of including externality costs in mobility cost calculation is reflected, as well as their gravity on a social impact level: one third of total mobility cost is attributed to externalities.

When looking at ownership cost, it is clear that the largest chunks belong to the vehicle purchase cost as well as the custom/excise taxes. For the operating cost however, the cost of fuel is dominating.

In terms of externalities, the two most critical components are accident cost and travel time, which on the one hand stresses on the importance of reducing road accidents, and on the other hand, points to the severity of the indirect consequences of traffic congestion.

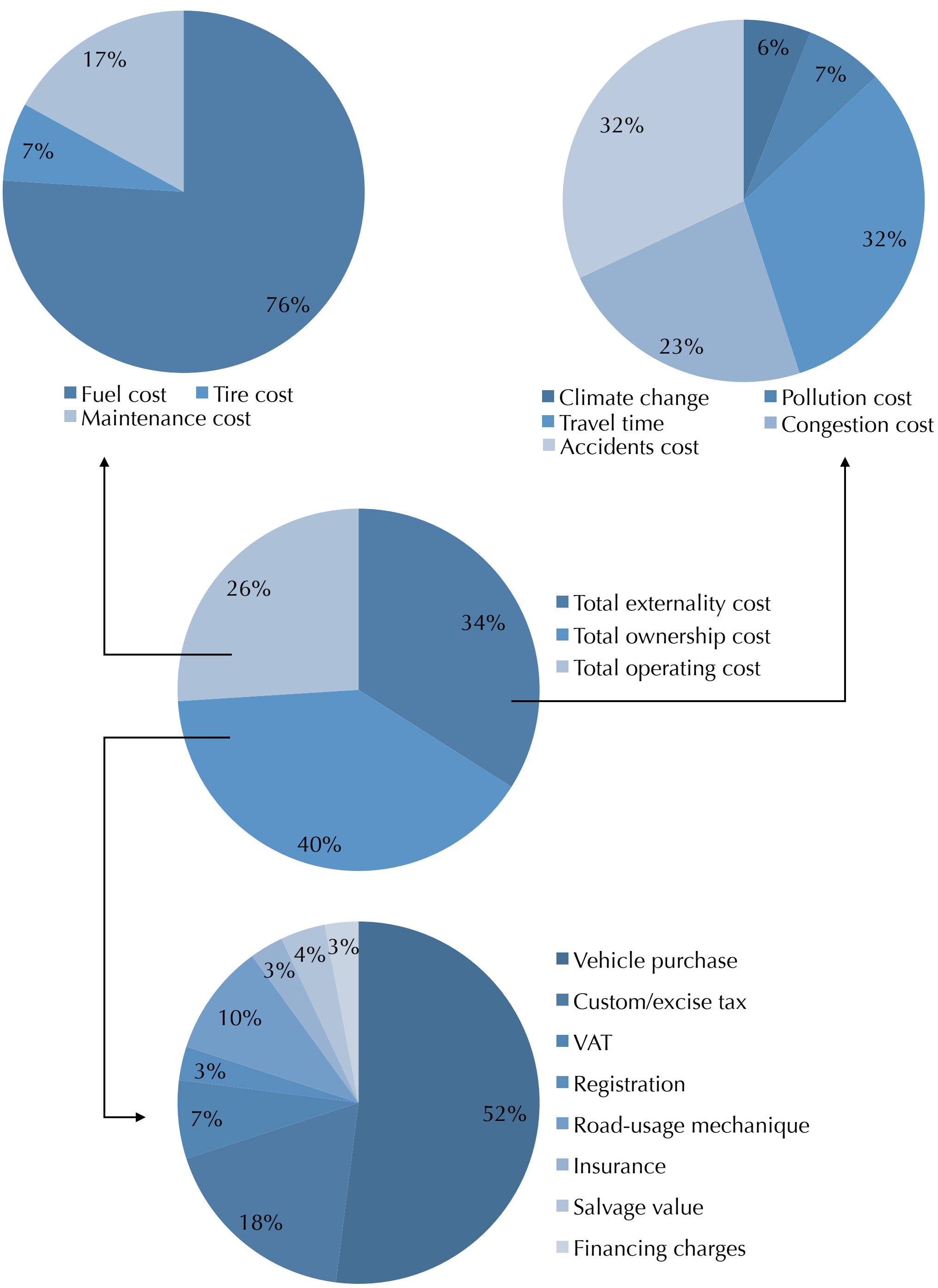

Figure 3: Average results for mobility cost and its components

5.2. Social cost of carbon lower and upper bounds

Comparing the results above with the upper bound for SCC (125 USD/t CO_2), the corresponding pie chart shows the externality percentages. The share of climate change cost increased from 6% to 14%, a significant change further reinforcing the importance of the SCC in computing mobility cost and the difficulty in selecting which value to adopt.

