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Affordable and common modes of transportation in developing cities and their effect on the sustainability of streets

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Abstract

Sustainable transportation – or green transportation – is an important field in terms of generating a healthy environment and upgrading city planning. Street design and modes of transportation are the two main factors that can affect the sustainability of city planning. This paper focuses on designing and planning an efficient, sustainable street using affordable and common modes of transportation, with an emphasis on two cities in Egypt and Lebanon as case studies.

Observing developing cities in the field of transportation planning reveals many weaknesses that have a major effect on citizens, such as traffic congestion, a shortage of pedestrian walkways or cycling paths, a lack of affordable public transportation or its sequential movement, and the new modes of informal transportation that have appeared in recent years and have affected the street transportation movement.

The aim of this paper is to analyse developing cities in terms of modes of transportation, to discover an effective method of planning city streets.

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Keywords: sustainable transportation – modes of transportation – developing city streets

1. Introduction

Sustainable transportation applies sustainability concepts to the field of transportation, including the three basic dimensions of sustainability: social, economic and environmental dimensions.[1,2,3] The transportation sector is very

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important in sustainable design and research as it is inevitably linked to the climate-change challenge, given that it is currently responsible for 13% of Greenhouse emissions worldwide and 23% of the total energy-related emissions [4]. In addition, there has been a tremendous increase in daily trips by private cars in urban areas, estimated to number 6.2 billion by 2025, which represents an 80% rise from 3.5 billion in 2005 [5]. However, most research on sustainable transportation focuses on the sustainable mechanisms of the transportation modes, which rely on two dimensions: namely the economic and environmental impacts of the modes. Research somewhat ignores the needs of the users (the social and, partially, economic aspects), who will use and move through the spaces located for different modes of transportation. In addition, there are huge variations between urban and rural morphologies and between different typologies of spaces, different cultures of using public spaces and different locations (developed or developing countries), which should be considered in finding the appropriate planning or transportation modes. The shortage in supplying the demand for the users' needs in street planning heavily affects sustaining these modes.

In literature, the environmental dimension in sustainable transport refers to the impact of human activities on changing the global and local environment, including the impact of transit on air pollution, noise pollution, water pollution, climate change and other related areas. The economic dimension considers the quality of accessibility, infrastructure costs, traffic congestion, accident damage and depletion of non-renewable resources. The social dimension focuses on the human health impact, community livability, affordability and other related issues.[1, 2,3,6,7]

Due to the rapid urban growth, the increasing rate of motorization, which is more than 10% per annum [8], and the lack of comprehensive planning, developing countries have a less than adequate amount of formal public transportation that is capable of supplying the entire demand for mobility needed within the city, as well as considering the needs of different social strata of society. In addition to the deficiency of the street design elements, which don't always consider the users' behaviour, this problem has resulted in the inevitable emergence of informal public transportation modes, which mainly consider the economic needs of the users at the expense of the other dimensions.

This paper studies the conflicts between modes of transportation (formal and informal) and the street design elements, as the two main factors that affect the transportation sustainability of city planning. In addition, it analyses the informal transportation in two case studies: Giza (Egypt) and Tripoli (Lebanon).

2. Modes of transportation

The hierarchy of sustainable transportation modes begins with the most desirable types – pedestrian, cycling and public transportation – and ends with a single vehicle or private vehicle. The concept of sustainability in transportation is reached by decreasing the number of fuel-based vehicles in the city streets, in order to decrease the levels of non-renewable energy consumption (fuel) and air pollution (mainly carbon dioxide and monoxide) as well as increasing mobility flow without causing traffic jams. In addition, sustainable transportation increases the role of public transportation and encourages the community to use it. Transportation modes can be classified into two main types: formal transportation and informal transportation modes.

The formal modes of transportation are traditionally considered to be a government's responsibility [9]. They are the modes that city streets are designed and planned around, such as walking, biking, automobiles, taxis, buses, trucks, heavy rail, light rail transit, trams and other means. Given that the formal transportation services in developing countries are rarely up to the task of satisfying the escalating demands for travel, informal transport modes have started to appear.

