Towards integrated sustainable transportation profile: a case study of Gharb El-Balad district, Assiut City, Egypt

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Abstract: Despite transportation is a key necessity for humans, it was argued a significant contributor to environmental degradation. Responding to that, drafts of sustainable transportation (ST) were sketched, guiding principles were argued, and rating systems were pursued. However, the selection of the appropriate method to implement ST is a challengeable task; not only due to the diversity and multidimensionality of local contexts, but also due to the numerous attributes of ST and their varying relative weights.

This paper aims at defining an integrated profile of ST. Firstly, the motive behind tackling the issue was introduced and the methodology was worked out. Definitions, guiding principles, indicators, and rating systems were reviewed. After that, taxonomy of ST indicators was carried out, the interrelationship of key-attributes was investigated, and strategic directions to ST were proposed, to be applied over a selected case study. At last, a discussion took place highlighting the opportunities and challenges.

Keywords: sustainable transportation; ST; street network; Gharb El-Balad district; GEBD; Egypt.

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1 Introduction

Historically, the concept of sustainable transportation (ST) was developed before the phrase was coined. The international literature has pointed out the dominance of car-based transportation highlighting its impacts on the built environment. Urban transportation systems were argued to behave in unsustainable manners; e.g., consuming energy, affecting the health of population and negatively influencing policy-making, practise and performance. All these transformations accelerated the rise of ST, as an integral part of the sustainable development movement. The issue was to save energy, minimise the instability of fossil fuel, limit emissions, reduce noise, protect the local and global ecology, maintain human health, support safety, create economic vitality, and pursue social equity (Sustainable Transportation Vision, 2006; Why sustainable choices are smart, 2009).

The term sustainability in relation to transportation is frequently advocated but rarely defined (May et al., 2008). It gained a great value due to the role it plays in adding multidimensional tasks through the agenda of transportation (Hull, 2005). Several governmental publications – particularly in the developed countries– have advocated a sustainable approach to be implemented in transport polices (May et al., 2008). However, to achieve the attributes of ST, guiding principles were proposed, checklists were pursued, rating systems were developed, and assessment methods were worked out (Litman, 2007).

The proposal of environmentally sustainable transportation (EST), which was carried out by the Organization for Economic Cooperation and Development (OECD) and followed by the efforts of Curitiba, Brazil, Bogota, Colombia Portland, Oregon and Vancouver, can be considered as a self-evidence (Towards Sustainable Transportation, 1996). These efforts varied in nature, scope and influence due to the varying conditions between and within countries and cities; versifying the way sustainability in transportation can be achieved, raising the environmental awareness, promoting responsible bodies to take appropriate actions, and opening the door on ST in a broader context.

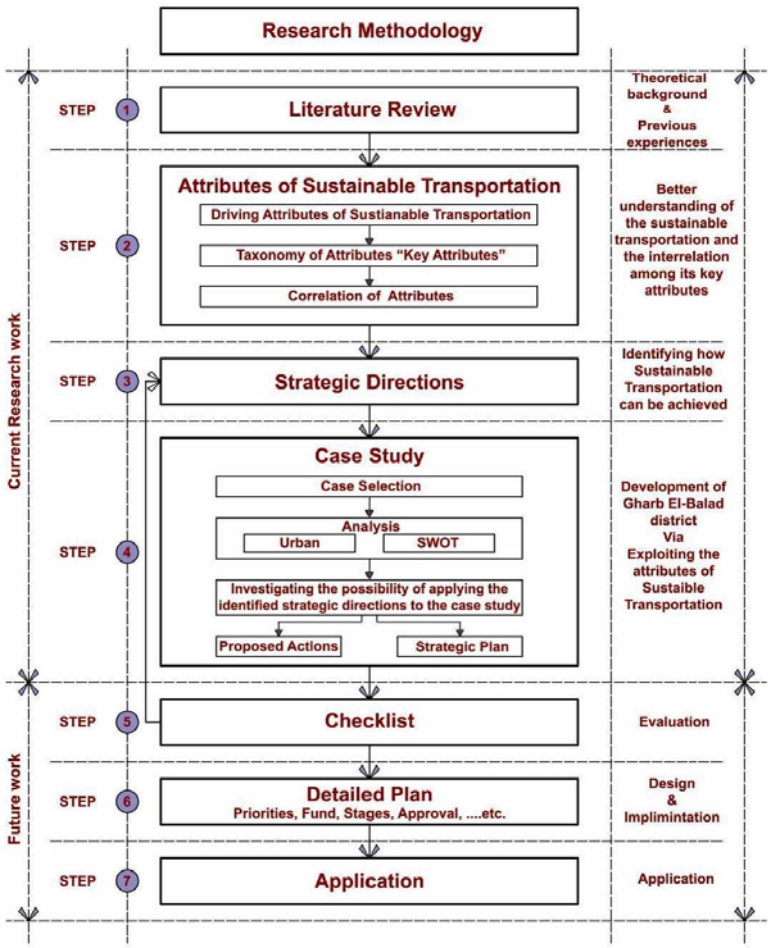
The implementation of ST can be considered a two-step process:

1 selection of indicators

2 proposing actions (Castillo and Pitfield, 2010).

Therefore, the identification of a concise integrated set of ST attributes can be considered a prerequisite to prioritise development schemes. Responding to that, the paper aims at defining an integrated and applicable ST profile. For the aim to be attained, definitions and guiding principles of ST were reviewed, and key attributes were identified. Further, the interrelationships of ST key-attributes were investigated, as a step to develop a set of strategic directions capable of filling the gap between theory and practise. After that, a case study application took place, to be followed by a discussion of the research results.

Figure 1 Research methodology (see online version for colours)



As shown in Figure 1, a seven-step research methodology was proposed to achieve the previously stated objectives. The scope of the paper was limited to carry out the first four steps, while the remaining steps would be the issue of future research work. Therefore, the scope of the paper would be limited to the following:

- investigating the complexity of sustainability in relation to transportation
- deriving, and further realising the correlation of, the key-attributes of ST

- identifying the strategic directions to achieve ST
- investigating the possibility of application through case study approach.

2 ST: a review

2.1 Definitions

The term sustainable development was introduced in 1980 and popularised in the 1987 report of the World Commission on Environment and Development. It was defined as the "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Per, 1994). Since its inception, sustainable development has been considered an umbrella term having the potential to accelerate the rise of other movements as integral parts of it. However, the essential attributes of ST were celebrated by three kinds of definitions: the literal economist's definition, the environmental definition and the comprehensive definition (OECD Guidelines, 2002).

As for the literal economist's definition, Nelson and Shakow (1996) argued that ST "is achieved when the total future discounted per-capita social costs… related to the transport system are equal to or less than the costs in a selected reference year". In other words, Schipper (1996) argued that ST can be achieved when "the beneficiaries pay their full social costs, including those paid by future generations".

The second kind of definitions is more concerned with EST. The OECD (2002) defined the environmentally ST system as the one that "does not endanger public health or ecosystems and meets needs for access consistent with (a) use of renewable resources at below their rates of regeneration, and (b) use of non-renewable resources at below the rates of development of renewable substitutes".

According to the comprehensive definition, the ST system is "the one that; (a) allows the basic access and development needs of individuals, companies and societies to be met safely; in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations; (b) is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy as well as balanced regional development; (c) limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable resources at or below the rates of development of renewable substitutes while minimizing the impact on the use of land and the generation of noise" (OECD, 2002).

Recently, many writings pointed out the definition of the ST in the context of the triple bottom life concept of economic, environment and social equity (Castillo and Pitfield, 2010; Litman, 2003; Loo, 2002; Mahmoud et al., 2010). Reacting to that, ST systems must insure economic growth combined with both social justice and environmental concerns. Efforts have been made to break down the complexity of the triple bottom life concept. Gudmundsson and Hojer (1996) and Black (2000) explained the economic theme of ST, whilst Lautso and Toivanen (1999), Gilbert and Tanguay (2000), and Marsden and Bonall (2006) focused on the environmental concerns of ST. In addition, May et al. (2001), and Castillo and Pitfield (2010) investigated the social attributes of the concept.