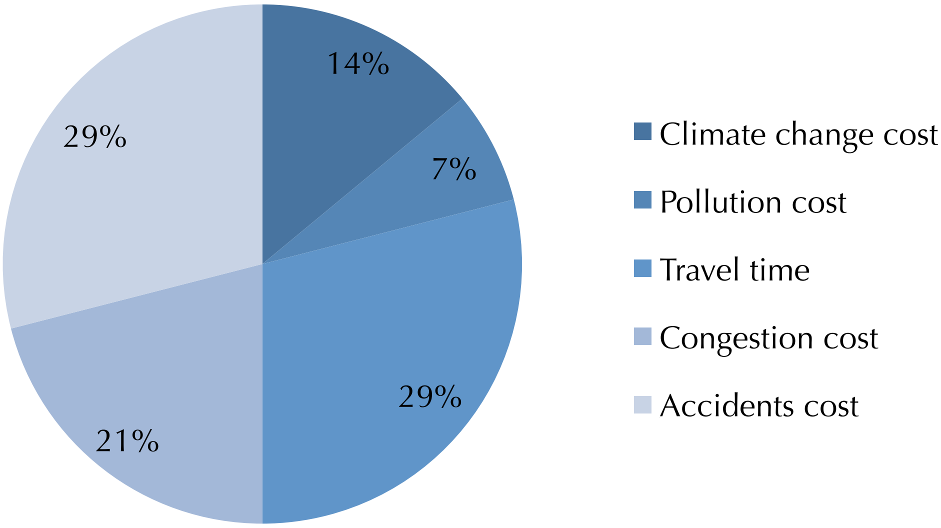

Figure 4: Externality cost results for SCC upper bound

5.3. Implications of externality costs

Globally, energy products are taxed to factor in the negative externalities from energy consumption. For transport fuels, excise taxes[13] are the most common form of taxing. Based on a compilation of energy prices and taxes from a number of Organization for Economic Cooperation and Development (OECD) countries (IMF, 2014), it is found that the average excise rate among 22 OECD countries is 60.2 US¢/liter. The gasoline excise rate in Lebanon stands well below this average: at 16.7 US¢/liter (LBP 5,000 per 20 liters). Table 12 below displays the externality cost of gasoline, segregated into pollution, carbon, congestion and accidents costs.

[13] An excise tax is an indirect tax charged on the sale of a particular good.

Table 12: Transporation-related externality costs for gasoline and diesel oil in Lebanon

Externality	Corresponding cost (US¢/liter)
Pollution	11.43
Carbon	0.034
Congestion	47.07
Accidents	51.03
Total	109.60

The externality cost at 109 US¢/liter is well above the current excise rate at 16.7 US¢/liter.

5.4. Mobility cost components comparison

Since data on international costs of mobility are scarce, the results of this study are compared to two other studies: Zachariadis (2008) and Litman (2011)[14].

Table 13: Difference between calculated mobility cost and values available in the literature

Cost component	Country	Value in 2010 currency	Difference relative to Lebanon's cost values[15] (%)
Accident cost	Cyprus	7.7	47.4%
	Europe	4.3	-2.1%
Air pollution cost	Cyprus	2.6	122.1%
	Europe	0.7	-25.0%
	USA	2.7	-129.8%
Travel time	USA	9.3	79.0%
GHG cost	USA	1.0	61.4%
Operating cost	USA	10.7	-15.7%
Ownership cost	USA	7.3	-62.2%
Mobility cost	USA	100.8	101.3%

[14] Litman's original cost values are in 2007 USD/veh.mile; 1 km = 0.6214 mile; Zachiaridis' values are in 2007 EUR cents.

[15] $\text{difference} = \frac{(\text{foreign value-Lebanon value}) \times 100}{\text{Lebanon value}}$

6. Comparing indicators

The following section is a discussion around the indicators and the conclusions that can be drawn from the comparisons.

6.1. Safety indicators

It is clear that Lebanon's fatality per capita is lower than its counterparts (Figure 5). However, in terms of fatality rate, it ranks third with 11.24% of road accidents ending with at least one fatality, after Syria (14.86%) and Armenia (12%). This could be attributed to the lack of traffic law reinforcement, such as not wearing the seatbelt or using the phone while driving.