The informal modes of transportation are mostly privately operated, small-scale services that are varyingly referred to as 'paratransit', 'low-cost transport', 'intermediate technologies', 'third-world transport', 'artisanal transport' and 'intermediate technologies'[10,11]. 'Informal transportation' is the term used in this study, as suggested by Robert Cervero (2000). It reflects the informal and illicit context in which this sector operates: somewhat in the background and outside the officially sanctioned public transport sector [11]. These modes appear as 'gap fillers' [9] when the governmental public transportation services are unable to meet the demands of the community. These informal transportation modes include different, affordable types that each city and community selects to use according to their user needs, space constraints, transportation distance and street dimensions.

On one hand, the informal transport sector is blamed for a long list of problems in the majority of the literature; on the other hand, it is also seen as a salvation for the incapability of governmental bodies in developing countries to

provide adequate means of transportation. Robert Cervero (2000) summarized the pros and cons of this type of mobility as follows [11]:

- Roles and benefits of informal transport: mobility and development; source of employment; complementarity; efficient; low-cost services; and market-responsiveness.
- Issues and concerns: traffic congestion; disorderly operations and unfair practices; accidents and public safety; air pollution and environmental problems; cream-skimming; and intangible factors.

3. Street design

Street design is a large and complicated domain that affects the sustainability of city planning. There are many factors that contribute to street-design efficiency; however, this paper focuses on two of these: the street design elements and accessibility principles that will be later used in the framework of analysis.

3.1. Street design basic elements

Street elements are the main components of street design that affect the movements of pedestrians and vehicles. The primary street elements are street reserve (the full width of street between two property lines opposite each other), carriageway (an area of street reserve that has movement and parking areas located between two opposite kerbs), travel way (an area of carriageway use for vehicle movement and that does not include a parking area) and verge (an area of street reserve located between the edge of adjacent lots and the carriageway). The verge contains public utilities, street lights, street furniture, foot ways and other elements,[12] bridges, pedestrian safety facilities (such as pedestrian paths, crossing bridges and others), a hierarchy of road widths and facilities, traffic calming facilities and other elements.

The design of the street reserve should integrate with users' activities and modes of transport needs in terms of safety and accessibility. For example, the following issues should be considered: walking and biking paths; public transportation lanes and stations; private car paths and parking areas; streetscape design, such as lighting, street furniture, vegetation, surface materials and other related facilities.

3.2. Accessibility

Accessibility is an important issue in street design that refers to people's ability (using any means of transport mode) to reach facilities and activities within a specific interval of time. The quality of accessibility has tremendous direct and indirect influences on the urban context it serves. The following general factors can affect the quality of accessibility [13,14]:

- Motor vehicle travel conditions: affordability and safety, traveling speeds.
- Quality of other modes: walking, cycling, public transit, telework, delivery service speeds, convenience, comfort, safety and affordability.
- Transport network connectivity: density of connections, source/destination relationships, the quality of connections between modes, such as the ease of walking and cycling to public transport stations.
- Land use proximity: type of activities, development density and mixed usages, and distances between activities.

4. Method

The research suggests a framework of analysis considering the basic elements of the street design and accessibility factors that were discussed earlier. The analysis depends on field observation to highlight the problem of developing plans within the two case studies. It criticizes the conflict between public formal and informal transportation, in addition to their mutual impacts on the design of street elements and facilities. The selected action areas are in two different developing cities; one is in Lebanon (Tripoli) and the other is in Egypt (Giza). Both cases are located in the MENA region, having similar environmental conditions, land topography and cultural behavior.

4.1. Suggested Framework

The suggested framework consists of three main phases: analysing modes of transportation in terms of type and availability; documenting the street elements available; and criticizing the conflict between the needs of different transportation modes and the availability of the street elements.

First, the modes of transportation are analysed, based on the type of transportation mode (formal or informal), the standard seating capacity, the average real occupancy, the type of station (planned stations or random stopping) and availability. Second, the availability of street elements in the case studies is checked, such as street carriageway, verge, pedestrian safety facilities, traffic calming elements, signs, parking areas, station design and availability and mobility bridges. Finally, the conflicts between the needs of different transportation modes and the available street elements are analysed.

Therefore, the research discusses the observed problems that caused the appearance of informal transportation modes, the conflicts between modes of transportation, and the missing street elements that negatively affect the users.