Although there are many trails to define ST, yet there is no single universally accepted definition (Castillo and Pitfield, 2010). Richardson (2005) argued that every individual and group addresses specific objectives of ST according to the role it plays in their context.

2.2 Guiding principles, checklists and rating systems

To support sustainability in relation to transportation, attributes were proposed, guiding principles and checklists were sketched, and rating systems were developed. Due to the varying environmental, social and economic conditions between and within countries, the OECD argued that there is no single best way to achieve ST, proposing a set of guiding principles upon which transition strategies can be built. The OECD (1996) Vancouver Conference revised, amended and further developed a set of draft principles proposed by Canada's National Round Table on the Environment and the Economy (NRTEE). The guiding principles were:

1 reasonable access to other people, places, goods and services

2 social, interregional and inter-generational equity; meeting transportation related needs of all people

3 encouraging individuals to make sustainable choices with regard to personal movement and consumption

4 protecting health, supporting safety and enhancing the quality of life

5 engaging people in the decision-making process

6 more integrated approaches to planning

7 efficient use of land and other natural resources

8 pollution prevention

9 contributing to improvements in economic and community well-being (Towards Sustainable Transportation, 1996).

Further, a number of strategic directions were proposed to move towards sustainability responding to more than one of the outlined guiding principles. For the attainment of EST in the target year of 2030, the OECD paper set out six criteria concerning transportation-related emissions of nitrogen oxides, emissions of volatile organic compounds, climate change prevention, emissions of particulates, land surface use and maintenance, and noise reduction. Based on these criteria, four scenarios to achieve ST for 2030 were established: a business-as-usual (BAU) scenario (the reference scenario), the high-technology scenario (EST1), the capacity-constraint scenario (EST2), and the optimum-combination scenario (EST3); which implied a combination of technological changes and demand management (Towards Sustainable Transportation, 1996).

In the light of these guiding principles, individuals and institutions started to develop checklists and rating systems in order to evaluate and develop transportation systems. Taylor and Sloman (2008) developed a sustainable transport master planning checklist. They identified eight aspects to achieve ST including: location of new developments, density of development, local facilities and jobs, street layout and design, public transportation, parking, restraint to car movement and smart travel behaviour. According

to their checklist, encouraging walking and cycling, adjacency to facilities, centres and services, more dependence on public transportation, restricted car movement and restricted parking can be considered the most significant attributes and strategic directions to achieve ST.

Furthermore, the pilot version of the Leadership in Energy and Environmental Design (LEED, 2005) rating system for neighbourhood development (LEED-ND) and its rating system for new constructions (LEED-NC) version 2.2 can be considered as the most widely accepted rating systems for sustainable development. To support ST, the LEED-NC assigned Credit No 4: Alternative Transportation – with 4 points from 69 points – highlighting the importance of several key elements including: public transportation access (1 point), bicycle storage and changing rooms (1 point), low emitting and fuel efficient vehicles (1 point) and parking capacities (1 point).

Whilst, for existing NDs, the LEED-ND assigned two groups of credits to support sustainability in relation to transport including: smart location and linkage (SLL), and neighbourhood pattern and design (NPD); with 26 points out of total 106 points. SLL included: reducing automobile dependence (credit 4 – 8 points) and bicycle network (credit 5 – 1 point), while NPD included: reducing parking footprint (credit 6 – 2 points), walkable streets (credit 7 – 8 points), street network (credit 8 – 2 points), transportation demand management (credit 10 – 2 points), access to surrounding vicinity (credit 11 – 1 point), access to public Spaces (credit 12 – 1 point), and access to active public spaces (credit 13 – 1 point) (LEED, 2007).

3 Towards an integrated profile of ST

3.1 Indicators and key-attributes of ST

In investigating the complexity of ST, dozens of definitions and proposals appeared to announce themselves, showing the term easy to use but hard to precisely exploit as a detailed guidance for detailed design. For instance, Castillo and Pitfield (2010) identified an initial list of 233 indicators of a ST system based on nine sources as illustrated in Table 1. In the light of the numerous amounts of indicators, one can argue that the utilisation of ST comes with two fundamental challenges:

1 the large number of indicators accommodated in the literature

2 some of these indicators are designed to focus only on a certain aspect of the concept, the fact that highlights the importance and significance of integration.