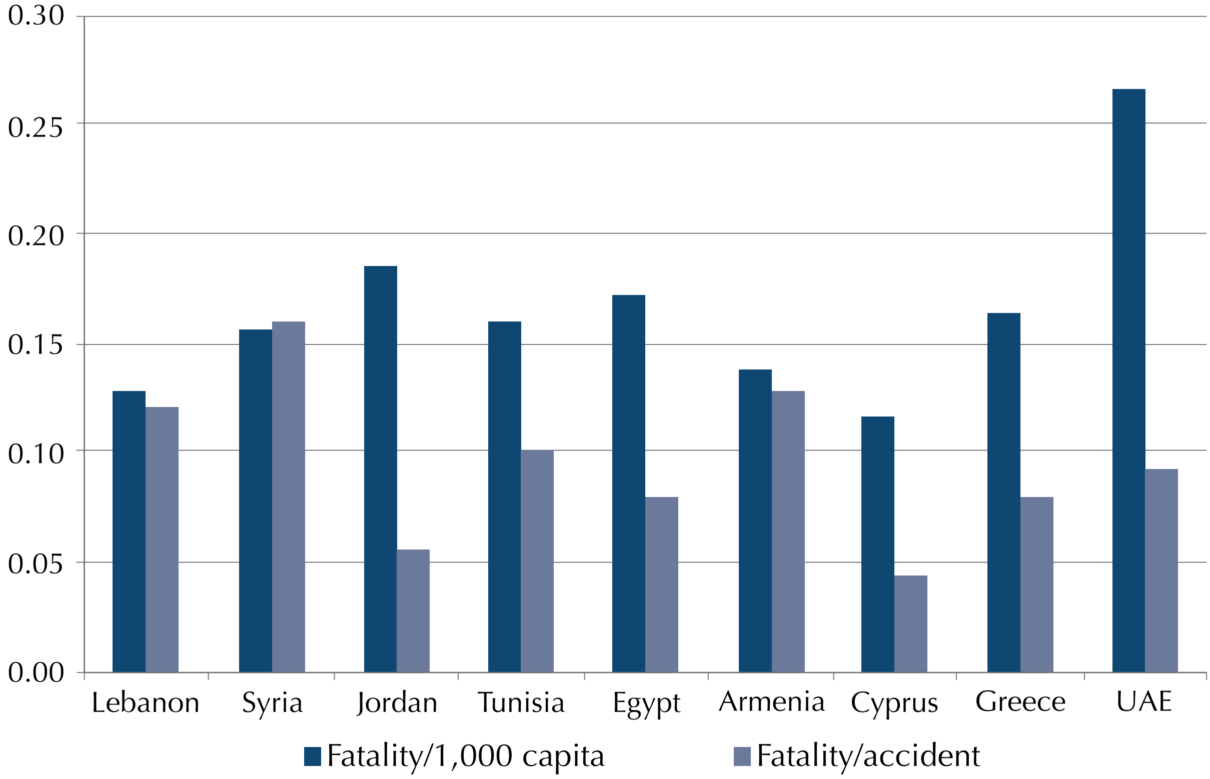

Figure 5: Ratio of fatalities per accident and number of fatalities per 1,000 capita

6.2. Energy consumption indicators

In terms of the percentage of energy consumed by the road transport sector, Lebanon ranks second highest with 27.2%, after Cyprus with 31.3%. The country consumes close to double the world average, which reflects the excessive energy requirements of the Lebanese transport sector. In fact, the passenger transport sector in particular has a high energy demand per capita, higher than the world average (Electris et al., 2009). This argument is further reinforced when gasoline consumption per capita is investigated: an average Lebanese consumes about 2.7 times more than the world average and 2.3 times more than a citizen of the Arab world.

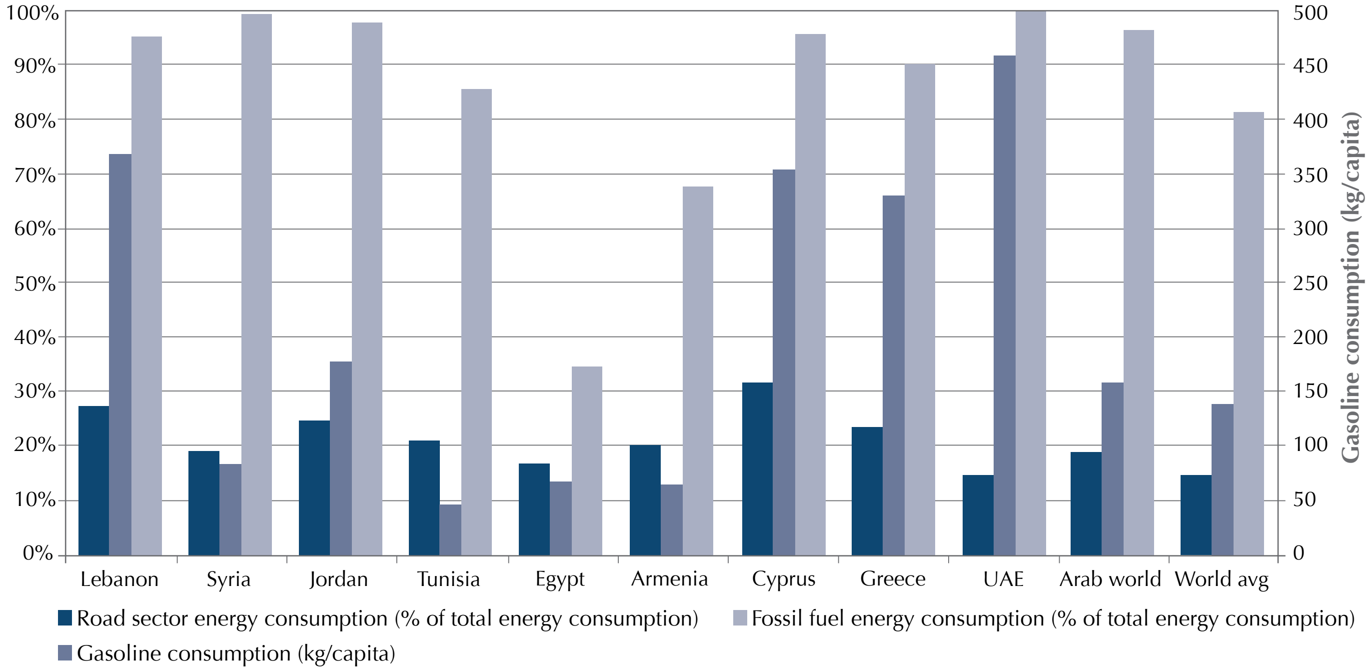

Figure 6: Energy consumption indicators

Source | World Bank, 2014c

Furthermore, it is found that Lebanon is on par with the Arab world average and most countries in comparison (except Tunisia and Armenia) in terms of fossil fuel consumption percentage of total energy consumption; however, it still exceeds the world average. Therefore, the argument that the Lebanese transport sector is dependent on finite fossil fuels is further reinforced, and thus should be a main objective to tackle when formulating policies.