5. Case study 1 (Giza, Egypt)

The selected action area is located in Giza; it is the most crowded area, with high numbers of traffic jams, and is located beside Cairo University metro station at El Soudan Street. El Soudan Street connects the two main districts (Mohandesin and El Haram), passing through a highly crowded area on the western edge of Cairo University. Cairo University has many gates; the main gate is located in the study area in front of the metro station. Saft El Laban corridor is a highway perpendicular to El Soudan Street; it is connected with the ring road and Mehwar 26 July. This corridor has only two ends; one is in the area of the case study, beside the metro station. Fig. 1 shows the location of the case study area.

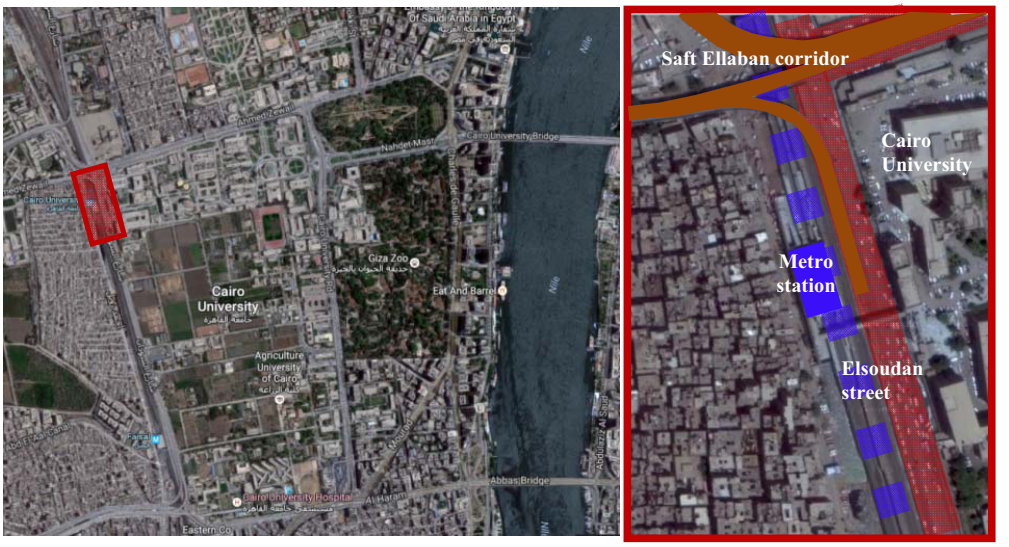


Fig. 1. The urban context of the case study 1

5.1. Modes of transportation analysis

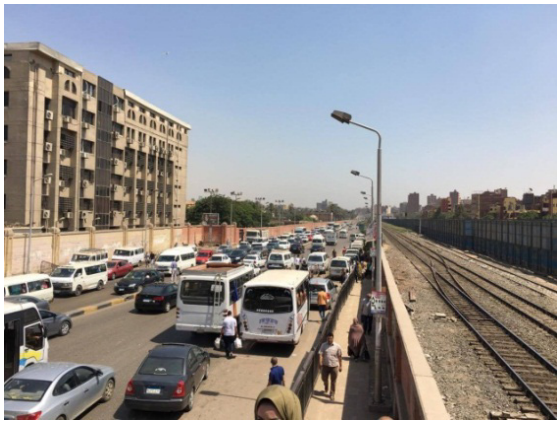
There are various modes of transport in this action area; some of them are formal transport, such as metro, buses, taxis and private cars, while others are informal transportation, such as minibuses and microbuses. All these modes serve the main entrance gate of Cairo University in El Soudan Street, which is the main provider of source/ destination movements. Table 1 shows the modes of transportation analysis of case study 1.

Table 1. Modes of transportation analysis of case study1

Transportation mode	Type of mode formal / informal	Standard seating capacity	Average real occupancy	Planed Station exiting / random stopping	Availability
Buses	Formal	50	50-70	No station	Not available
Metro	Formal			Planned Station	3 minutes.
Private cars	Formal	5	2	Random stopping	
Taxi	Formal	4	2	Random stopping	Available
Microbus	informal	14	14	Random stopping	Always available
Minibus	informal	26	26-40	Random stopping	Always available

5.2. Available street elements

Street carriageway elements are the movement and parking areas between two opposite kerbs. This street consists of a two-way movement area. The part next to the railway is four lanes of movement paths and the other is two lanes of movement with one more drop-off lane in front of Cairo University entrance gate. There are no available parking areas in the carriageway of El Soudan Street; it is just random stopping for informal transportation modes. Fig.2 shows El Soudan Street carriage way and the entrance gate of Cairo University located in this street.