Rationally reacting to these challenges, a wide range of ST indicators were derived from the literature based on two hypotheses. Firstly, the conception of ST is extended to include a wide range of definitions (literal, environmental, social, and triple life concept). Secondly, the derived indicators can be grouped into smaller sets; key-attributes. By implementing these criteria, the review of literature has revealed a list of 27 indicators categorised into 11 interrelated groups; key-attributes, Table 2. According to these key-attributes, accessibility is to be supported; i.e., people, goods, vicinity, public transportation, services, public spaces and active social spaces are to be easily accessed through inter-connected street network. Walking, cycling and public transportation are to be encouraged, and safety of pedestrians are to be supported. As a result, transportation

demands, in general, and dependence on automobile, in particular, are to be strongly minimised. Further, more parking capacities to support inter-connectivity and parking management to reduce its footprint are emphasised. The issue is to reduce emissions, prevent pollution, lower consumption rates and support the economic progress, health and ecosystem as well as the social equity.

Table 1 Initial list of ST indicators

Source	*No. of indicators*
• Modelling for sustainable cities: the transport sector (Kupiszewska, 1997)	32
• Indicators for the integration of environmental concerns into transport policies (OECD, 1999)	27
• Indicators of transport and environment integration TERM 2002 (European Environmental Agency, 2002)	38
• Sustainable Transport Indicator Project, CST (Gilbert et al., 2002)	14
• The 'Civilising Cities' initiative (Jones et al., 2003)	15
• PROSPECTS project's methodological guidebook (Minken et al., 2003)	19
• Securing the future (Department for Environment, Food and Rural Affairs, 1998)	68
• Local quality of life counts (Department of the Environment, Transport and the Regions, 2000)	12
• How to monitor indicators in Local Transport Plans and Annual Progress Reports – 2005 Update (Department for Transport, 2005)	8
Total numbers of indicators	*233*

Source: Castillo and Pitfield (2010)

Table 2 ST indicators and key-attributes

Key-attributes	*Indicators*	
Accessibility	• Access to goods	• Access to services
	• Access to active social spaces	• Access to public transportation
	• Access to public	• Spaces access to vicinity
	• Access to people	• Inter-connectivity through street network
Cycling	• More dependence on cycling	• Safe cycling
Walkability	• Pedestrian safety	• Encouraging walkability
Less automobile	• Reduce automobile dependence	
Demand management	• Less transportation demands	
Less pollution	• Pollution prevention	• Reduced emissions
Economic value	• Reduced consumption	• Economic progress
Health and ecosystem	• Public health and ecosystem	
Social equity	• Less dependence on the non-renewable	• Sharing the environmental cost
	• Sustainable choices	• Exploiting renewable resources
Parking	• More parking capacities	• Parking management
	• Reduced parking footprint	
Public transportation	• More dependence on public transportation	

3.2 Interrelationships of ST indicators: in-depth analysis

In analysing the indicators of ST and identifying their interrelationships, an in-depth analysis was conducted. These indicators were argued to be linked according to seven types of relationships: two-way strong correlation, one-way strong correlation, two-way weak correlation, one-way weak correlation, weak negative correlation and strong negative correlation. As presented in Figure 2, these seven correlation types were assigned values of +4, +3, +2, +1, –1 and –3 referring to the strength and type of relationships, respectively. The correlation analysis was carried out assigning values for each pair-wise comparison. Further, the overall correlation value of each indicator was determined showing how far this indicator would influence and be influenced by other indicators, Figure 3.