6.3. Climate change indicators

Among the countries in comparison, Lebanon ranks second highest in terms of road transport CO_2 emissions, with 27.1% of total CO_2 emissions, close to the Arab world average, but 1.4 times higher than the world average.

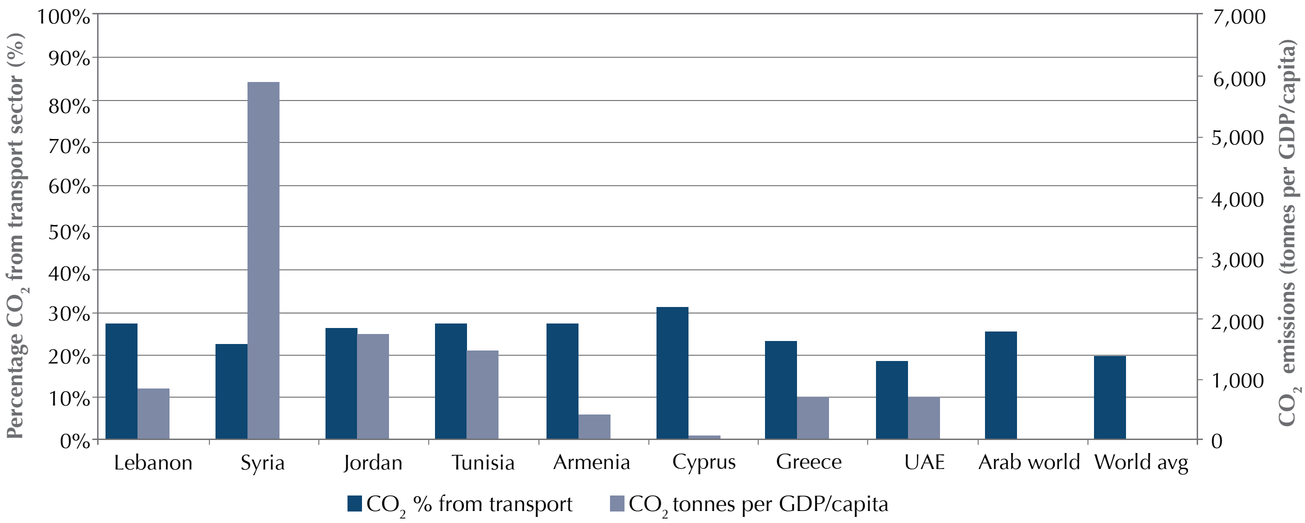

Figure 7: CO_2 emission indicators

Source | World Bank, 2014d

However, when CO_2 emissions per capita and per GDP/capita are compared, Lebanon ranks among the lowest countries: the figures for CO_2 emissions per capita are 7 times lower than the Arab world average and 4 times lower than the world average. Furthermore, Lebanon ranks amongst the lowest emitters in terms of CO_2 per GDP/capita figures.

6.4. Car ownership indicators

Passenger car fleet indicators:

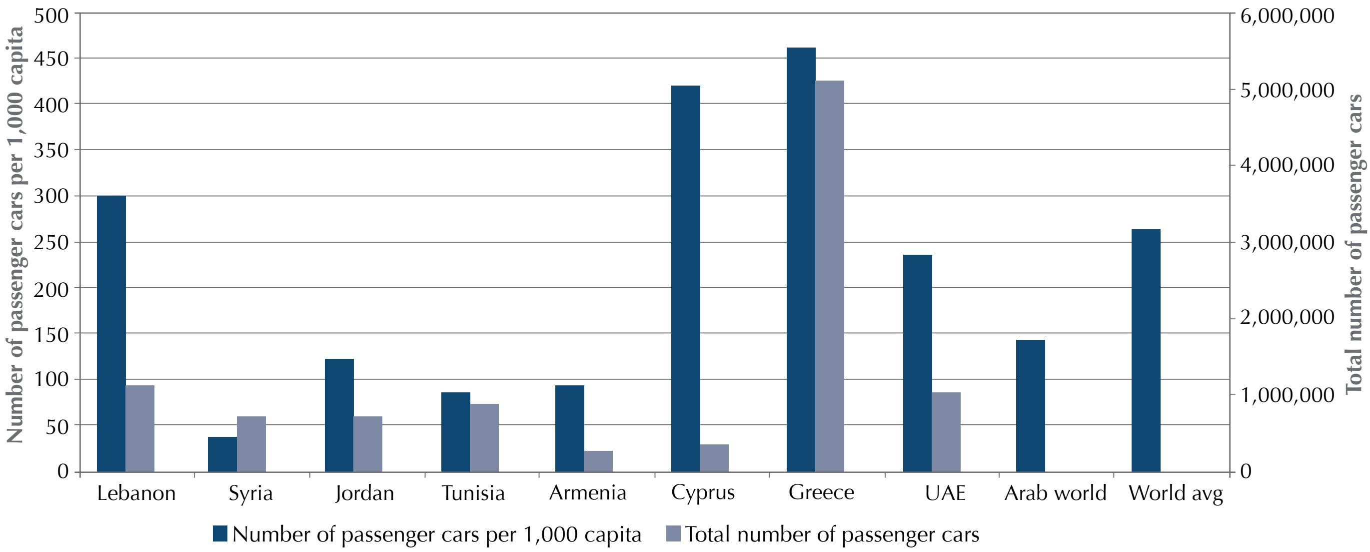

Figure 8: Car ownership indicators

Source | World Bank, 2014e

When the total number of passenger cars is investigated, it is found that Lebanon has the second highest number after Greece, which is higher than the world average and double the Arab world average. Furthermore, as shown in the chart below, there is one passenger vehicle for approximately every four Lebanese, a rate similar to that of the UAE, which falls somewhere in between the numbers for the rest of the countries in comparison. In Greece and Cyprus it is around 2 individuals, whereas in the remaining countries it is much higher, ranging between 8 and 27 individuals per passenger car.

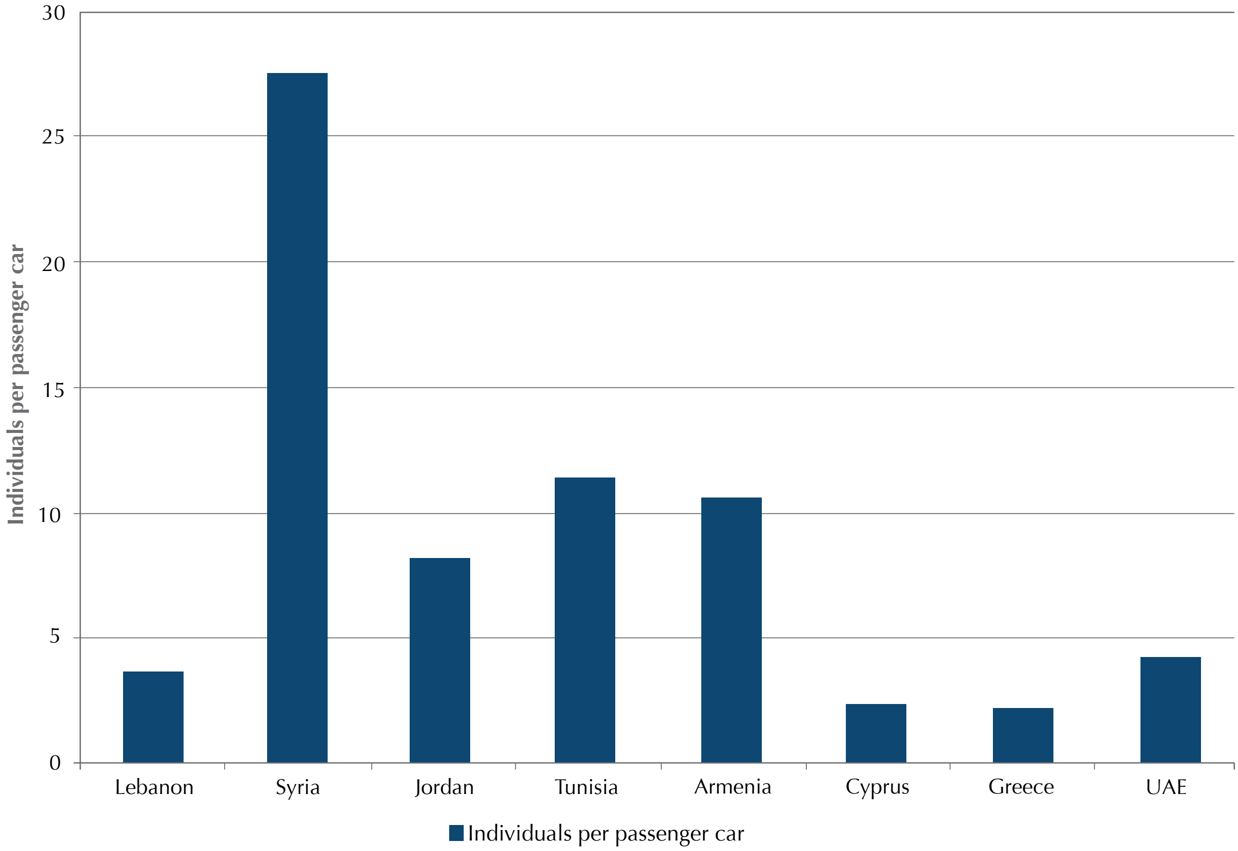

Figure 9: Number of individuals per passenger vehicle

Share of private motorized vehicles:

By adding Beirut to the original map by UNEP, it is clear that Lebanon lies outside the North American pattern, somewhere in between Riyadh and Kuala Lumpur, an unsustainable position from a private passenger car perspective. As for the countries in comparison, Athens (Greece) is spotted close to the North American pattern, with a Motorized Private Mode (MPM) share close to 60%, while Tunis (Tunisia) has a much lower MPM share (around 20%).

This situation in Lebanon can be backtracked to the absence of an organized public transport system, where individuals are pushed to the use of personal cars to commute. Hence, a high number of passenger vehicles is observed, in an absolute figure as well as per individual.