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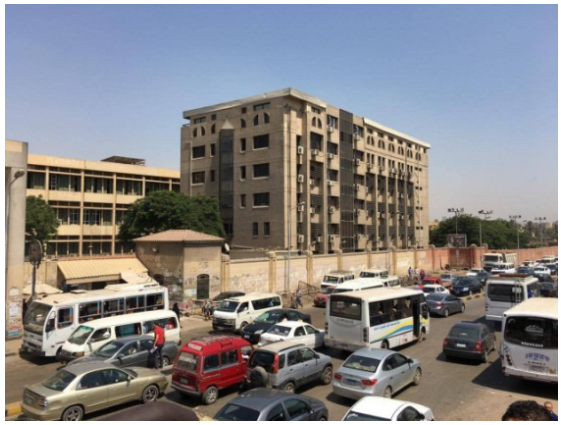


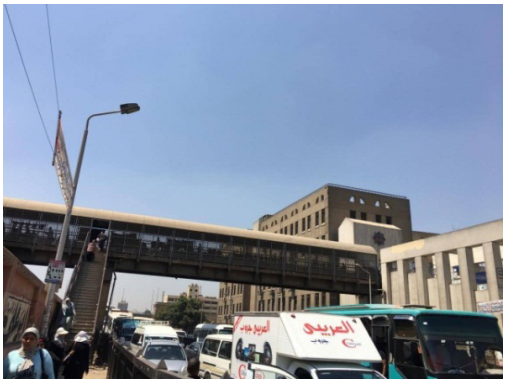
b

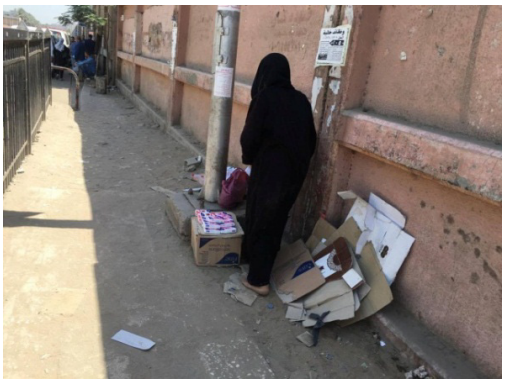
Fig. 2. (a) shows the street carriage way , (b) shows the entrance gate of Cairo university located in El Soudan Street

Verges in this street have a small width, which is not enough for pedestrian path flow. The metro station pedestrian bridge, which has hundreds of people exiting every three minutes (based on the frequency of metro service), also use that small verge. The verge elements in this case are a small footway path, lighting elements and a safety fence for pedestrians. Fig. 3 shows the pedestrian bridge exit and the street verge elements.

Pedestrian safety facilities exist in the area of study but they are not without problems. Pedestrians crossing the bridge, which is a very useful element in the area of study, are mainly metro station-travellers, using it to get in or out of the station, while it is rarely used for actually crossing the road – pedestrians prefer surface-crossing (jaywalking) if not using the metro. The pavement area in the verge is too small, in addition to the location of the safety fence beside the railway forcing pedestrians to use the carriageway lanes for walking and waiting for different transportation modes. The safety island existing in the street is too small to handle crossing from one side to another. Fig. 4. Shows the pedestrian safety facilities located in the case study area.

b

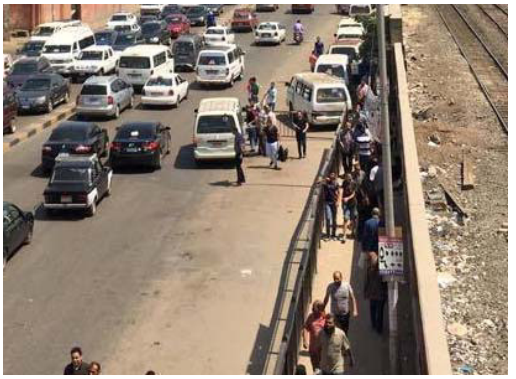


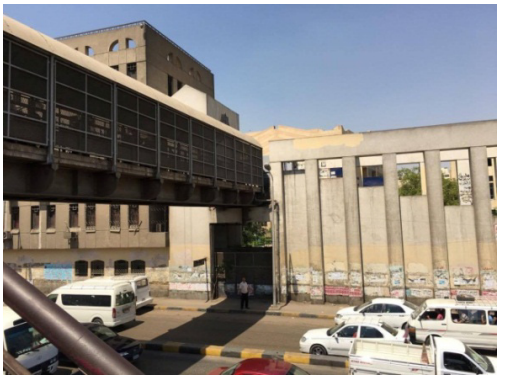


a

Fig. 3. (a) shows the pedestrian bridge exit stairs , (b) shows the street verge elements

