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Economic Impacts of Adopting a Sustainable Transport System in Beirut

Working Paper #28

Mazen Omran, Johnny Ojeil, and Youssef Fawaz

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The Climate Change and Environment in the Arab World Program aims to understand the climate change and environment policy process in the region and define the most appropriate policy recommendations by linking development in applied sciences on issues related to climate change and environment to social sciences.

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Executive Summary

The proposed Beirut Master Plan aims to put the city back on the international map as a hub for trade and investment, a place to work, and a destination for leisure. The execution of this plan has started with major construction works taking place in the Beirut Central District (BCD) and its planned natural extension on reclaimed land known as the New Waterfront District (NWD).

However, this proposed Master Plan may not achieve its main economic objectives due to the lack of transport infrastructure and multi-modal systems, i.e. transport is lagging behind. Congestion levels are currently unacceptable and will get worse in the future as a result of these development proposals. The key missing link is that Beirut is lagging on the sustainable public transport front and therefore it will not be able to economically compete in a strong manner with other cities in the region.

The work carried out in this paper demonstrates the economic benefit of a sustainable transport system. It compared a scenario with and without such system, and calculated loss time as a result of being held up in congestion during key peak hours mainly due to relying entirely on the private car. The work demonstrates that in addition to reducing congestion levels a sustainable transport system will generate benefits related to travel time, accident costs, vehicle operating costs, carbon emissions, environmental impacts, wellbeing of individuals, attraction of international companies to locate in Beirut with reduced congestions levels prevailing, positive effect on business efficiency, and wider labor catchment in terms of penetration of non-car owning communities thus improving labor mobility and accessibility.

Qualitative and quantitative analyses were carried out to determine the impacts of adopting a sustainable transport system on the economy. The results were alarming for the 'Do Nothing Scenario', i.e. remaining reliant on the private car as a sole means of transport. The analyses showed that without a road map adopting a sustainable transport system, Beirut will reach an economic standstill. Therefore, Beirut will have to develop a multi-modal transport system to become resilient and to be able to meet the economic growth that is being pursued by stakeholders and interested parties alike.

A broad but critical Action Plan was produced as part of the work that set the key functions required to move transport into a full multi-modal system that will give people a real choice to choose based on policy changes and traffic management initiatives including parking control.

1. Introduction

The continuous increase in the urban population of Beirut, the centralization of main government divisions (whom are almost exclusively located in the BCD Area), and the presence and insistence of main public and private companies to be located in Beirut directly contribute to the high traffic volume. These, together with inadequate public transport services are all factors leading to what is now a very high private vehicle transport demand within and around the city of Beirut.

Collectively, Lebanon, via its government, its appropriate ministries, and key stakeholders (such as property developers in Beirut) are hoping to attract international investors and global companies, particularly to the BCD area and in the future to the New Waterfront District (NWD) as part of a longer term redevelopment plan.

To date, this ambition has been somewhat semi-successful but still has without doubt a long way to go. This is reflected by the level of construction activities for example associated with international hotel chains, office type developments and residential flats for sale in the BCD and NWD areas. Beirut has attracted internationally renowned architects who have helped develop a new footprint proving that the City is attractive and it is seen as a potential important destination.

The current Beirut Master Plan features the development of prime areas, such as the Beirut Waterfront District (BWD) that will form a natural extension to the current BCD Area. The proposed Master Plan aims to bring Beirut back on the world map as a hub for international trade and investment, a place to work, and a destination for leisure.

An economic boost represented by possible sharp growth is expected as a result of the implementation of the Beirut Master Plan. It is noticeable that international code standards are being applied to buildings whether it is to combat potential seismic activity or whether to try and achieve sustainable building designs. These indicate advancement in thinking, a willingness to put the city on the Arab and world maps, and more importantly a commitment to adhere to and use best design practices from around the globe.

Many factors are vital in maintaining economic growth in modern economies. A robust multi-modal transport system is one of the key elements required for economic growth and stability. Without reliable transportation, it will not be possible for example to consistently piece together the various trips that are undertaken that may include journey to work, home to leisure, and supply to logistics. Therefore, the presence of a reliable transport system will contribute towards a well-functioning city which will in turn reflect positively towards economic performance.

To date, it is clear that for Beirut and Lebanon, transport in general is not taken seriously as when it is compared to international standards applied to buildings as described previously for the BCD and the NWD areas. Thus, there is a current mismatch with transport lagging behind in terms of its development whether it is in terms of overarching transport policy, traffic management including parking policy and control, a clear public transport strategy offering a real choice of transportation, and the issue of carbon emissions and climate change impact as a result of car-borne policies.

Current congestion levels experienced in Beirut are considered to be very high by any international standard and a large percentage of the Lebanese active labor force spend a substantial amount of time commuting.

The Beirut Master Plan and existing land plots under construction will generate additional traffic that will stretch the existing transport system, which relies on private cars (taxis are classified as car-borne trips and are not a mass transport system). This will worsen congestion levels experienced on the road network, which will in turn have a direct impact on the economy, the environment, and people's health. In fact, an unreliable transport system will result in direct costs to business whether it is lost time for employees to access work related activities, or on logistics as an example to name a few.

Most of Beirut's geographical area is currently urbanized and hence there is a limited number of spaces to develop the existing transport system further (widening or new roads). It follows therefore, that alternative means are required to meet the future transport demand other than introducing physical changes to the existing transport system. In this paper, the authors are proposing a sustainable transport system for Beirut particularly the BCD and NWD areas.

This paper also provides linkages to the influence that a sustainable transport system has on business efficiency, labor markets, and labor flexibility. It investigates whether a sustainable transport system will reduce the cost to stakeholders, developers, and owners of plots in the city center. It also focuses on the extent an adequate sustainable transport system will have on attracting the right caliber of investors and international corporations to Beirut as its first choice of destination.

This paper also provides important information related to the quantified lost time caused by being stuck in traffic congestion and its impact on the "Beirut" economy as it addresses a central area of Beirut and is not intended to address the entirety of the country's economy. This type of research has not been previously undertaken and it is hoped that it will lead to further investigative work that will ultimately result in journeys being less congested, and more sustainable types of travel introduced helping other important issues such as climate change, which is a global issue. It is hoped that Lebanon and Beirut will play their part in adopting a sustainable transport system in the near future.

A point to bear in mind is that by 2050 it is expected that some 75% of the world's population will be living and working in cities and Lebanon will be no different. Thus cities like Beirut will become more attractive leading to intense pressure on getting transport policy decision-making and implementing of multi-modal transport schemes high on the local agenda in Lebanon.

The authors, through this paper, aim at building a stepping stone that will allow the decision-makers to understand the impact of a credible transport system on the economy and on wider issues. A sustainable transport system will lead to a more productive population which in turn will have a direct effect on productivity and thus a successful growing economy. The danger being that enough evidence is provided in this paper to conclude that a 'do nothing' scenario, i.e. no real investment in sustainable public transport, is not an option.

2. Sustainable Transport – A Key Requirement for Beirut

In this section, a more detailed explanation on why Beirut requires a public transport system will be explained, and what the broad objectives are that it may need to fulfill.

In Lebanon, commuters mainly rely on private vehicles as a means for commuting to work and leisure purposes due to the lack of credible mass public transport services. Such a transport system has a significant impact on the environment because of the continuous greenhouse gas emissions and local air pollution.

The World Energy Council (2007) estimated that transport systems account for 25% of the world energy consumption. Additional social costs are associated with conventional transport systems due to lost factors associated with congestion, such as the value of time spent in commuting, cost of accidents, vehicles operation costs, and carbon emission costs.

Sustainable transport systems and mass systems in particular reduce economic, social and environmental impacts. In general, sustainable transport systems help reduce travel time, lower vehicle operation costs, result in less carbon emissions, decrease the number of road accidents, and improve overall road safety. In addition, they are considered to be affordable by most commuters, can operate at a high frequency, and are proven operationally to be very efficient. Sustainable transport systems do not always require additional major infrastructure but they do provide a real multi-modal choice of transport for all network users.

Such systems at this moment in time are featured in all major cities which show signs of economic stability and growth. To name a few we can cite London, Paris, Istanbul, New York, Dubai, and Abu Dhabi. Understanding the transport systems in these cities, how they grow and what constrains them are important factors, as Beirut will certainly be competing with other cities around the region and in particular cities around the Mediterranean and Gulf to attract new investments. These investments may be via the relocation of already established companies, or by attracting new companies including international and multi-national ones.

Thus a sustainable transport system is needed in Lebanon and in Beirut in particular, to address transport issues and objectives that include:

- The limited road network in Lebanon, particularly Beirut, as it suffers from severe congestion, and a reduction in these congestion levels are sought, whilst not necessarily building more expensive infrastructure, as the only solution facing us
- Increasing cost for businesses due to traffic congestion, as (1) employees are losing productive time being stuck in traffic jams rather than being at work (journey reliability a key issue exposed here), (2) employee commuters are under a lot of stress due to long hours on the road, which results in lower productive levels
- Restriction on changes in the existing road infrastructure that does not allow for further widening to increase capacity, causing road bottlenecks that will get worse with the further development and growth
- The spreading of the existing traditional peak hours causing constant congestion levels for a larger period of the day. This trend is on the increase as a result of the reliance on private cars as the main means of transport
- The expected increase of congestion levels when the Beirut Master Plan is put into place with the heavy reliance on private cars as the main means of transportation. The city will be expected to be in a complete gridlock during the peak hours, and if private cars is the main means of transport then congestion levels are expected to get even worse, bringing the city to a complete gridlock during peak hours that are continuously spreading throughout the day

- The continuously rising costs associated with using private cars (related to petrol, vehicle maintenance, parking, insurance etc.) turning the affordability of owning and using a car into an issue
- The continuous rise of pollution levels in Beirut will get worse when the BCD and NWD are fully developed. The existing car dominated transport system is one of the main factors contributing to this air pollution problem. Thus a modal shift to public transport is welcomed on environmental grounds in terms of CO_2 car emissions

Nowadays, modern sustainable public transport systems, such as bus rapid transit, light rail, and guided bus-way, are environment friendly, energy efficient, and provide high levels of comfort and reliability.

Therefore, for this study, the authors will assume that a modern public transport system will be adopted as a sustainable transport system in Beirut whilst not assessing the various merits and demerits of each of the systems listed above.

3. Methodology

This section of the paper explains the methodology followed by the authors, which started with an assessment of the economic impacts of adopting a sustainable public transport system. The analysis was divided into two distinct parts, the first being a quantitative part and the second a qualitative part.

The conducted quantitative analysis covered the monetary savings related to the value of time, accident costs, vehicles' operating costs and carbon emissions resulting from adopting a sustainable transport system.

The qualitative analysis that was undertaken showed how a sustainable transport system would affect business efficiency, labor markets, labor flexibility, and how it might assist in attracting investors and international companies, as an example, to Beirut as their destination of choice.