Figure 2 Correlations of ST key-attributes (see online version for colours)

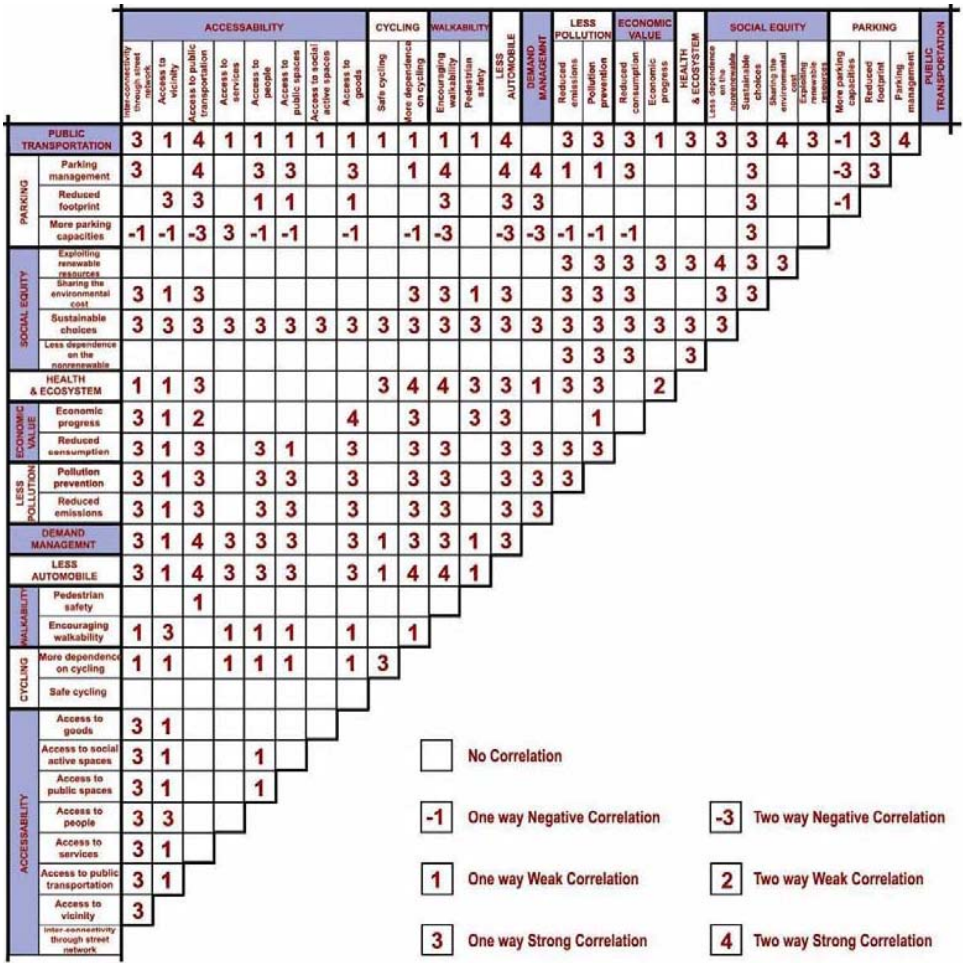
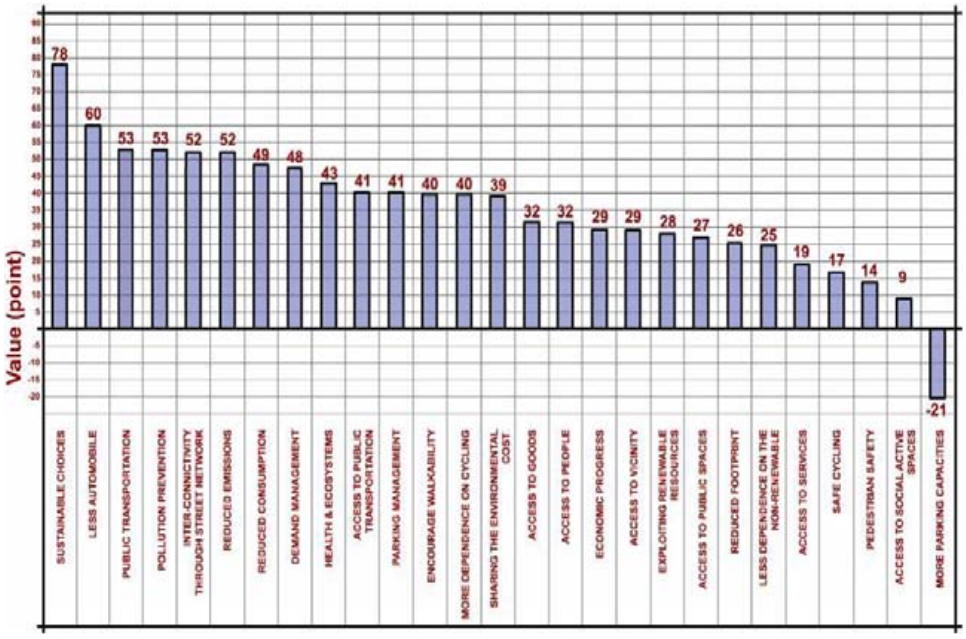