a





b

Fig. 4. (a) shows side walk and safety fence , (b) shows the pedestrian crossing bridge

Traffic-calming elements do not exist at all in the case study area, in addition to a lack of traffic signs. Cairo University metro station is the only formal public transportation; the other formal modes do not have any station in this area of the study. A mobility bridge exists at the end of Saft El laban corridor, which has a major effect on the traffic congestion of this area. Fig.5 shows the metro station and Saft El laban corridor that exist in the case study area.

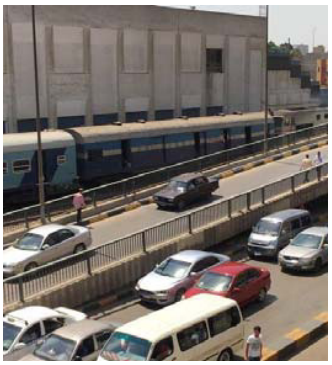
a   b

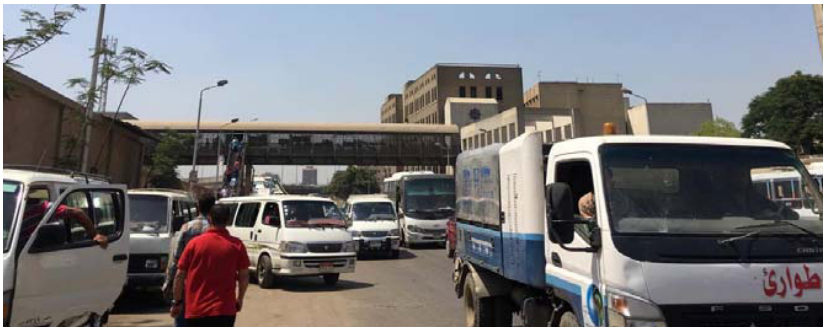
Fig. 5. (a) Shows the metro station , (b) shows Saft ellaban corridor

5.3. Conflicts between transportation modes needs and street elements

Cairo University is one of the largest educational complexes in Egypt (as an example, 187,576 students enrolled during the academic year 2008/2009 [15]); it has a huge number of students from several districts in Cairo, Giza and other places. There are many conflicts in this action area between the design of street elements and the existing transportation modes, which explain the high traffic congestion in this area. The major conflict is that of neglecting the users' needs.

Understanding the history of planning/construction phases might give an indication of the reason for the current situation. The metro station was constructed in its location more than ten years before the construction of Saft El laban corridor. The modes of traffic from Saft El laban corridor are mainly private cars, because of the current regulation of this road; in addition, no formal bus stations are located in this area next to the metro station. The different phases of construction and the lack of planning and coordination between theses phases have caused the appearance of informal public transportation, such as minibuses and microbuses, to service the people with transport from/to other places.

The planning deficiency of informal transportation modes negatively affects the mobility flow. Minibuses and microbuses create informal stations on the two sides of the street near the exits of the metro and the entrance gate of Cairo University. Despite their informality, these stations have an order in movement; the driver stops to take his place while waiting for the maximum number of passengers to fill the seat capacity, while the other informal transport modes wait to reach their turn. Therefore, an informal parking lane exists, detracting from the mobility lanes, which decreases the street's efficiency in handling the necessary traffic flow. Other types of driver prefer to simply stop in any lane to pick up passengers, moving suddenly to switch to another lane. As a result, the informal transport modes take up two to three lanes of the carriageway mobility lanes on both sides of street, which leaves only one mobility lane free for other transportation modes to pass. The effect of the informal stations is that the street is crowded for a kilometre on each side, reaching Saft El laban corridor. Fig. 6 shows the informal station location and its effect on traffic flow.