One of the main challenges was the limited historical data available related to the research required to be conducted as part of this paper. Therefore, the authors adopted an indirect approach to quantify the monetary impacts of adopting a sustainable transport system. The key adopted/ adjusted methodology is summarized as follows:

- The study area was limited to the BCD area bounded by Avenue Mir Majid Irslane to the north, Avenue Fouad Shehab to the south, Avenue Georges Haddad to the east and by Avenue Fouad Shehab to the west.
- Traffic counts were carried out in the study area to determine daily traffic volumes and to establish their variation throughout the day, as well as to identify vehicular composition. The methodology and results of the traffic survey are presented in later sections of this paper.
- The authors derived local estimates for the value of time, accident costs, vehicle operating costs, and carbon emissions to be used in the quantitative analysis. The adopted approaches for these estimates are presented later in the paper.
- In order to determine the impact of a sustainable transport system on the traffic volumes and congestion levels in the defined study area, the authors developed a micro-simulation traffic model using the software known as VISSIM that will be presented in the traffic modeling section of this paper.

The qualitative analysis part determined the impacts of adopting a sustainable transport system on business efficiency, labor markets, labor flexibility, and the level of attraction to investors and international companies.

Specific applications in terms of an action plan with recommendations for Beirut were presented.

4. The Study Area and its Key Environs

The Beirut Master Plan is in essence proposing to develop reclaimed land (Lebanese Council of Ministers Decree, 2005), shown bounded by a blue cordon in Figure 4.1, which is known as the New Waterfront District (NWD). The NWD will be a natural extension of the existing Beirut Central District (BCD), marked in a red cordon as shown in Figure 4.1 below.

The Master plan aims to develop approximately 3.3 million square meters of mixed use development in total, of which around 1.7 million square meters will be within the central BCD area and the remainder in the NWD area. As there are currently significant queue and delay problems on most links and junctions within the study area (BCD) it is not surprising to conclude that these proposals will result in an increase in traffic volumes which will add to these existing unacceptable congestion levels on the road network particularly within the BCD area. When the NWD is built and fully developed it is important to note that it will need to gain access via the existing BCD area thus adding to the problem of congestion.

This paper will assess the impact of adopting a sustainable transport system within the BCD area that is bounded by Avenue Mir Majid Irslane to the north, Avenue Fouad Shehab to the south, Avenue Georges Haddad to the east, and Avenue Fouad Shehab to the west. This will eliminate the need to take into effect the large volumes of traffic expected as part of the NWD, although the values established in relation to loss time and other factors affecting productivity will only get higher once these trips are taken into account and no public transport system is put in place.

Figure 4.1: Study Area

5. Traffic Surveys

5.1 Introduction

As highlighted in the methodology (Section 3.0), the authors developed a micro-simulation model, using VISSIM, a well-known international transport planning tool, for the study area. This model firstly aimed to reflect existing current traffic conditions (Base Year) for defined peak periods and then to test a future base year peak hour model against an option that accounted for a public transport system in place. This allowed for a comparison to be provided and quantified based on several congestion-related parameters to be defined later on in the paper.

The Base Year Model was developed by using actual traffic volumes and calibrated against a set of traffic survey data collected at defined locations within and on the boundary of the study area.

5.2 Traffic Survey Types

Two types of traffic surveys were conducted in December 2013 which entailed automatic classified counts known as ATC's and manual classified counts known as MCC's.

The ATC surveys provided information related to daily traffic volumes and patterns. Traffic data collected was recorded at 15-min intervals over a 24 hour day thus providing hourly summary volumes including peak hours. The ATC surveys took place over a whole week in order to determine weekday traffic volumes and weekend traffic volumes and patterns. The ATC data provided traffic volumes in terms of total number of vehicles and did not distinguish between vehicle types.

The MCC counts provided traffic volumes per type of vehicle. The MCC surveys were conducted during a typical weekday. Vehicles were classified into eight main categories as follows.

- **Private Cars:** These are defined as private vehicles.
- **Taxis:** Taxis were defined as 'Service' vehicles picking up passengers for a certain fee.
- **Vans:** Vans are defined as vehicles picking up passengers for a certain fee. Vans are a bigger version of taxis with their loading capacity varying between 10 to 15 passengers.
- **Mini-Buses:** Defined as Mini-buses that can carry up to 28 passengers for a certain fee.
- **Light Good Vehicles (LGV):** LGV are vehicles delivering goods.
- **Heavy Good Vehicles 1 (HGV1):** Trucks with 2 axles.
- **Heavy Good Vehicles 2 (HGV2):** Trucks with more than 2 axles.
- **PSV:** PSV are large buses that can accommodate in capacity terms between 50 to 60 passengers.

5.3 Traffic Survey Locations

ATC's were located on main arterial roads leading in and out of the study area in order to capture total traffic volumes to and from the BCD area. The MCC counts were conducted at main intersections within the study area to determine traffic composition as well as turning movements required for validating the VISSIM peak hour traffic model. As illustrated in Figure 5.1, ATC's were carried out at four locations, while the MCC surveys covered 19 junctions in total.

Figure 5.1: Traffic Survey Locations (ATC and MCC)

5.4 ATC Results

ATC data in both directions of flow were analyzed and the average of all the ATC survey locations was obtained. The results are presented in Figure 5.1 showing the average daily traffic over a typical weekday and the average daily traffic over a typical weekend. The following can be concluded from Figure 5.2.

- The average daily traffic distribution during a typical weekday shows that there are two distinct peak periods, a morning peak period (AM) and an evening peak period (PM).
- The morning peak period is between 08:00 and 11:00hrs.
- The evening peak period is between 16:00 and 18:00hrs.
- The peak traffic volumes for the AM and PM peak periods are virtually identical.
- There is no distinct peak hour in either the AM or PM peak periods (i.e. no peak of peaks within the peak hours).
- The average weekend traffic volumes show two distinct peak hours of relatively similar magnitude. The first peak occurs from 13:00 to 14:00hrs and the second from 17:00 to 18:00hrs.

The identified peak periods indicate a relatively flat profile with little difference between the traffic volumes of each hour identified within the peak period. This is not a complete surprise as it reflects increasing car ownership and a lack of alternative travel to the private car. In addition no real investment in network infrastructure and equipment is evident either to support public transport or to tackle congestion hot spots. Thus congestion is spreading and the network is operating way beyond its capacity threshold in terms of links and mainly junctions that are seen as the main bottleneck.

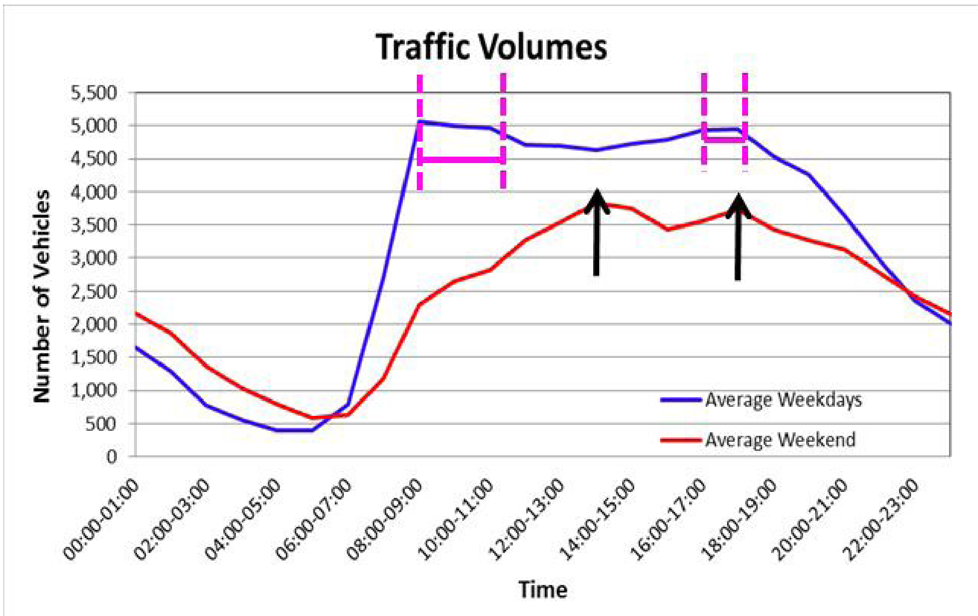


Figure 5.2: ATC Results

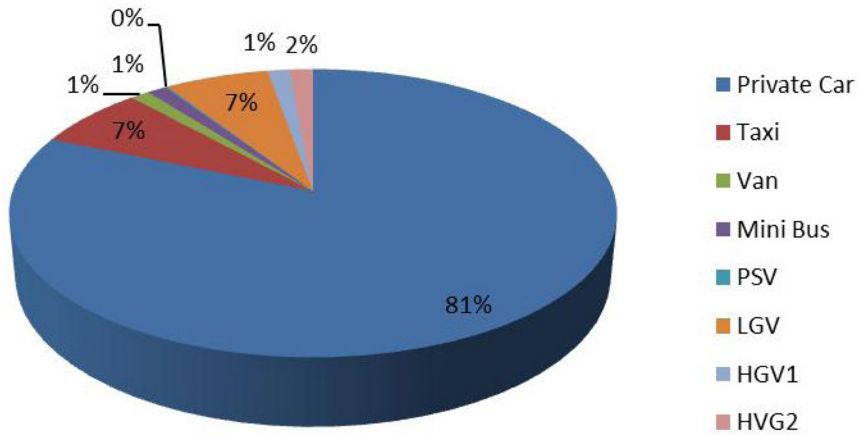
5.5 MCC Results

The average traffic composition based on the eight vehicle categories previously identified is represented in Table 5.1 and Figure 5.3. The MCC counts were conducted for the morning peak hour (AM) and evening peak hour (PM). Based on Figure 5.2, the AM and PM peak hours are from 08:00 to 09:00hrs, and 16:45 to 17:45hrs respectively.

Figure 5.3 was derived from the average of all the MCC survey locations. It shows that private cars form the majority of vehicles followed by taxis then LGVs.

Vehicle Composition	Private Car	Taxi	Van	Mini-Bus	LGV	HGV1	HGV2	PSV
Expressed as a Percentage	81.3	6.9	1.2	1.2	6.4	1.3	1.5	0.1

Table 5.1: Vehicles Composition



Note that during the peak hours, the traffic composition consists of private cars (84%), taxis (7%), vans (1%), mini-buses (1%), and LGVs (7%).

Figure 5.3: Pie Chart of Vehicle Classification Percentage Split

Vehicle Registration Administration

A comparison between the survey data results and the data obtained from the Vehicle Registration Administration in Lebanon (VRAL) was done. According to the VRAL, the total number of registered vehicles including motorcycles is 1,525,738. These are distributed among the different vehicle types as summarized in Table 5.2.