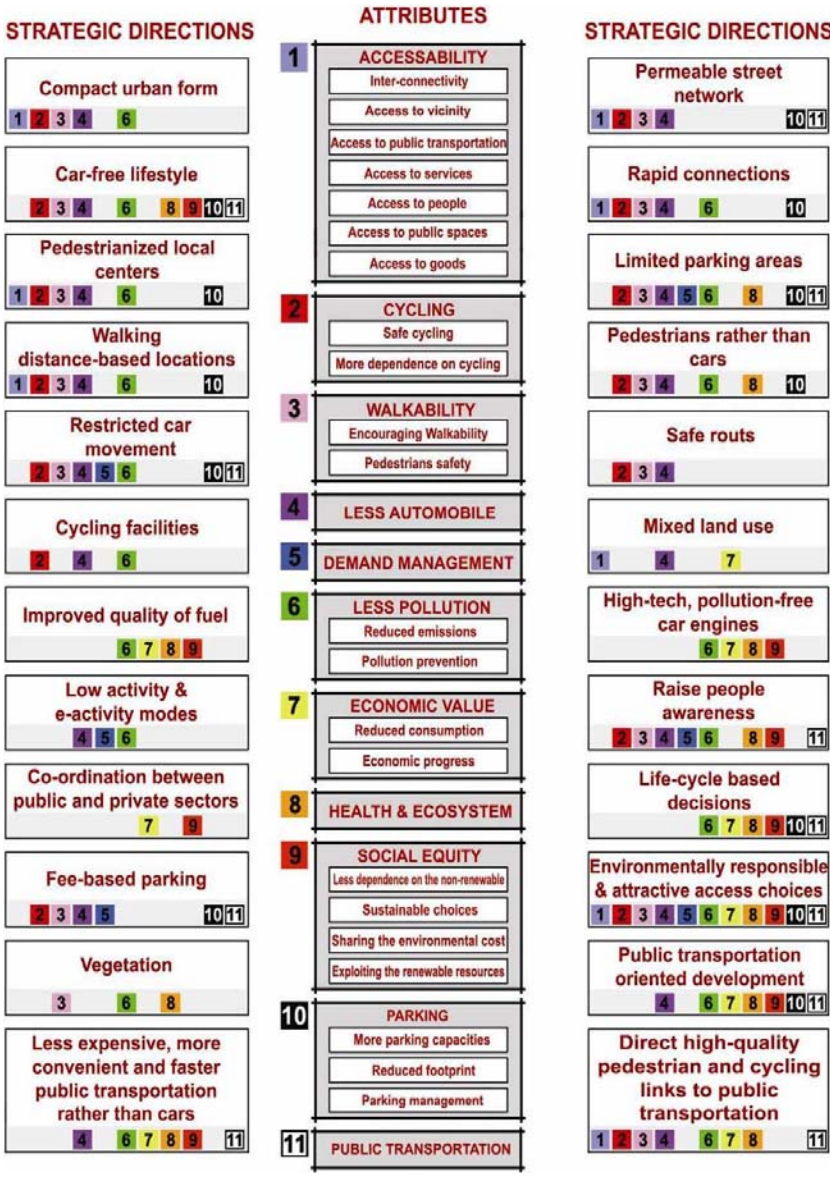
Figure 3 Correlation values of sustainable transport indicators (see online version for colours)