a 

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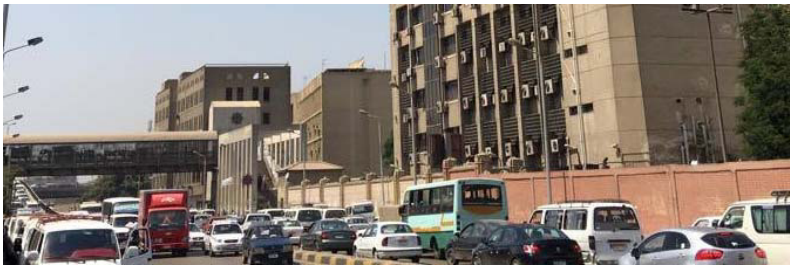

Fig. 6. (a) shows informal station, (b) shows the traffic jam coursed by informal stations

The small verge and high flow of users causes the presence of pedestrians in the travel way and affects the pedestrians' safety. The pedestrian bridge is not used only for passing or crossing the road but also for several informal commercial activities. These activities affect the movement of pedestrians, especially during the rush hours. Fig.7. shows the pedestrian crossing bridge and the existing of informal activities.

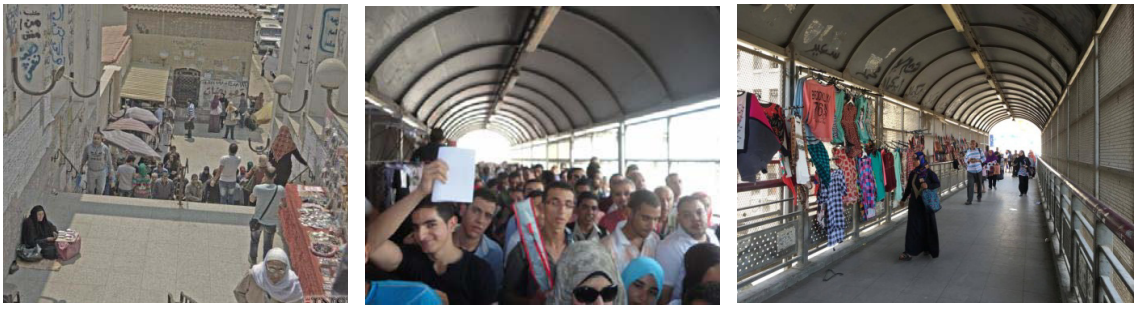

Fig. 7. shows the pedestrian crossing bridge and the existing of informal activities

6. Case study 2 (Tripoli , Lebanon)

Tripoli is the second largest city in Lebanon after Beirut, located on the north coast. The case study area is in El-Tal; it represents one of the famous, old landmark areas in Tripoli. Because of its location on the main boulevard and the edge of the historic city, it is a very crowded area, which includes all modes of informal transportation and their informal stations. Some of these stations are dedicated to local trips and others for outside Tripoli. Fig. 8 shows the location of the case study.