Category	Description	Number	Percentage
Category 1	Number of vehicles with four wheels including light vehicles and light trucks	1,410,140	92.42%
Category 2	Number of vehicles with two or three wheels	76,573	5.02%
Category 3	Number of heavy trucks	25,270	1.66%
Category 4	Number of buses	13,755	0.90%

Table 5.2: Vehicles Classification based on the Vehicle Registration Administration

Table 5.3 provides a comparison between the vehicle composition resulting from the traffic surveys and those provided by the VRAL. It was assumed for this comparison that Category 1 of Table 5.2 covers private cars, taxis, vans, mini-buses, LGVs, and HGVs1. Category 3 was assumed to be identical to HGV2, and Category 4 to PSVs. The conducted travel survey did not account for motorcycles; therefore Category 2 cannot be associated with the traffic survey.

Table 5.3 shows that there is a similarity between the results where Category 1 represents more than 90% of vehicles, Category 3 around 1.5%, and Category 4 less than 1%.

Category	Survey Results	Vehicle Registration Administration
Category 1	98.30%	92.42%
Category 2	n/a	5.02%
Category 3	1.5%	1.66%
Category 4	0.10%	0.90%

Table 5.3: Comparison of Vehicles Composition Results

5.6 Vehicle Occupancy

The authors did not conduct any comprehensive full day vehicle occupancy surveys during the period that traffic counts were carried out, but adequate spot checks were carried out at intervals throughout the day that included the peak hours under study. Vehicle occupancy information was obtained from Lebanon's National Physical Plan Report and is summarized below in Table 5.4.

Vehicle Type	Average Occupancy (person/vehicle)
Private Cars	1.6
Taxis	2.2
Vans	1.7
Mini-Bus	8.3
LGV	1.7
HGV1	1.6
HGV2	1.4
PSV	10.4

Table 5.4: Vehicle Occupancy

However, during the conduction of the surveys the enumerators carried out spot checks on vehicle occupancy levels during the peak hours and it was observed that the average occupancy of private cars dropped to 1.1 which is a lower rate that that shown in Table 5.4 above.

Following several discussions and consultations, 1.1 persons per private car was selected and applied to the analysis in this paper although the authors accept that this value may be higher outside the peak hours the lower value was applied.

6. The Value of Time

6.1 Introduction

Shifting towards a sustainable transport system would reduce congestion levels and hence shorten time spent in commuting. In any transport economic study, it is necessary to quantify the benefits associated with travel time savings as they are one of the major benefits resulting from investments in transport infrastructure. There is a direct link between reducing congestion i.e., queues and delays on links and junctions, and reducing travel time leading to travel time savings.

In order to quantify travel time savings, one has to determine the value of time, distinguishing between the purposes for travel (1), being travel related to work and (2), being travel related to non-work. Time spent travelling by an employee during a working day results in a direct cost to the employer's business.

While performing economic analysis, it is important to recognize that savings in travel time can result in the conversion of non-productive time to productive time. This saving is assumed to be passed to the wider economy and reflected in the wage rate paid (UK - TAG Unit 3.5.6, April 2011). This is particularly true when congestion is at a high level and the performance of the network as a whole is unpredictable. Or indeed, if congestion as experienced in Beirut is resulting in peak spreading thus prolonging year on year the classified peak hour periods.

Non-work trips are made for non-wage earning purpose journeys and therefore are difficult to quantify as they are mainly based on the 'willingness to pay' of an individual. There is no clear relationship between the value of time of non-work trips and salary income. Each individual tends to subjectively quantify the value of time of non-work trips based on their journey purpose, comfort, trip attractiveness, and urgency. However, the values of some of these factors are related to income and any change in income will be reflected in the value of time of non-work trips.

It follows therefore that one has to determine the income before quantifying the value of time for work and non-work purposes. Unfortunately there are no reliable or historical up-to-date statistics in Lebanon that provide the required information related to income or values of time.

Hence, the authors adopted an indirect approach to quantify these variables based on the population, average income, and gross domestic product. The methodology and results are presented in the sections that follow.

6.2 Population

The last official population census in Lebanon took place in 1932 and no comprehensive population surveys were carried out since that date. Hence, the only semi-official source that is available for the authors to estimate the Lebanese population and their distribution among the different governorates (regions) is the Living Conditions of Households – The National Survey of Household Living Conditions (referred to as NSHLC Report from this point onwards) – published 2007 by the UNDP with the collaboration of the Lebanese Ministry of Social Affairs and the Lebanese Central Administration for Statistics.

The NSHLC Report estimated that the total population in Lebanon in 2007 as being 3,759,135 (excluding those residing in the Palestinian camps). The population cited is distributed among the different governorates (regions) of Lebanon as illustrated in Table 6.1.

Post-2007, and in the absence of any local historical data or any future local projections the authors adopted an average growth in population of 1.3% per year based on information obtained from the International Monetary Fund (IMF). Based on this assumption, the projected population in Lebanon is provided in Table 6.2.

Governorate	Population	Percentage (%)
Beirut	361,366	9.6
Mount Lebanon[1]	1,484,474	39.5
North Lebanon	763,712	20.3
Bekaa	489,865	13.0
South Lebanon[2]	659,718	17.5
Total	3,759,135	100

1 Including Beirut's suburbs
2 Including Nabatieh

Table 6.1: Population Distribution by Governorates (2007)

Year	2014	2015	2020	2025	2030	2035	2040	2045
Population	4,114,850	4,168,344	4,446,424	4,743,054	5,059,473	5,397,001	5,757,046	6,141,111

Table 6.2: Projected Population Based on IMF Growth estimates:

It is difficult to estimate the growth for each individual governorate or region in terms of their future population and as such the authors have, for the purposes of the analysis conducted as part of this paper, assumed that the percentages presented in Table 6.1 will be applicable for future years. This is appropriate as it is the only available source of data to date that is deemed acceptable to rely on.

6.3 Average Income

The NSHLC Report provides information related to the average income of households in the different governorates (regions) as illustrated in Table 6.3 below.

Beirut registers the largest average income value at around 909,000 LBP with South Lebanon the lowest average income region at 562,885 LBP.

Governorate	Average Income (LBP)
Beirut	909,000
Mount Lebanon	708,385
North Lebanon	597,000
Bekaa	626,000
South Lebanon	562,885
Weighted Average	668,770

Table 6.3: Average Income in Lebanese Pounds (2007 Prices)

6.4 Gross Domestic Product and Elasticity

The NSHLC Report also provides average salaries based on 2007 prices. However, these salaries are known to change each year depending on gross domestic product (GDP), inflation and other factors. Therefore, the yearly variation in salaries needs to be determined. The growth index associated with this variation will be applied to other variables featured in this paper, such as the value of time and value of accidents.

The variation in GDP was determined from the International Monetary Fund – World Economic Outlook Database. The database provides actual and projected information covering the period to 2018. The IMF data was filtered to start from 2007, the year corresponding to the NSHLC Report. The GDP data results from 2007 to 2018 are provided in Table 6.4 below. It should be noted that the GDP values post-2010 are projected by the IMF.

Year	GDP (billions of Lebanese pounds)	GDP Growth (%)	GDP Growth Index (Base 2007)
2007	33,803	0.0%	100.0
2008	36,710	8.6%	108.6
2009	40,014	9.0%	118.4
2010	42,815	7.0%	126.7
2011	43,457	1.5%	128.6
2012	44,109	1.5%	130.5
2013	44,991	2.0%	133.1
2014	46,791	4.0%	138.4
2015	48,662	4.0%	144.0
2016	50,609	4.0%	149.7
2017	52,633	4.0%	155.7
2018	54,738	4.0%	161.9

It is relevant to point out that post 2018, the authors assumed a constant growth in GDP equivalent to 4% corresponding to the IMF's 2018 growth.

Table 6.4: GDP and GDP Growth

The growth in monetary values per year, such as salaries and value of time was determined as a growth factor based on the GDP per capita variation and elasticity. Guidelines, such as the HEATCO, recommend using an internal-temporal elasticity of 0.7 to the GDP per capita growth in case of the absence of data (which is the case that we are facing in Lebanon).

A sensitivity analysis also needs to be carried out with an elasticity of 1.0 in this case. The GDP per capita was determined from the estimated population in Table 6.2 and the GDP values in Table 6.4. The results are presented in Table 6.5 below.

Year	GDP per Capita (millions of Lebanese Pound)	GDP per Capita Growth Index	Monetary Growth Factor (0.7 Elasticity)	Monetary Growth Factor (1.0 Elasticity)
2007	8.99	1.00	1.00	1.00
2008	9.64	1.07	1.05	1.07
2009	10.37	1.15	1.11	1.15
2010	10.96	1.22	1.15	1.22
2011	10.98	1.22	1.15	1.22
2012	11.00	1.22	1.16	1.22
2013	11.08	1.23	1.16	1.23
2014	11.37	1.26	1.19	1.26
2015	11.67	1.30	1.21	1.30
2016	11.99	1.33	1.23	1.33
2017	12.30	1.37	1.26	1.37
2018	12.63	1.40	1.28	1.40

Table 6.5: GDP per Capita and Monetary Growth Factor

Table 6.5 shows that for the year 2014 the monetary growth factor is 1.16 and 1.23 for an elasticity of 0.7 and 1.0 respectively. These growth factors were used to estimate the average salary predicted for 2014 based on the information provided in Table 6.3. The results are summarized in Table 6.6.

Governorate	Average Income (0.7 Elasticity)	Average Income (1.0 Elasticity)
Beirut	1,077,340	1,149,485
Mount Lebanon	839,572	895,796
North Lebanon	707,560	754,943
Bekaa	741,930	791,615
South Lebanon	667,127	711,802
Weighted Average	792,621	845,700

Table 6.6: Average Income in Lebanese Pounds (2014 Prices)

Table 6.6 shows that there is a difference of 6.2% between the '0.7 elasticity' and '1.0 elasticity' values.

Based on the authors' knowledge and know-how of the local market, the salaries resulting from the '1.0 elasticity' are deemed to be closer to reality than those produced by the '0.7 elasticity'. Therefore, in this study, an elasticity of 1.0 will be adopted in determining growth in monetary values.

6.5 General Value of Time

The Lebanese Labor Law sets the maximum working hours per week at 48. The working hours per week varies in Lebanon depending on if an employee works for the private sector or the public sector.

In general, employees of the public sector work around 33 hours per week. The majority of employees in the private sector work between 40 and 45 hours per week, while others work up to 48 hours per week (the maximum normal working hours under the Lebanese Labor Law).

For the purpose of this paper, it is assumed that the average working hours per week is 40.5 based on the average minimum working hours per week in Lebanon (33 hours) and the maximum working hours per week (48 hours).