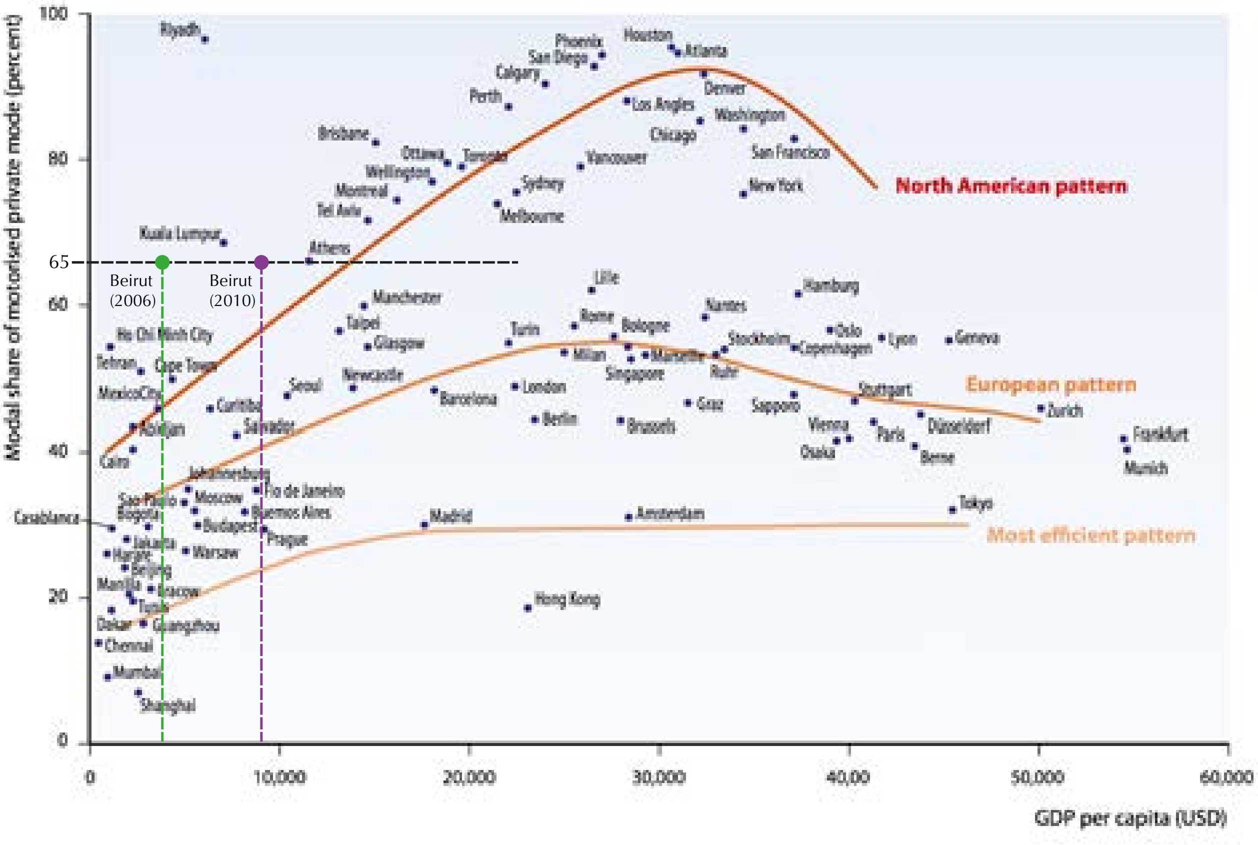

Figure 10: Modal share of motorized private mode vs. GDP/capita

Source | Adapted from UNEP, 2011

7. Conclusions and future work

This paper represents a first attempt at calculating the average cost for mobility in Lebanon. The methodology presented in this study has some limitations and yields a rather conservative value for Lebanese mobility cost, which can be progressively refined, component-by-component.

Another aim of the study is to provide a platform where certain policies and recommendations could be highlighted to improve certain aspects of the passenger transport sector. This was achieved upon analyzing cost components and referring to sustainable mobility indicators incepted throughout the case study.

It is clear that there are two fronts to investigate further: the energy strategy of the passenger transport sector and the high number of vehicles.

The "energy strategy" for the transport sector needs to be optimized, since it entirely relies on fossil fuels. Not only are fossil fuel reserves finite and the price of fuel highly volatile, but environmental consequences of fossil fuel combustion are also significant, which were partly highlighted through the "climate change" indicators. Cutting down on fuel (gasoline in this case) would relieve pressure on finite fossil reserves and the monetary pressure it exerts on the Lebanese government through subsidies. The latter could be achieved by directly reducing the number of gasoline cars in the fleet: extremely old, high-polluting and inefficient vehicles are to be removed or preferably scrapped, and newer, efficient and hybrid vehicles (and in the future electric vehicles) are to be introduced within the fleet. Of course, these measures are to be taken along with fiscal incentives, concessional financing and promotional campaigns to ensure the success of the policy.

As for the high number of vehicles, it is the consequence of the absence of other mobility alternatives, such as PT. It has been repeatedly proven that the inception of a public transport system with a BRT system on the highway from Tripoli to Beirut would dramatically decrease emissions and relieve traffic (MoE/URC/GEF, 2011; MoE/URC/GEF, 2012). In that case, individuals are presented with a greener, quicker and stress-free mobility option, and more "extreme" policies could also be implemented, such as raising some taxes (gasoline and excise), or progressively increasing registration and mécanique fees on a second and third car purchased within the same household.