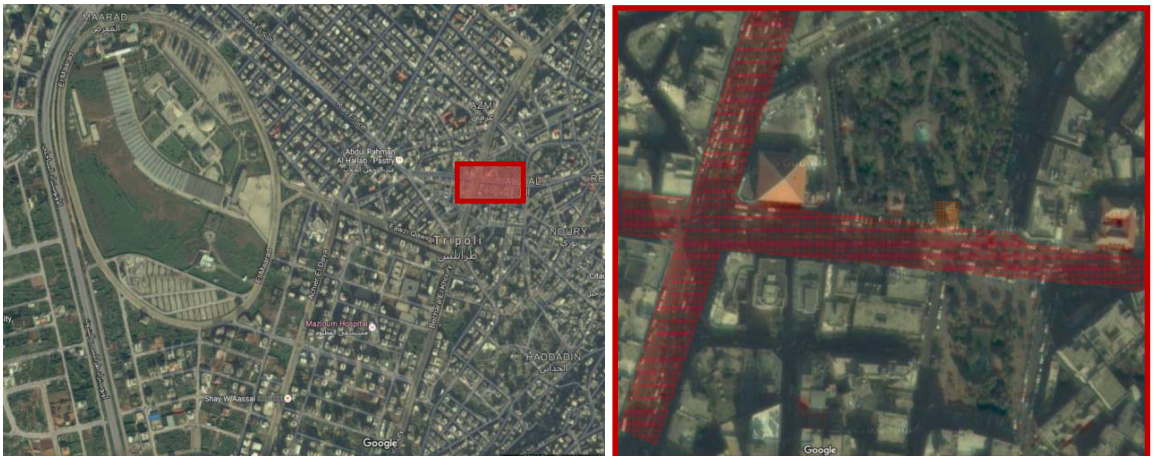

Fig. 8. The location of the case study 2

6.1. Modes of transportation analysis

Tripoli's community prefers private cars to public transportation modes for their movement, due to the lack and lower efficiency of the latter modes. In the case study area, informal transportation (taxis, minibuses and microbuses) are the common modes of transportation. Taxis (old Mercedes cars) are oriented to inside-Tripoli trips and to nearby places, while the minibuses and microbuses are oriented to outside-Tripoli trips only. Table 2 shows the modes of transportation analysis of case study 2.

Table 2. Modes of transportation analysis of case study

Transportation mode	Type of mode formal / informal	Standard seating capacity	Average real occupancy	Planed Station exiting / random stopping	Availability	Type of transportation trips (inside/ outside city)
Private cars	Formal	5	2	Random stopping		
Taxi	informal	4	3-5	Random stopping	Always available	Inside and Outside Tripoli trips
Microbus	informal	14	14	Random stopping	Always available	Outside Tripoli trips
Minibus	informal	26-35	26-35	Random stopping	Always available	Outside Tripoli trips

6.2. Available street elements

The carriageway design of all streets consists of two to three lanes, including the parking areas beside the verge. Parking areas for private cars are available and designed parallel to the verge, with parking meters to each car space. The small verge, with a small walkway path and commercial activities, is most common in this area. The furniture elements of the verge are random between lighting facilities and vegetation elements. There is no formal station for public transportation modes.

Due to the high traffic and low speeds of car movements, the pedestrian safety facilities exist only through pavement paths and safety islands. There is an absence of all types of traffic-calming facility, even traffic signals – where they do exist, they do not work and cause traffic congestion in the street intersections. Fig. 9 shows the available street elements in the area of study.