It is also assumed that, on average, each month comprises 4.33 weeks. Therefore, the average working hours per month are calculated to be 176 hours. The average hourly salary was calculated based on these assumptions and the results are summarized in Table 6.7 below.

Governorate	Average Hourly Salary (LBP)
Beirut	6,531
Mount Lebanon	5,090
North Lebanon	4,289
Bekaa	4,498
South Lebanon	4,044
Weighted Average	4,805

Table 6.7: Average Hourly Salary (2014 Prices)

The average hourly salary then needed to be converted into work and non-work hourly values to be adopted and applied in this study.

6.6 Value of Working Hour

The value of work trips of an employee is directly related to the salary rate. Work values of time are estimated by factoring the average hourly salary to reflect additional costs related to other factors such as overheads, paid holidays, sickness, etc.

In the absence of any existing Lebanese national data, the 'Toolkit for the Economic Evaluation of World Bank Transport Projects' recommends a factor of 33% to reflect these additional costs. This assumption was used to determine the values of time for working hours. The results are provided in Table 6.8.

Governorate	Average Work Hourly Salary (LBP)
Beirut	8,686
Mount Lebanon	6,769
North Lebanon	5,705
Bekaa	5,982
South Lebanon	5,379
Weighted Average	6,391

Table 6.8: Values of Time for Working Hours (2014 prices)

The value of time for working hours directly varies in line with salary. Therefore, the growth index of the GDP per capita was applied to obtain the future values of time for the working hour with an elasticity of 1.0.

6.7 Value of Non-Working Hour

There is no reliable theoretical basis linking the value of the non-working hour to the wage rate, however its value is related to income, and hence any change in the income should be reflected in a change in the value of non-working hour (notes on the Economic Evaluation of Transport Projects, The World Bank, January 2005). In the absence of local data, which is the case in Lebanon, the 'Toolkit for the Economic Evaluation of World Bank Transport Projects' suggest a value of 30% of the wage rate (Table 6.7). The results are summarized in Table 6.9.

Governorate	Average Work Hourly Salary (LBP)
Beirut	1,959
Mount Lebanon	1,527
North Lebanon	1,287
Bekaa	1,349
South Lebanon	1,213
Weighted Average	1,442

Table 6.9: Values of Time for Non-Working Hours (2014 prices)

Studies in the UK and the Netherlands showed that the elasticity varies between 0.5 and 0.8 between the value of time for the non-working hour and income. The 'Toolkit for the Economic Evaluation of World Bank Transport Projects' recommends that the value of time for the non-working hour should increase with increasing GDP per capita unless there is local evidence showing the contrary. Therefore, for the purpose of this paper, the authors assumed an elasticity of 0.8 between the growth in GDP per capita and the value of time for the non-working hour.

6.8 Work Value of Time for Car Users

Car drivers tend to have a higher value of time than the average population. People commuting on a daily basis using their cars are expected to have a higher salary than average. As a result, the associated values of time should be higher than those presented in Table 6.8.

The authors assumed that car users consist of a wide range of people working as high ranking employees, managers at various levels, professionals, specialists, and administrative support positions. The NSHLC Report provides the average salaries of these professions as illustrated in Table 6.10.

Profession	2007 Prices (LBP)	2014 Prices (LBP)
High Ranks and Managers	1,929,000	2,439,337
Professionals	1,077,000	1,361,932
Specialists	884,000	1,117,871
Administrative	743,000	939,568
Average	1,158,250	1,464,677

Table 6.10: Average Monthly Salary for Car Drivers

Table 6.10 shows that the average monthly salary of car users is 1,464,677 LPB in 2014 prices. This is higher than the average salaries derived in Table 6.6. Therefore, growth factors should be applied when calculating the value of time for car users. These factors are provided in Table 6.11 and they were applied to determine the value of time (car-users) for both working and non-working hours.

Governorate	Growth Factor
Beirut	1.27
Mount Lebanon	1.64
North Lebanon	1.94
Bekaa	1.85
South Lebanon	2.06
Weighted Average	1.73

Table 6.11: Growth Factor in the Value of Time for Car Users

6.9 Work Value of Time for Bus Users

In Lebanon, the perception of using buses for transportation is not seen as a sustainable means of transport since the majority of bus users are people with relatively low salaries who cannot afford using a car on a daily basis. This perception is clearly an issue and can be a barrier in the face of adopting a multi-modal transport approach.

The authors assumed that bus users in Lebanon are mainly sales and service employees, workers in the fishing industry and agriculture, skilled workers, drivers, unskilled workers, and military personnel (based on the categories defined in the NSHL Report). The average salaries of these categories of employees and workers was covered in the NSHLC Report and summarized in Table 6.12.

Profession	2007 Prices (Lebanese Pounds)	2014 Prices (Lebanese Pounds)
Sales and Service	495,000	625,957
Fishing and Agriculture	272,000	343,960
Skilled Workers	476,000	601,931
Drivers	541,000	684,127
Unskilled Workers	359,000	453,977
Military Personnel	720,000	910,483
Average	477,167	603,406

Table 6.12: Average Monthly Salary for Bus Users

From assessing Table 6.12 it can be concluded that the average income salary for relatively low paid employees and workers is 603,406 LBP, which is less than the average salaries presented in Table 6.6. Hence, reduction factors should be applied when deriving the value of time for bus users. These factors are presented in Table 6.13 and they were applied to calculate the value of time (bus-users) of both working and non-working hours.

Governorate	Growth Factor
Beirut	0.52
Mount Lebanon	0.67
North Lebanon	0.80
Bekaa	0.76
South Lebanon	0.85
Weighted Average	0.71

Table 6.13: Reduction Factor in the Value of Time for Bus Users

6.10 Value of Time in Beirut

This paper focuses on the economic impact of introducing a sustainable transport system in Beirut. Therefore, the focus from this point forward will be on the value of the time in Beirut that will be derived based on the information previously provided. The results are summarized in Table 6.13.

Users	Work (LBP / Hour)	Non-Work (LBP / Hour)
Car Users	11,068	3,320
Bus Users	4,560	985

Table 6.13: Value of time in Beirut (using 2014 prices)

The projected values of time for future years (up to 2045) are provided in Table 6.14 below.

Description	2014	2015	2020	2025	2030	2035	2040	2045
Car Users – Work Time	11,068	11,363	12,961	14,399	16,860	19,230	21,933	25,016
Car Users – Non Work Time	3,320	3,409	3,888	4,320	5,058	5,769	6,580	7,5050
Bus Users – Work Time	4,560	4,681	5,339	5,932	6,946	7,922	9,036	10,306
Bus Users – Non Work Time	985	1,007	1,126	1,233	1,416	1,592	1,793	2,022

Table 6.14: Projected Values of Time (LBP per hour)

7. Vehicles Operating Costs

7.1 Introduction

Drivers and passengers encounter operational costs when using their vehicles. These costs are split into two categories: costs related to fuel consumption and costs related to non-fuel elements respectively. The latter category includes costs associated with lubricants, tires, maintenance/ parts, maintenance labor, depreciation and interest.

7.2 Vehicle Operation Cost – Fuel Related Costs

Fuel Consumption

The UK Department of Transport (TAG Unit 3.5.6, April 2011) estimates the fuel consumption per vehicle as a function of the average speed as follows:

$$L = \frac{a+bv+cv^2+dv^3}{v}$$

Where L is the fuel consumption in liters per km, v is the average speed in kilometers per hour, and a, b, c, d are parameters defined for each vehicle category. These parameters are provided in Table 7.1 below.

Vehicle Type	a	b	c	d
Petrol Car	1.042850982	0.044837250	-0.00004913	0.00000217810
Diesel Car	0.480988603	0.064502969	-0.00057789	0.0000045415
Average Car	0.957447900	0.047826440	-0.00012976	0.00000253734
Petrol LGV	1.628611034	0.067231691	-0.00077899	0.0000105213
Diesel LGV	1.082489985	0.059963265	-0.00044831	0.00000831097
Average LGV	1.162824392	0.061032451	-0.00049695	0.00000863611
HGV1	1.564481329	0.260097879	-0.00378306	0.0000324446
HGV2	3.613294863	0.420269140	-0.00494707	0.0000382806
PSV	4.115603124	0.306464813	-0.00420643	0.0000365263

Table 7.1: Fuel Formula Parameters

Fuel Price

For Lebanon, fuel prices and the fuel price structure were obtained from the Ministry of Energy and Water (MEaW) website. In Lebanon, fuel prices vary on a weekly basis; hence for this study the prices corresponding to the second week of January 2014 will be adopted. The fuel prices and associated price structure are provided in Table 7.2 below.

Item	Petrol 98 Octane	Petrol 95 Octane	Diesel
Paid Price (LBP/1000 Kilo liter)	1,195,000	1,160,500	1,290,000
Taxation (LBP/1000 Kilo liter)	224,000	226,500	0
Distribution Company Share (LBP/1000 Kilo liter)	15,000	15,000	7,000
Transportations Fees (LBP/1000 Kilo liter)	18,000	18,000	18,000
Station Commission (LBP/1000 Kilo liter)	80,000	80,000	20,000
Total without VAT (LB/1000 Kilo liter)	1,532,000	1,500,000	1,335,000
VAT (10%) (LBP/1000 Kilo liter)	153,200	150,000	0
Pump Price per 20 Liters	33,700	33,000	26,700

Table 7.2 Fuel Prices and Price Structure

The economic price of petrol was obtained based on the prices shown in Table 7.2 excluding taxation and VAT and is summarized in Table 7.3 below.

Cost	Petrol 98 Octane	Petrol 95 Octane	Diesel
Cost (LBP/ liter)	1,308	1,274	1,335

Table 7.3: Fuel Economic Prices (2014 prices)

For the purpose of this study, the authors assumed that petrol is used by private cars and taxis while the remaining vehicle types (Table 5.1) use diesel.

It is also assumed that all vans and 75% of private cars use 95-octane petrol. Based on these assumptions, Table 7.4 provides the economic prices of fuel for each vehicle type.

Vehicle Composition	Private Car	Taxi	Van	Mini-Bus	LGV	HGV1	HGV2	PSV
Price	1,308	1,274	1,335	1,335	1,335	1,335	1,335	1,335

Table 7.4: Economic Price of Fuel per Vehicle Type (2014 prices in LBP)

The US Energy Information Administration (EIA) has projected the yearly increase in the cost of fuel as provided in Table 7.5 below.

From Year	To Year	Yearly Growth
2014	2015	8.97%
2016	2020	4.00%
2021	2025	2.95%
2026	2030	2.33%
2031	2035	1.86%

Table 7.5. Projection in Fuel Costs

Post 2035, the authors assumed that the 2035 projected growth (1.86%) applies. The projected fuel price was determined based on Table 7.5 and this assumption. The results are summarized in Table 7.6 below.