However, regardless of the state of PT, simple and short-term options are still viable: NGOs would work hand-in-hand with the community in awareness campaigns, in order to first raise awareness on the unsustainable state in which Lebanon is. Furthermore, the campaigns would help in promoting car sharing/carpooling in Lebanon, mainly among the younger generations. The latter would partly relieve traffic especially in the highly congested areas of Beirut, and would decrease the level of pollutants and GHG emitted per day.

The suggested policies and their impact are to be tested through a System Dynamics (SD) modeling, as part of future work. SD modeling will allow to weigh the effects and benefits of policies, and to determine the optimum mix of policies to shift the passenger transport sector towards sustainability. Furthermore, more intricate work is to be done on the level of some components of mobility cost, such as further surveying for fuel consumption data for the different car categories, and refining some subcomponent costs.

8. References

Black, W., (2010). Sustainable Transportation: Problems and Solutions. New York, USA.

Buekers, J., Van Holderbeke, M., Bierkens, J. and Int Panis, L., (2014). Health and environmental benefits related to electric vehicle introduction in EU countries, Transportation Research Part D, vol. 33, pp. 26-38.

CAS, (2011). The Labour Market in Lebanon. Statistics in Focus.

Choueiri, E., Choueiri, G. and Choueiri, B., (2010). Analysis of accident patterns in Lebanon, 4th International Symposium on Highway Geometric Design. Valencia, Spain. June 2-5 2010.

Delucchi, M., and McCubbin, D., (2010). External Costs in the US, Institute of Transportation Studies, University of California, Davis.

Department of Environment and Conservation NSW, (2005). Air Pollution Economics: Health Costs of Air Pollution in the Greater Sydney Metropolitan Region. Sydney, Australia.

Electris, C., Raskin, P., Rosen, R., and Stutz, J., (2009). The Century Ahead: Four Global Scenarios. Technical Documentation. Tellus Institute, Boston. USA.

Fardoun, F., Ibrahim, O., Younes, R. and Louahlia-Gualous, H., (2012). Electricity of Lebanon: Problems and Recommendations. Energy Procedia, vol. 19, pp. 310-320.

IEA, (2008). International Energy Agency database by country, statistics for 2008. Lebanon.

IMF, (2014). Subsidy Reform in the Middle East and North Africa: Recent Progress and Challenges Ahead. IMF, Middle East and Central Asia Department.

iRAP, (2010). The True Cost Of Road Crashes: Valuing Life And The Cost Of A Serious Injury, International Road Assessment Programme. <www.irap.net/documents/pdf/iRAPValueoflifeseriousinjurypaper.pdf>

Lebanese Customs Website: http://www.customs.gov.lb/customs/others/faq.asp

Litman, T., (2011). Transportation Cost and Benefit Analysis. Techniques, Estimates and Implications. Second Edition 2009. Victoria Transport Policy Institute.

Mansour, C. and Zgheib, E., (2012). Existing driving conditions in Greater Beirut Area. Unpublished.

Mansour, C., Zgheib, E. and Saba, S., (2011). Evaluating impact of electrified vehicles on fuel consumption and CO_2 emissions reduction in Lebanese driving conditions using onboard GPS survey. ELSEVIER - Energy Procedia, Vol. 6, pp. 261-276.

Massoud, R., Shihadeh, A., Roumie, M., Youness, M., Gerard, J., Saliba, N., Zaarour, R., Abboud, M., Farah, W., and Aoun Saliba, N., (2011). Intraurban variability of PM10 and PM2.5 in an Eastern Mediterranean city in Atmospheric Research, vol. 101, pp. 893-901.

MoE/UNDP/GEF, (2011). Lebanon's Second National Communication to the UNFCCC. Beirut, Lebanon.

MoE/URC/GEF, (2012). Technology Needs Assessment Report for Climate Change, Chapter 5: Transport. Beirut, Lebanon.

MoE/UNDP/GEF, (2015). Lebanon's Third National Communication to the UNFCCC. Beirut, Lebanon. Draft report. Unpublished.

MoF, (2011). Car Imports and Related Government Revenues (1997-2010). Beirut, Lebanon.

MoIM, (2012). Car Registration Database, Traffic, truck and vehicle Management Authority. Beirut, Lebanon.

Muller, Nicholas Z. and Robert Mendelsohn, (2007). Measuring the damages of air pollution in the United States, Journal of Environmental Economics and Management, vol. 54, pp. 1-14.

OECD, (2014). The Cost of Air Pollution: Health Impacts of Road Transport, OECD Publishing. http://dx.doi.org/10.1787/9789264210448-en

Park, C., S., (2011). Contemporary Engineering Economics, 5th Edition, Prentice Hall. USA.

Ricardo-AEA, (2014). Update on the Handbook of External Costs of Transport, no.1, reference ED 57769. London, United Kingdom.

UNEP, (2011). Transport: investing in energy and resource efficiency, Towards a Green Economy.

Van den Bergh, J.C.J.M., and Botzen, W.J.W., (2014). A lower bound to the social cost of CO_2 emissions. Nature Climate Change, no. 4, pp. 253-258, DOI:10.1038/NCLIMATE2135.

WHO, (2009). Global Status Report on Road Safety: Time for Action, Department of Violence and Injury Prevention and Disability, Geneva, Switzerland, ISBN 978 92 4 156384 0.