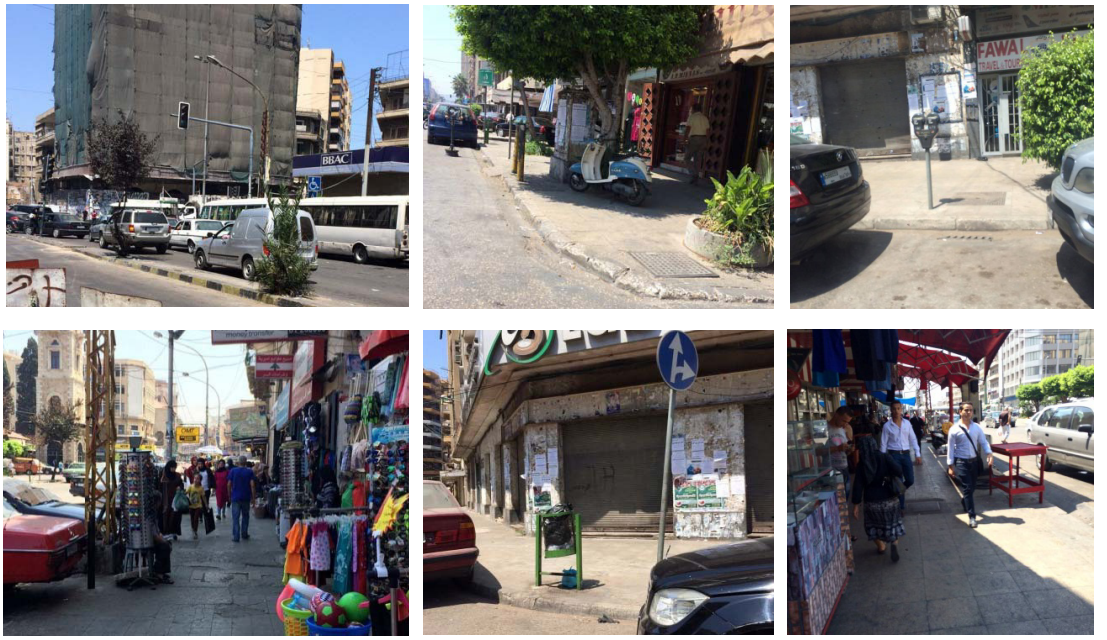

Fig. 9. Shows available street elements in case study 2 area

6.3. Conflicts between transportation modes needs and street elements

This study area has many conflicts between the existing transportation modes and street design elements, which cause hours of congestion for the traffic passing through it. One of these conflicts is the absence of formal public transportation, which represents the main reason for the appearance of the informal transportation modes, such as minibuses, microbuses and taxis (most of these are old private cars but used as taxis). The informal stations are extending across the case context. These stations take up one to two lanes of streets, causing trouble in parking and mobile movement lanes. In addition, the unused traffic signals negatively affect the street intersection flow. Commercial activities that are located in the verges sometimes affect the pedestrian flow on the pavement. Fig. 10 shows the location of the informal transportation stations.

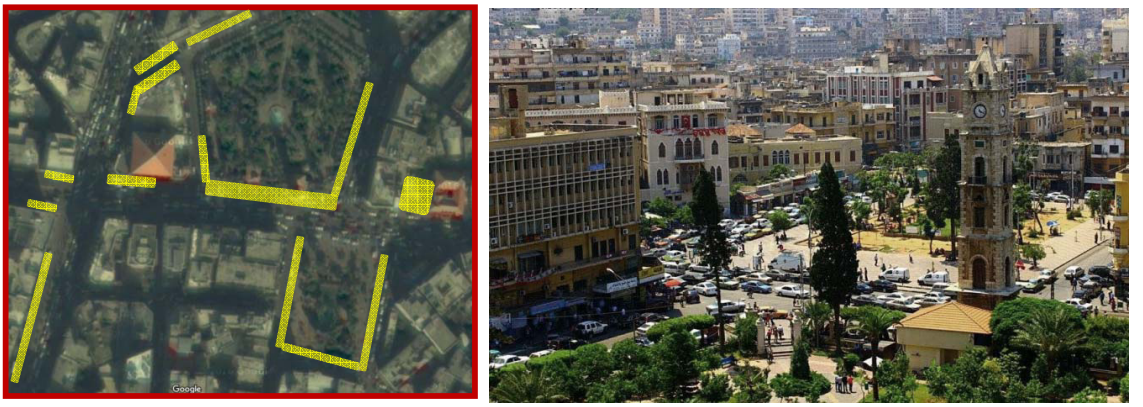

Fig.10. shows the location of informal transportation stations.

7. Conclusion

In both case studies, there is a clear absence of planning and consideration of the needs of users, whether these are the needs of vehicles or pedestrian movements. This absence has allowed other informal modes of transport to fill this gap. With their current performance, the informal modes represent a huge threat to any regeneration sustainability plans for both cities, as mentioned earlier in this paper. The current lack of policy attention and knowledge related to informal public transport systems indicates the need for policy research regarding these systems.

In the Giza case study, the incremental construction of the site was only planned for the vehicles' physical needs. It did not consider the surrounding land use that it serves, and it definitely did not consider the types of users and their travel habits (source/destination) and plans. On the other hand, the informal modes have done an excellent job in fulfilling the needs of the users, considering their economic levels and travel plans, but they do not consider the mobility needs of the routes and cause traffic congestion in addition to air pollution.

In the Tripoli case study, through history, this action area was designed on the edge of the historic city of Tripoli. It was not meant to be a transportation hub. Tripoli city had a railway terminal station in the 1960s that linked it with parts of Syria, an active airport and the marine harbour; unfortunately, none of these formal modes now operate. Due to its current location, the deterioration of the formal transportation mode and the absence of clear plans for urban regeneration, El Tal attracts all informal modes of transportation.

In developing countries, it is difficult for the governments to attract investments in the traffic infrastructure, as it does not have a payoff or fast economic returns. Moreover, they cannot deprive the informal transport modes, as they are 'filling the gap' of transportation needs – in particular, the social needs. Therefore, despite their apparent sustainable problems (environment, social and economic), they are more affordable solutions for developing countries. This paper argues that it is better to find solutions to make these modes more sustainable, upgrading their current status from informal to being more regular and environmentally friendly, enhancing the drivers' behaviour, establishing formal stations and, eventually, integrating them with the entire transportation planning system of the city.

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