Year	2014	2015	2020	2025	2030	2035	2040	2045	2050
Petrol 98 Octane	1,308	1,553	1,889	2,185	2,451	2,688	2,948	3,233	3,546
Petrol 95 Octane	1,274	1,513	1,840	2,128	2,387	2,618	2,871	3,149	3,454
Diesel	1,335	1,585	1,928	2,230	2,501	2,743	3,009	3,300	3,619

Table 7.6. Projected Fuel Costs (LBP/liter)

Vehicle Operation Costs – Non Fuel Related Costs

Based on the UK's Department for Transport TAG Unit 3.5.6, Value of Time and Operation Costs (April 2011), the costs associated with non-fuel elements of VOC are combined in one formula as follows:

$$C = a_1 + \frac{b_1}{V}$$

Where a1is a parameter for distance related cost for each vehicle category, b1 is a parameter for vehicle capital saving, and V is the average link speed in km/hr. The second term of Equation 2 is only relevant for vehicles commuting for work purposes.

The a1 parameter was determined by adopting the World Bank's HDM-IV and UK COBA (Cost Benefit Analysis) software. For each vehicle type, factors related to lubricants, tires, maintenance parts, maintenance labor, depreciation, and interest were adopted to calculate the cost per km. The results are provided in Table 7.6 below.

Vehicle Type	Private Car	Taxi	Van	Mini-Bus	LGV	HGV1	HGV2	PSV
a_1	200.25	200.25	342.00	354.00	279.75	669.00	1,044.00	481.60
b_1	1,127.84	1,127.84	390.86	390.86	390.86	2,188.67	4,218.81	5,762.08

Table 7.6: Non-Fuel Costs – a1 Parameters (LBP/km) and b1 Parameters (LBP/hr)

8. Accident Costs

8.1 Introduction

The continuous growth in the urban population of Beirut has resulted in a rise in the number of vehicles on the network. This poses a major concern as the number of road accidents is expected to increase as traffic volume increases (United Nation 2012, Rogat et al. (2009)).

Introducing a sustainable transport system will reduce the number of vehicles and hence decrease the number of accidents, especially when more stringent safety measures are incorporated and, more importantly, additional rigorous enforcement regimes are introduced. Traffic enforcement is currently a key concern in Lebanon and Beirut.

The reduction in the number of accidents results in economic benefits that constitute an important element in any project appraisal (DMRB, 2004, UK). Therefore, it becomes necessary to put a monetary value for accidents in order to quantify the benefits as a result of accident savings.

8.2 Accident Costs

Road traffic accidents are associated with losses to the economy. According to Choueiri et al. (2010), the economic costs of road traffic accidents pose a significant burden on the Lebanese economy.

The cost of each accident depends on its severity and whether personal injuries took place or not. Direct (visible) and indirect (invisible) costs are associated with each accident. An example of direct costs is the costs of property damage that is visible and can be easily quantified. However, indirect costs such as the lost production of the injured person are invisible and hence difficult to estimate.

In addition to the direct and indirect costs to the economy, a 'human value' cost is usually introduced to quantify the human life of the injured person. This value tends to be higher than the estimated economic losses.

In order to determine the accident cost, one needs the average accident costs and the total number of accidents. For the purpose of this paper, the authors divided accidents into two types, a personal injury accident and a damage-only accident. The former was sub-divided into fatal, serious injury, and slight injury accident types.

The SweRoad organization undertook a study in 2004 to determine the cost of road traffic accidents in Lebanon. This cost included the costs associated with medical treatment, emergency services, police and investigators, property damage, production loss, and the 'human value'.

The Traffic Control Center for Greater Beirut used the information developed by the SweRoad Report (2004) to determine the accident costs for 2010. The results are summarized in Table 8.1.

Cost	Fatality	Serious Injury	Slight Injury	Property Damage
Total Cost	197.72	309.34	15.18	126.34

Table 8.1: Accident Costs in 2010 (USD Million. Source: Traffic Control Center for Greater Beirut)

The Traffic Control Center in Lebanon reported a total of 4,583 accidents which are summarized in Table 8.2 and are broken down into fatal and serious injury type accidents.

Year	Number of Accidents	Number of Fatalities	Number of Serious Injuries
2010	4,583	549	6,583

Table 8.2: Accident Data for 2010 (Source: Traffic Control Center Lebanon)

The SweRoad Report (2004) concluded that there was a considerable under-reporting of road accidents in Lebanon. The degree of under-reporting is not fully quantified; however under-reporting is common. As such, this is not unusual as in some western countries such as the UK accidents are not recorded if the police was not present at the accident site.

If police are absent from an accident site, there will be not be any data recorded in the local police database. This happens often, which leads to an incomplete picture of the total number of accidents in the UK.

Whilst you can obtain records from insurance companies and establish an estimate of total accidents, it lacks important details that include cause of accident, road conditions, weather conditions and other important factors to name a few.

In order to determine the split between serious and slight accidents, the SweRoad Report (2004) suggested using a ratio of 1:38 of fatal to serious and slight accidents. Applying this ratio to the information provided in Table 8.2, the estimated number of slight injury accidents in 2010 would be 14,279.

Table 8.3 provides the cost per accident in 2010 based on the information provided in Table 8.1, and Table 8.2, as well as the derived number of slight injury accidents. It should be noted that no information was available to the authors regarding the 'property damage' accidents; therefore it was decided to drop it/ side-line it from the analysis. A growth factor of 1.038 was used to derive the 2014 prices from 2010 prices.

Cost	Fatal	Severe Injury	Slight Injury
Cost per Accident (2010 Prices)	360,146	46,991	1,063
Cost per Accident (2014 Prices)	373,832	48,777	1,103

Table 8.3: Cost per Accident (USD)

8.3 Accident Rates

The Lebanese Traffic Control Center does not hold information related to accidents per type of road. In addition, no detailed information is provided regarding where the accident took place in terms of location. As a result, it will be difficult to determine the number of accidents and the reduction in the number of accidents after adopting a sustainable transport system within the study area.

In the absence of relevant data, the authors adopted the Economic Assessment of Roads Schemes, The COBA (UK Cost Benefit Analysis) Manual, The Valuation of Costs and Benefits DMRB 2004. The followings were assumed for the study area:

- The speed limit with the study area is less than 40mph (64 km/h);
- The study area includes links and junctions, therefore the combined coefficients for links and junctions were used;
- Accidents are given as personal injury accidents per million vehicle kilometer (mvk); and
- The split of the personal injury accident among fatal, serious, and slight is constant.

Based on these assumptions, the accident rate (personal injury accident per million vehicle kilometer – pia/mvk) and severity splits are provided in Table 8.4.

Accident Rates (pia/mvk)	Fatal Injury (per pia)	Serious Injury (per pia)	Slight Injury (per pia)
1.004	0.006	0.082	1.377

Table 8.4: Accident Rate and Severity Splits

9. Carbon Emissions

9.1 Introduction

Due to the lack of availability of any local guidance for appraising carbon emissions, the authors relied on the guidance set by the UK's WebTAG guidance UNIT 3.3.5 and HEATCO Deliverable 5. The amount of the emitted carbon is directly related to the fuel consumed by vehicles using the road network in the study area.

The carbon emission assessment primarily focused on the change in the emissions associated with the change in fuel consumption in the study area by comparing the current carbon emission with the one resulting from adopting a sustainable transport system. The appraisal undertaken was based on associating monetary values to carbon emission figures.

9.2 Proposed Approach

In order to quantify the carbon emissions, the authors adopted the following approach:

- The amount of fuel consumed was calculated distinguishing between petrol and diesel vehicles based on the formula in Section 7.2.1.
- The consumed fuel was converted into carbon emissions using the amount of carbon emitted from burning one liter of fuel. Table 9.1 provides the estimated carbon emission per liter of fuel burnt. Note that the values of Table 9.1 do not take into account any reductions resulting from introducing biofuels as it is unlikely that such a type of fuel will be present in the near future in Lebanon.

Emission from Petrol (g carbon/liter)	Emission from Diesel (g carbon/liter)
637.91	719.73

Table 9.1 Carbon emissions per One Liter of Fuel Burned

The last step consists of converting the carbon emission into monetary values. The authors adopted the HEATCO guidance for carbon emission prices. The average prices in the HEATCO report were converted to Lebanese Pounds taking into consideration the ratio of the average GDP per capita in Europe to that in Lebanon based on the World Bank data. The authors assumed a constant exchange rate between the Euro and the Lebanese Pound. The results are provided in Table 9.2 below.

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Year	Price (LBP per 1 ton of carbon)
2014 - 2019	19,191
2020 - 2029	23,620
2030 - 2039	29,525
2040 - 2049	40,596
2050	61,264

Table 9.2 Monetary Values for Each One Ton of Carbon Emission (2014 prices)

10. Traffic Modeling

10.1 VISSIM Micro-Simulation Modeling Tool

The authors built and developed a traffic model for the BCD area using the internationally recognized VISSIM micro-simulation software developed in Germany by a company called PTV.

VISSIM is mainly used for multi-modal traffic flow modeling accounting for the movements and interactions of individual road users. It adopts a psycho-physical methodology because of the combination of the psychological aspects and physiological restrictions of the driver's perception.

VISSIM provides two main methods for traffic simulations: Static Assignment and Dynamic Assignment.

- Static Assignment – route choice is fixed, vehicle routing is independent from queues and delays. For Static Assignment, the travel demands as well as the road network are constant in time. Therefore, the number of trips in the network is constant.
- Dynamic Assignment –an entry/exit pattern is needed. Trips are assigned to routes based on costs and delays. In Dynamic Assignment, several options to travel from one point in the network to another are provided and vehicles are distributed amongst all the alternative routes.

The dynamic assignment method was adopted for this study providing less rigid route choice for vehicles.