World Bank, (2014a). "Road sector energy consumption (% of total energy consumption)", International Road Federation, World Road Statistics and electronic files, except where noted, and International Energy Agency (IEA Statistics © OECD/IEA, http://www.iea.org/stats/index.asp) < http://data.worldbank.org/indicator/IS.ROD.ENGY.ZS/countries/LB?display=graph>

World Bank, (2014b). "Road sector gasoline fuel consumption per capita (kg of oil equivalent)", International Road Federation, World Road Statistics and electronic files, except where noted, and International Energy Agency (IEA Statistics © OECD/IEA, http://www.iea.org/stats/index.asp) <

http://data.worldbank.org/indicator/IS.ROD.SGAS.PC/countries/LB?display=graph>

World Bank, (2014c). “Fossil fuel energy consumption (% of total)”, International Energy Agency (IEA Statistics © OECD/IEA, http://www.iea.org/stats/index.asp), http://www.iea.org/stats/index.asp) < http://data.worldbank.org/indicator/EG.USE.COMM.FO.ZS?display=graph

World Bank, (2014d). “CO_2 emissions from transport (% of total fuel combustion)”, IEA Statistics © OECD/IEA, http://www.iea.org/stats/index.asp), International Energy Agency electronic files on CO2 Emissions from Fuel Combustion, <http://data.worldbank.org/indicator/EN.CO2.TRAN.ZS?display=graph>

World Bank, (2014e). “Passenger cars (per 1,000 people)”, International Road Federation, World Road Statistics and data files.

World Bank Website: http://data.worldbank.org/indicator/IS.VEH.PCAR.P3/countries/LBSY?display=graph

World Business Council for Sustainable Development (WBCSD). Mobility for Development Project, ISBN: 978-3-940388-42-1.

Zachariadis, T., and Clerides, S., (2008). The effect of standards and fuel prices on automobile fuel economy: An international analysis. Energy Economics , 30 (5), 2657- 2672.

Annex I: Data related to vehicle imports in Lebanon

Table 14: Customs and excise taxes fees for new and used vehicles

	Used vehicles	New vehicles
Customs	LBP 500,000 if import price is less than LBP 20 million	5% of value
	LBP 500,000 + 5% of difference between import price and LBP 20 million	
Excise	LBP 4,500,000 if import price is less than LBP 20 million	15% of import price if up to LBP 20 million and 45% if above
	LBP 4,500,000 + 45% of difference between import price and LBP 20 million	

Source | Lebanese customs website[16]

Table 15: Yearly mécanique fees for different car models and horsepower

HP	Before 1997	2005 – 1998	2008 – 2006	2009 – 2010
1 to 10	USD 22	USD 50	USD 103	USD 217
11 to 20	USD 35	USD 80	USD 163	USD 350
21 to 30	USD 73	USD 160	USD 337	USD 700
31 to 40	USD 93	USD 206	USD 486	USD 1,016

Source | MoF, 2011

[16] Lebanese Customs website: http://www.customs.gov.lb/customs/others/faq.asp

Annex II: Results for mobility cost for all four car categories

Table 16: Results for small and medium categories*

		Small	Medium
	Cost component	US¢/veh.km	US¢/veh.km
Ownership cost	Vehicle purchase	8.4	8.9
	Custom/excise tax	2.1	2.0
	VAT	1.1	1.1
	Registration	0.6	0.6
	Road-usage mécanique	2.3	1.4
	Insurance	0.4	0.5
	Salvage value	0.6	0.7
	Financing charges	0.3	0.5
	Total ownership costs	14.6	14.3
Operating cost	Fuel cost	8.7	9.3
	Tire cost	0.6	0.8
	Maintenance cost	1.3	2.1
	Total operating cost	10.6	12.2
Climate change cost		2.3	2.5
Pollution cost		1.2	1.2
Travel time		5.2	5.2
Congestion cost		3.8	3.8
Accident cost		5.4	4.9
Total externality cost		17.9	17.6
Total cost		43.1	44.1

*Note that the cost sub-components and the total ownership cost, total operating cost and total externality cost are the weighted averages of the costs from the four car categories depending on their respective percentage shares in the Lebanese private vehicle fleet.

Table 17: Results for large and SUV categories*

		Large	SUV
	Cost component	**US¢/veh.km**	**US¢/veh.km**
Ownership cost	Vehicle purchase	12.6	16.0
	Custom/excise tax	5.2	6.9
	VAT	1.8	2.3
	Registration	1.0	1.3
	Road-usage mécanique	2.8	2.6
	Insurance	0.7	0.8
	Salvage value	1.1	1.2
	Financing charges	0.8	1.3
	Total ownership costs	23.8	30
Operating cost	Fuel cost	10.1	10.6
	Tire cost	1.0	1.4
	Maintenance cost	2.3	2.6
	Total operating cost	13.4	14.6
Climate change cost		2.7	2.8
Pollution cost		1.2	1.2
Travel time		5.2	5.2
Congestion cost		3.8	3.8
Accident cost		5.4	5.9
Total externality cost		18.3	18.9
Total cost		55.5	63.5

***Note that the cost sub-components and the total ownership cost, total operating cost and total externality cost are the weighted averages of the costs from the four car categories depending on their respective percentage shares in the Lebanese private vehicle fleet.**