10.2 Modeling Approach

Figure 10.1 illustrates the modeling procedure and steps in broad terms adopted by the authors and these steps are summarized below:

- The links and connectors were coded to reflect the existing road network in the BCD area
- The type of junctions were coded which also provide an indication of the priority rules for traffic. Existing traffic signal stage and cycle plans for existing signalized junctions were surveyed
- The external and internal zones were clearly defined (Figure 10.2)
- Input the origin / destination (OD) matrix based on the traffic survey results carried out and other available information
- Calibrated and validated the Base Model; i.e. duplicate how the transport network, including junctions, behaved or performed in reality with that shown in the VISSIM Micro-simulation Model
- Extracted the Base Model results
- Calculated the additional trips resulting from the future urban development in the BCD area
- Incorporated these trips in the Base Model to generate the Future Scenario Model
- Ran the Future Scenario Model and extracted the Model results
- Compared the results obtained from the Base Model and Future Scenario Model
- Reduced the trips to reflect the introduction of a sustainable transport system and re-run both the Base Model and Future Scenario Model
- Extracted all results and used them in the quantitative economic assessment of adopting a sustainable transport system in the BCD area

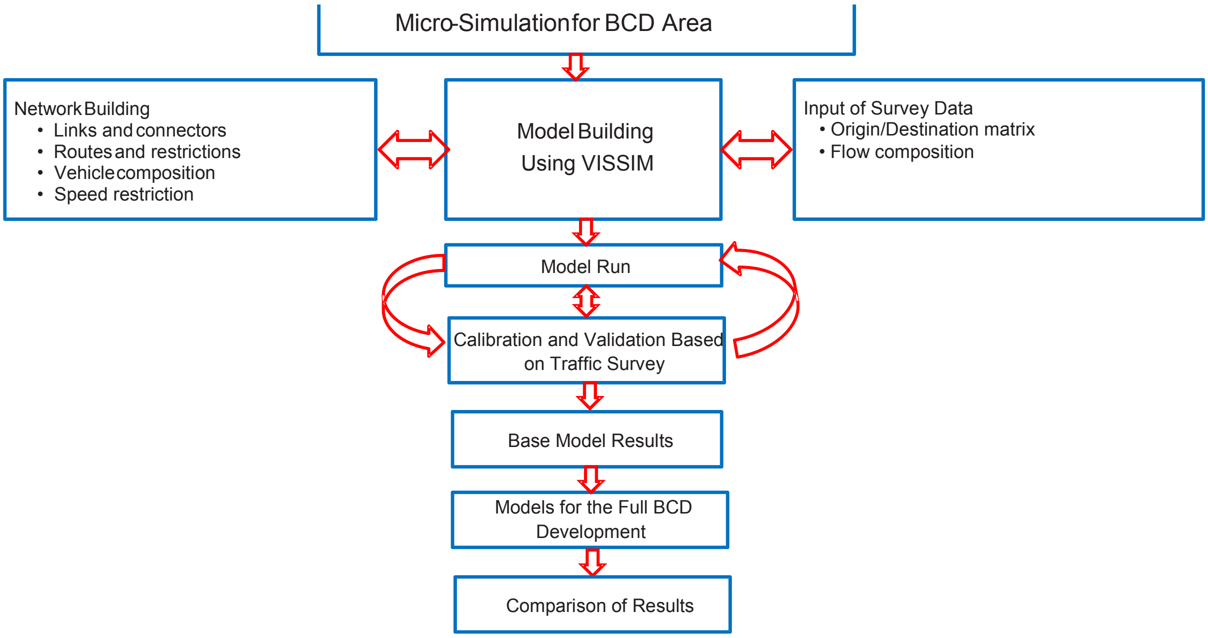

Figure 10.1: Modeling Approach

10.3 Zoning Systems

The modeled BCD area was divided into 9 external zones and 13 internal zones as illustrated in Figure 10.2. The external zones represent the urban settlements surrounding the BCD area while the internal zones represent the actual BCD area. Note that the coloring system in Figure 10.2 is random.

Figure 10.2: Zoning System

10.4 Modeling Periods

The selected modeled time periods reflect the morning AM peak and the evening PM peak.

- The AM peak represents traffic flow from 08:00 to 09:00hrs
- The PM peak represents traffic flow from 16:45 to 17:45hrs
- 1.5 hours were modeled to analyze shoulder peak periods and to allow traffic to build up
- AM modeling 07:45 – 09:15hrs
- PM modeling 16:30 – 18:00hrs

10.5 Trip Generation - Calibration and Validation

The trip generation procedure, and calibration and validation of the Base Model will not be covered in this paper in further detail. However, in short, trips were developed for each land use under consideration and hourly peak hour arrival and departure profiles were established. A comparison of these derived trips was also carried out in relation to existing parking requirements for each plot which is a constraint upon trips wishing to access a particular land use in the study area. This resulted in adjustments being carried out to produce a final set of trip generations from each land use proposed.

To calibrate the model a large amount of work was carried out which compared survey locations that included data with results from the model and a best fit was established to ensure that the AM/PM peak hour model was reflecting reality on the ground.

11. Modeling Results

11.1 Introduction

This section provides the modeling results for all the scenarios as well as a comparison between them. The comparison was based on the following key elements:

- **Number of vehicles** – Total number of vehicles that will be using the road network within the BCD area during the peak hour.
- **Distance (in km)** – Total distance travelled by all vehicles using the road network within the BCD area during the peak hour.
- **Travel time (in hours)** – Total travel time of all vehicles on the road network within the BCD area during the peak hour.
- **Average speed (km/h)** – Average speed of vehicles on the road network within the BCD area during the peak hour.
- **Total delay time (in hours)** - Total delays of all vehicles due to congestions, reductions in speed etc. when using the BCD road network.
- **Average delay time (in seconds)** – Average delay time encountered by each vehicle when using the BCD road network.

11.2 Base Model

AM Peak Hour – No Sustainable Transport System

The traffic surveys as well as additional traffic information available to the authors showed that during the AM peak hour, a total of approximately 14,300 vehicles accessed the BCD area. The analysis showed that only 5,777 vehicles (40.4%) used the BCD as destination while the remaining 8,523 vehicles are classified as through traffic using the BCD road network to gain access/ egress outside this area. In this analysis, the authors assumed that during the AM peak hour, traffic leaving the BCD area towards the external zones is minor and therefore will be ignored.

It should be noted that it is not part of the current scope to address the through traffic effects and propose appropriate mitigations. However it is important to note that in terms of transport planning this is a key flaw as normally traffic associated with a city center should be seen as having an origin or destination within that area.

This kind of result that shows a high through put element can only add to congestion problems and contribute to what is an already highly congested network with high delays and queues developing for peak periods and sometimes beyond. In reality this is happening because no real alternatives exist regarding route choice as when congestion spreads onto networks rat-running and illogical route choices start to occur.

Table 11.1 below provides the results of the VISSIM Base Model without the introduction of a public sustainable transport system for the morning peak hour period.

Total Number of Vehicles	Average Delay (s)	Average Speed (km/h)	Total Delay Time (h)	Total Distance Travelled (km)	Total Travel Time (h)
14,304	284.15	12.46	1,129	19,060	1,530

Table 11.1: Base Model Results – AM Peak Hour -No Sustainable Transport System

AM Peak Hour – With Sustainable Transport System

If a sustainable mass type public transport system was to be introduced, it could potentially remove or reduce the overall volumes. A 30% reduction in overall traffic volumes is estimated if such a system is adopted.

This reduction is important as it would be the level at which the network would be able to show some signs of normality and acceptable network performance levels within a city center concept. This figure was validated by work undertaken by ARUP for Solidere as part of NWD Transport Planning advisory services. This is also not too far away from previous work undertaken by consultants advising on public transport for Beirut immediately after the end of the civil war.

Thus it is fair to assume that there is agreement within the stakeholders engaged in the transport planning field in Lebanon, that as a minimum, a public transport shift of some 30% is reasonable as a starting point.

If such a public transport system is implemented, the AM peak hour traffic volumes would then reduce from 14,304 to 10,013 vehicles, representing that 30% modal shift from the private car.

Thus the VISSIM Micro Simulation Base Model was re-run with an overall reduction of 30% in traffic volumes, the results of which are summarized in Table 11.2 below.

Total Number of Vehicles	Average Delay (s)	Average Speed (km/h)	Total Delay Time (h)	Total Distance Travelled (km)	Total Travel Time (h)
10,013	204.94	15.30	570	13,044	852

Table 11.2: Base Model Results – AM Peak Hour - With a Sustainable Transport System

Comparing the results shown in Table 11.1 with those in Table 11.2, it is noticeable that the average delay per vehicle was reduced by approximately 80 seconds, the average speed was increased by 23%, and the total vehicle-km travelled was reduced from 19,060 to 13,044.

PM Peak Hour – No Sustainable Transport System

The total number of vehicles using the BCD road network during the PM peak hour was estimated to be approximately 14,000. The through traffic (traffic not having the BCD zones as origins or destinations) was estimated to be 8,984 vehicles representing 64.1% of the total PM peak hour flows.

Therefore, the BCD traffic during the PM peak hour was estimated to be 5,031 vehicles. Again a high through traffic element is observed and is considered to be a transport planning flaw in city design terms. At some stage, this issue will need addressing for the city to prosper and to eliminate issues such as severance from taking hold to the disadvantage of other users such as pedestrians.

Table 11.3 below summarizes the results of the VISSIM Base Model for the PM peak hour without any sustainable transport system in place.

Total Number of Vehicles	Average Delay (s)	Average Speed (km/h)	Total Delay Time (h)	Total Distance Travelled (km)	Total Travel Time (h)
14,015	290.07	11.92	1,157	20,043	1,519

Table 11.3: Base Model Results – PM Peak Hour -No Sustainable Transport System

PM Peak Hour – With Sustainable Transport System

For the reasons explained above as part of the AM Peak hour analysis a 30% modal shift is deemed appropriate and as such the effects of adopting a sustainable transport system was modeled by applying an overall reduction factor of 30%. The modeling results are summarized in Table 11.4 below.

Total Number of Vehicles	Average Delay (s)	Average Speed (km/h)	Total Delay Time (h)	Total Distance Travelled (km)	Total Travel Time (h)
9,811	187.84	17.00	511	13,483	784

Table 11.4: Base Model Results – PM Peak Hour - With Sustainable Transport System

From the comparison of Table 11.3 and Table 11.4 it is evident that by introducing a sustainable transport system a reduction in the average delay encountered per vehicle, increase in the average speed, decrease in delay, and decrease in the total vehicle-km will occur.

11.3 Future Scenario Model

AM Peak Hour – No Sustainable Transport System

A Future Scenario Model run for the AM Peak with no sustainable transport in place was carried out.

The future urban development of the BCD area will result in an additional 5,045 trips on top of the existing 5,777 BCD trips. Therefore, the total number of vehicles that would be using the highway network within the BCD area will be in the region of 19,345 vehicles.

The Future Scenario VISSIM Model was run with these predicted 19,345 vehicles and the results of this assignment are summarized in Table 11.5 below.

Total Number of Vehicles	Average Delay (s)	Average Speed (km/h)	Total Delay Time (h)	Total Distance Travelled (km)	Total Travel Time (h)
19,345	532.75	6.34	2,862	21,069	3,325

Table 11.5: Future Scenario Model Results – AM Peak Hour - No Sustainable Transport System

Table 11.5 shows that if a sustainable transport system is not adopted for Beirut, the total delays in the BCD area for the AM peak hour will increase by 1,733 hours when compared to the Base Model results. This delay will get worse when adding the traffic volumes that will be generated from the NWD which have not been part of our analysis in this paper.

The comparison of Table 11.1 with Table 11.5 shows that in the absence of a sustainable transport system, the average delay per vehicle will nearly double, the average speed will be halved, and the total vehicles-km will increase from 19,060 to 21,069.

AM Peak Hour – With a Sustainable Transport System

To model the effect of adopting a sustainable transport system for the Future Scenario Model, the traffic volumes of Section 11.3.1 were reduced by 30%. The reasons for the selection of 30% have already been explained previously. The results of this AM Peak assignment are summarized in Table 11.6 below.

Total Number of Vehicles	Average Delay (s)	Average Speed (km/h)	Total Delay Time (h)	Total Distance Travelled (km)	Total Travel Time (h)
13,542	323.30	10.96	1,216	17,392	1,586

Table 11.6: Future Scenario Model Results – AM Peak Hour - With a Sustainable Transport System

The comparison of Table 11.5 and Table 11.6 shows that with the implementation of a sustainable transport system, the delays encountered by each vehicle are reduced, an increase in the average speed is shown, and a reduction in the vehicle-km value is evident.

PM Peak Hour – No Sustainable Transport System

Based on the proposed land uses of the future urban development within the BCD area, it was estimated that an additional 5,530 vehicles will be added to the Base Model flows. These additional trips are directly related to the BCD and therefore have either their origins or destinations within the BCD area (the majority of trips will have the BCD as an origin during the PM peak hour i.e., a migration out of the city area under study).

The Future Scenario VISSIM Model was run with a total traffic flow of 19,545 and the results are summarized in Table 11.7 below.

Total Number of Vehicles	Average Delay (s)	Average Speed (km/h)	Total Delay Time (h)	Total Distance Travelled (km)	Total Travel Time (h)
19,445	664.08	5.03	3,586	20,286	4,037

Table 11.7: Future Scenario Model Results – PM Peak Hour - No Sustainable Transport System

PM Peak Hour – With Sustainable Transport System

Table 11.8 summarizes the modeling results obtained by reducing the traffic volumes by 30% to reflect the introduction of a sustainable transport system on the network.

Total Number of Vehicles	Average Delay (s)	Average Speed (km/h)	Total Delay Time (h)	Total Distance Travelled (km)	Total Travel Time (h)
13,612	302.35	11.43	1,143	17,377	1,520

Table 11.8: Future Scenario Model Results – PM Peak Hour - With Sustainable Transport System

Adopting a sustainable transport system reduced the average delay, the total delay, and the vehicle-kilometer, and it increased the average speed.

12. Quantifying the Benefits of Adopting a Sustainable Transport System

12.1 Introduction

In Section 11, the work carried out demonstrated through traffic micro-simulation techniques, mainly by the application of VISSIM that adopting public transport as a sustainable transport system in the BCD area would achieve the following:

- Reduce the amount of delays encountered by each vehicle
- Increase the average speed
- Decrease the overall delay time
- Reduce the total vehicle-kilometer travelled

All of the above will result in monetary benefits when it comes to the value of time, vehicle operating costs, value of accidents and carbon emissions. Reducing the delays will reduce the time spent by commuters in congestion and hence add benefits to the value of time. An increase in speed (up to 60km/h) will reduce the fuel consumption and hence will decrease carbon emissions.

It will also result in a reduction to vehicle operational costs and the carbon costs associated with the fuel burnt. The number of accidents is linearly related to the total vehicle-kilometer, therefore a reduction in the vehicle-kilometer would reduce the number of accidents, and hence the associated costs.

A comprehensive cost-benefit analysis is outside the scope of this paper. The authors instead quantified the economic benefits of adopting a public transport system for the AM and PM peak hours. The authors considered years 2014 and 2045 for the analysis as the current year based on which the Base Model was generated and the year where all the proposed urban plans will be developed and be completed in the BCD area, respectively.

12.2 AM Peak Hour

Base Model – Year 2014

Table 11.1 and Table 11.2 provide the modeling results for the AM peak hour of the Base Model without and with a sustainable transport system respectively. Table 12.1 summarizes the economic analysis for the Base Model AM peak hour corresponding to two scenarios, one without a public transport system and one with a public transport system.

Parameter	Without Sustainable Transport (LBP)	With Sustainable Transport (LBP)	Benefits (LBP)	Benefits (%)
Value of Time	13,550,291	8,285,384	5,264,907	66.0%
Vehicle Operation Cost	7,432,894	4,799,513	2,633,381	33.0%
Accident Cost	222,758	152,448	70,310	0.9%
Carbon Emission Cost	30,544	18,981	11,562	0.1%
Total	21,236,487	13,256,327	7,980,160	100.0%

Table 12.1 AM Peak Hour – 2014 Base Model – Summary of Benefits

Table 12.1 shows that for the AM peak hour, the costs associated with the value of time (VOT), vehicle operation costs (VOC), accident costs (AC), and carbon emission costs (CEC) were estimated at 21,236,487 LBP for the AM peak hour of a typical weekday. This cost would be reduced to 13,256,327 LBP if a sustainable public transport system was adopted. Therefore, the public transport system will result in approximately 8,000,000 LBP of benefits during the AM peak hour for a typical weekday. The majority of these benefits (66%) are associated with the savings in the VOT.

Future Scenario Model – Year 2045

The same analysis was carried out for the AM peak hour developed for the Future Scenario Model based on the results summarized in Table 11.5 and Table 11.6. The resulting economic analysis outputs are provided in Table 12.2.

Parameter	Without Sustainable Transport (LBP)	With Sustainable Transport (LBP)	Benefits (LBP)	Benefits (%)
Value of Time	77,651,895	39,950,498	37,701,397	73.4%
Vehicle Operation Cost	30,971,469	17,459,757	13,511,712	26.3%
Accident Cost	556,498	459,377	97,121	0.2%
Carbon Emission Cost	117,595	65,701	51,894	0.1%
Total	109,297,456	57,935,332	51,362,124	100.0%

Table 12.2 AM Peak Hour – 2045 Future Scenario Model – Summary of Benefits

Table 12.2 shows that during the AM peak hour of a typical weekday, the availability of a sustainable public transport system results in 51,362,124 LBP of benefits. The net present value of this is approximately 9,800,000 LBP based on an economic discount rate of 5.5%. The majority of these benefits result from time savings (73.4%) followed by the savings established from vehicle operational costs (26.3%).

12.3 PM Peak Hour

Base Model – Year 2014

The impacts of adopting a sustainable transport system will be quantified based on the results summarized in Table 11.3 and Table 11.4. The economic modeling results are summarized in Table 12.3.

Parameter	Without Sustainable Transport (LBP)	With Sustainable Transport (LBP)	Benefits (LBP)	Benefits (%)
Value of Time	13,555,016	7,441,449	6,113,567	65.7%
Vehicle Operation Cost	7,675,058	4,574,582	3,100,477	33.3%
Accident Cost	234,247	157,579	76,668	0.8%
Carbon Emission Cost	33,127	18,010	15,116	0.2%
Total	21,497,447	12,191,619	9,305,828	100.0%

Table 12.3 PM Peak Hour – 2014 Base Model – Summary of Benefits

The presence of a sustainable transport system will result in approximately 9,300,000 LBP of benefits during the PM peak hour. These benefits are mainly obtained from time saving benefits (65.7%), followed by the savings in vehicle operating costs (33.3%).

Future Scenario Model – Year 2045

The data from Table 11.7 and Table 11.8 were adopted for the quantitative economic analysis. The results are summarized in Table 12.4 overleaf.

Parameter	Without Sustainable Transport (LBP)	With Sustainable Transport (LBP)	Benefits (LBP)	Benefits (%)
Value of Time	97,296,296	37,554,606	59,741,690	76.8%
Vehicle Operation Cost	35,070,779	17,204,535	17,866,245	23.0%
Accident Cost	535,816	458,980	76,836	0.1%
Carbon Emission Cost	134,570	64,200	70,370	0.1%
Total	133,037,462	55,282,321	77,755,141	100.0%

Table 12.4 PM Peak Hour – 2045 Future Scenario Model – Summary of Benefits

Table 12.4 shows that 77,755,141 LBP is the direct resulting monetary benefits of adopting a sustainable transport system with a modal shift of 30%. These correspond to the PM peak hour for a typical weekday during 2045. The net present value of these benefits is approximately 14,800,000 LBP based on 5.5% economic discount rate.

12.4 Summary

Section 12.2 and Section 12.3 demonstrated that positive economic benefits were obtained by adopting a modern sustainable public transport system even with a 30% shift from the private car. These benefits were obtained for both the AM and PM peak hours as summarized in Table 12.5 below.

Peak Hour	AM Peak Hour	PM Peak Hour
Base Scenario – 2014	7,980,160	9,305,828
Future Year Scenario - 2045	9,768,249	14,787,776

Table 12.5: Summary of Benefits (LBP 2014 Prices)

These benefits are considered as direct benefits to employers, employees, and the environment resulting from adopting a sustainable transport system.

In addition there are direct health benefits that the authors have not carried out in the assessment. However, with improved living conditions, such as CO_2 reductions and accident and stress reductions, as an example, there will be a reduction in healthcare access requirements from the population which is transferred to the public purse as savings.

13. Transport Impacts on the Economy

13.1 Introduction

According to the Eddington Transport Study (UK - 2006), a robust (multi-modal) transport system is vital in maintaining economic success in modern economies. In fact, a reliable transport system ensures the connectivity between people and jobs, production and markets, and supply and logistics. Therefore, the transport infrastructure, the reliability of the transport system, and the costs associated with transport form important key links and factors that contribute to the successful performance of an economy.

This is important as it recognizes that not all transport users are the same and neither do they have a similar level of economic wealth. A transport system needs to be able to reach out to large parts of society and create employment opportunities. Transport is seen as a key link.

13.2 Transport System and the Economic Growth

Craft and Leunig (2005) adopted Ireland's economy to illustrate how transport can halt the economic growth. Serious traffic congestions are reported in growing urban areas since the investment in transport lagged behind economic growth. As a result, access routes to ports and airports became inadequate to serve the economic growth. Hence, economic growth results in increasing demand on the transport system. This increase in demand will reach a point where transport systems become a factor undermining any economic growth.

The World Bank study on the Indian economy concluded that major improvements are required in the transport sector to meet the continuous anticipated economic growth. This is the result of having mainly a transport system lagging behind the economic growth (The Eddington Transport Study, December 2006).

So there are some key indicators from around the world that economic growth and its success must have a viable and adequate transport system underlying it.

13.3 The Economic Need of a Sustainable Transport System

Over the last two decades, China adopted a major infrastructure development to meet the economic growth to a point where nowadays the total length of roads in China is second to the United States. However, investing in new roads, railways, ports, and airports is not always the proper or only transport response to meet economic growth (The Eddington Transport Study, December 2006).

The Chinese approach adopted in the transport sector to meet on-going economic growth cannot be applicable to all countries. This approach is not feasible in Lebanon due to the limited undeveloped area, i.e. land and space are a key issue, the unorganized urbanism rise, the relatively small size of the country, and the unavailability of funds that can be invested in new infrastructure.

In Lebanon, a relatively well-established but not well-organized road network is already in place connecting the main economic centers (irrespective of the condition and level of maintenance). In this case, the focus should be on the efficiency of the road network rather than the investment in new roads, albeit limited new build is required, but clearly the country cannot build roads as means to building our path out of existing and future congestion projections.

Erenburg (1994) stated that using the existing transport system more efficiently can have an impact on economic growth. Hulten and Schwab (1996) estimated that a 1% increase in the effectiveness of the infrastructure would have a seven times larger impact on the economic growth rather than a 1% investment in the infrastructure.

In 2001, the OECD concluded that wider economic benefits can be achieved by shifting users more efficiently between existing infrastructures. In 2003, the Victoria Transport Policy argued that investing in alternative modes of transport results in more economic benefits than expanding existing highways to reduce congestion.

13.4 A Key Action Plan

It is clear that Lebanon needs a starting point that would be a plan to run along the following lines ensuring that economic growth demands are met in the future. If standstill occurs via congestion issues then the economy cannot grow, as transport would be a key constraint or bottleneck.

1. Establish what sort of public transport system is required and not start by asking if we need one
2. Establish the cost of any additional infrastructure needed to deliver this public transport system
3. As part of the point 2 above, establish what traffic management measures are needed to help also provide benefits to other users such as private car drivers
4. A balance needs to be established between points 2 and 3
5. Establish a traffic management plan that can provide priority to public transport users and to encourage users to see these benefits in order for it to be successfully taken up by the population
6. Establish a clear environmental and climate change policy that buys into transport proposals and vice versa
7. Provide 'value for money' studies to help finance the above under the auspice of a transport plan for Beirut as part of a comprehensive plan for the country. By doing so donors and funding institutions can see the wider picture and are more likely to find their investment attractive

The above will require a fundamental change in approach to transport planning and to ensure its success for all parties concerned.

Work undertaken in this paper shows how traffic, during the peak hours of 2045, will virtually come to a standstill as a result of ever increasing congestion if a sustainable public transport system is not put in place.

14. The Role of a Transport System in Attracting Stockholders including International Companies to Beirut

14.1 Optimizing the Core Systems

The global economic hubs are experiencing a transformation in the drivers of economic growth from traditional drivers, such as natural resources and labors, towards the ability to create and absorb innovation (Smarter Cities for Smarter Growth – IBM Institute for Business Value - 2010). The majority of the highly skilled, educated population and international companies are present in the world's major cities. Therefore, to keep the economic competiveness the focus should be on optimizing the city to meet the needs of the highly skilled and attract more international companies rather than attracting labor pool. This will be achieved by providing a better quality of life making a city more attractive to retain its skilled people and attract international firms.

14.2 Transport as a Core Fundamental System

According to IBM (2010), an investment in the core systems of a city will result in cost savings, and position it for long-term economic growth. Transport is one of the main core systems of a city and it has a direct impact on other systems. Therefore, reducing congestion in the transport system should be one of the targets a city will need to focus on for economic growth and economic competiveness.

Congestion imposes significant costs on cities, individuals, and companies resulting from the followings:

- Cost of time spent in congestion
- Cost of fuel burnt in congestion
- Cost of the loss in productivity
- Cost of road accidents
- Costs of environmental damage

A sustainable transport system will reduce congestion and hence the costs associated with it. This will save money for the city, the individuals, and the companies making an area more accessible and attractive for both workers and firms. In addition, a reliable public transport system will improve the general health of commuters by reducing the carbon emission and lowering the stress level associated with traffic congestion.

A sustainable transport system will boost life's quality in the city and its environment and therefore play a major role in attracting international companies.

14.3 The Current Position of Beirut

Beirut's competitiveness arguably suffers due to its poor transport links. For this reason, major companies would think twice before basing themselves here. Mobility and choice of transport is recognized as another weak link.

Office space is one of the major land uses proposed in Beirut's Master Plan particularly in the BCD and NWD areas. These spaces will be located in prime land locations and therefore expected to be occupied by international/large multi-national companies. As stated previously in this paper, the levels of congestion are expected to reach unacceptable levels once Beirut's Master Plan is implemented in the BCD and NWD areas. Indeed, there is an argument to say that present congestion levels would put off potential tenants.

These levels of congestions are considered as a draw-back for international companies to move to Beirut due to the consequences on individual employees and the firms resulting from the inadequate transport system, not to mention the health hazard implications that come with a car-borne dominant society.

Many cities in the Arab world are shifting toward adopting sustainable transport systems such as the main cities in the United Arab Emirates and Saudi Arabia. Unfortunately, Beirut is lagging behind on this front and a sustainable transport system has not featured on any of the governments' agendas yet.

Hence, although construction seems to be on-going according to plan, the main objective of attracting international/ multi-national firms to Beirut may not be achieved as from a key component transport point of view when compared against other destinations it will score very low, with no plan in sight to tackle the problem.

Companies these days calculate overheads very seriously and make decisions to relocate based on how competitive they would be if they took the plunge and moved or expanded. Transport is a key cost applied in such calculations as it impacts upon employee time (lost time travelling, wellbeing, frame of mind to name a few), and for goods/ logistics congestion will no doubt increase the price of goods to the consumer or result in the worst case in them being delivered late, which is not acceptable to some areas of work.

For Beirut to function it needs to be resilient and have an adaptive resilient multi-modal transport system. That in itself is seen as a major attractor to investors in the city.

14.4 Employee Attractiveness and Skills

From work carried out in a large number of European cities it has been established that if stakeholders or key companies want to relocate into a new geographic destination, the quality of the labor market and workforce is an important factor in addition to key overhead and cost matters.

As such Lebanon is blessed with a highly educated and literate population that would in itself be very attractive. However transport forms a key link between cost and employees and a reasonable match needs to be formed and established. A well-balanced transport choice thus is a main component to a successful workforce being able to successfully deliver in society or to contribute to our society fabric.

14.5 Geographical Catchment and Social Spread

For any transport system to succeed and form linkages with the economy it is important that such a system is able to:

- Reach out to members of the population that do not have access to the private car (geographical spread)
- Reach out to key low income areas (geographical spread)
- Able to accommodate a range of diverse users
- Be able to attract some members of society from their private cars to public transport

Thus it needs to be:

- Cheap to use
- Reliable
- Frequent
- Worth it, time-wise, in comparison with the private car

14.6 Geographically Spread Benefits of a Public and Sustainable Transport System

The main transport/ employee/ employer benefits are listed below of such a diverse wide geographical spread:

- A diverse reach out that includes non-car drivers (inclusive not exclusive policy)
- Reduce company costs by reducing for example cost of building underground car parking or parking space rental
- Reduce stress and increase productivity
- Reduce lost time due to congestion allowing employees to focus on tasks ahead
- Certainty in delivery of action plans for the business and shown on a day-to-day basis via more reliable employee attendance rates
- The more it is used the more investment can be ploughed back into the system to retain/ maintain it as a first class operation
- Diverse catchment means all skills required can be reached out to i.e., not excluding non-car drivers (inclusive ,not exclusive policy)

14.7 Effect on Trade

There is a general acknowledgement that trading powers of companies can be stifled if there is a lack of good transportation links. We have touched upon the key link related to the movement of goods and logistics which currently cannot operate with certainty in Beirut. This is also true for employees and visitors who are customers coming and going to these companies in the BCD area.

The authors have not attempted to calculate the lost time from a lack of logistical certainty regarding delivery of goods, but it is not surprising to establish that it does certainly affect the price of these goods. Thus competitiveness becomes an issue if prices are not right and thus a company can lose some of its trading power.

14.8 Chances of Success for a Sustainable Public Transport System

This paper highlights the benefits in economic and other terms of the need to provide a more multi-modal type of transport system in Beirut and beyond. The authors firmly believe that, together with a coherent traffic management plan that includes parking and parking charges and the restriction of private parking, a successful public transport system can be put in place. Ultimately a change in policy is required as an example in the allocation of private car parking quotas and also public/ private parking charges. Long stay parking should be discouraged while short stay encouraged as a mean of forcing somewhat a shift to public transport.

Income levels in Lebanon are relatively low. For example, in a company of 100 employees the authors firmly believe that there are very good odds that at least 50% of them can be convinced to use public transport if criteria set out in the sections above are met. With low income levels and providing real transport alternatives, it is easier to make that transformation.

15. Conclusions and Recommendations

15.1 Conclusions

The authors performed qualitative and quantitative analysis to determine the economic impacts of adopting a mass type sustainable transport system in Beirut. The following conclusions were reached based on the findings of this paper:

- Currently congestion levels on the road network in Beirut, particularly the Beirut Central District Area (BCD) are not acceptable with large queues and delays developing on a consistent basis, with an AM /PM peak hour spreading beyond traditional hours. These levels of congestions are expected to get worse with further development proposed in the BCD Area and the New Waterfront District (NWD)
- Beirut will not be able to economically compete with other cities in the region as it is lagging in terms of a comprehensive multi-modal transport system including a sustainable public transport system. This reliance on the private car as the dominant method of transport will eventually contribute towards stifling or halting any economic growth at a certain stage of its growth
- Lost Time is significant and has been measured to be as follows:
  - 1,129 hours of delay in the AM peak hour of 2014
  - 1,157 hours of delay during the PM peak hour of 2014
  - 2,862 hours of delay in the AM peak hour of 2045
  - 3,586 hours of delay in the PM peak hour of 2045
- Beirut can recover its transport position via the introduction of a sustainable transport system. The results suggested that savings can be achieved in lost time as follows:
  - 559 hours during the AM peak hour of 2014
  - 646 hours during the PM peak hour of 2014
  - 1,646 hours during the AM peak hour of 2045
  - 2,443 hours during the PM peak hour of 2045
- The work demonstrated that in addition to reducing congestion levels a sustainable transport system will generate benefits related to travel time as illustrated above and in addition will result in:
  - Less accidents thus a reduction in costs
  - Reduction in vehicle operating costs
  - Reduction in carbon emissions
  - Positive environmental impacts
  - Positive wellbeing of individuals and increased productivity for employers
  - Attraction of international companies to locate in Beirut with reduced congestions levels prevailing
  - Positive effect on business efficiency
  - Wider labor catchment in terms of penetration of non-car owning communities thus improving labor mobility and accessibility

15.2 Recommendations

The following recommendations are proposed based on the findings of this research paper:

- Beirut must adopt a multi-modal transport approach including a sustainable transport system to establish and maintain economic growth
- A key action plan is needed to ensure that economic growth demands are met in the future. This plan must include items related to the choice of the suitable sustainable transport, and coherent traffic management
- Optimize the core systems of Beirut, in particular the transport system
- Develop and adopt a parking strategy to encourage the use of a multi-modal transport system
- Adopt new policies aimed to give advantages to users of a sustainable transport system whilst maintaining a balanced approach with traditional methods of transport i.e., the private car

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