The results show that sustainable choices – with a correlation value of 78 points – announced itself as a mother-indicator having one-way strong correlations with all other indicators. This mother-indicator is followed by less dependence on automobile with a correlation value of 60 points; showing its potential to support sustainability and being supported by the encouragement of public transportation (a correlation value of 53 points). In another context, pollution prevention, reduced emissions and reduced consumption were shown to have relatively high correlation values (53, 52 and 49 points respectively), emphasising the environmental responsibility as a vital issue. Inter-connectivity (52 points) followed by demand management (48 points) were seen to have strong correlations with other indicators. Despite encouraging walkability and dependence on cycling (each of 40 points) appeared to strongly support other indicators, pedestrian safety (14 points) and safe cycling (17 points) lagged behind. Further, accessibility related indicators had a wide range of correlation values ranging from 41 points (access to public transportation) downwards to 9 points (access to active social spaces). Despite the indicator of more parking capacities was claimed to support accessibility, it had negative correlations with most indicators (–21 points).

By analysing the results derived from the correlation matrix and the score of each indicator, new patterns of implementing ST have emerged. The results show that including additional criteria (correlation with other indicators) demonstrates the importance of each indicator and prioritises the implementation of ST. Based on that, on can argued that implementing highly correlated indicators may lead to massive enhancements of transport system in sustainable manners.

Figure 4 Strategic directions to ST (see online version for colours)



3.3 Strategic directions to ST; the way forward

In order to move a step towards ST and to bridge the gap between theory and practise, a number of strategic directions to achieve ST attributes were proposed in Figure 4 and summarised in Table 3. Each strategic direction appears to support more than one key-attribute. At the top of these directions comes the offering of environmentally

responsible and attractive access choices, which has the potential to support achieving the 11 key-attributes of ST; in terms of promoting accessibility, encouraging walking and biking, minimising the dependency on the car, supporting the demand management, minimising pollution, promoting economic value, contributing to the social equity, minimising parking requirement, and promoting the dependency on public transportation. After offering these responsible and attractive spaces comes the limiting of parking access, car-free life style, direct high-quality pedestrian and cycling, and raise public awareness, each supports achieving 8 key-attributes of ST. As strategic directions follow, fewer numbers of the key-attributes can be supported.

Table 3 Ranking of strategic direction according to the supported number of key-attributes

Rank	*Strategic direction*	*No. of supported ST attributes*
1	Environmentally responsible and attractive access choices	11
2	Limited parking access	8
3	Car free lifestyle	8
4	Direct, high-quality pedestrian and cycling	8
5	Raise public awareness	8
6	Restricted car access and movement	7
7	Public transport oriented development	7
8	Pedestrian-based local centres	6
9	Walking distance-based locations	6
10	Fee-based parking	6
11	Cheap, convenient, and fast public transport	6
12	Permeable street network	6
13	Rapid connections	6
14	Pedestrians rather than car accesses	6
15	Life-cycle-based decisions	6
16	Compact urban form	5
17	Improved fuel quality	4
18	Pollution-free car engine	4
19	Vegetation	3
20	Cycling facilities	3
21	e-activities work style	3
22	Safe pedestrians and cycling routs	3
23	Mixed land use	3
24	Coordination between public and private sectors	2

Based on the results illustrated in Figure 4 and Table 3, it could be argued that there is no silver bullet solution for implementing sustainability in transport. The results clearly show huge variation of the indicators attached to each strategic direction. Therefore, the research argues that the trade-off between different strategic directions should be

carefully crafted and should be sensitive to context. Indeed, these results support the existing literature on the sensitivity of sustainable transport schemes in different contexts (Litman, 2007), and further extend to clarify additional dimensions of ST implementations when transformed into strategic direction.

4 Case study: street network in Gharb El-Balad District

A case study approach has been applied to insure the applicability of the derived strategic directions. To do that, the local context of Gharb El-Balad district (GEBD) was introduced and analysed, and a SWOT analysis of the GEBD street network was conducted. As a result, an integrated profile to develop the network was worked out, proposing actions and arguing a strategic plan. The GEBD announced itself as a case study for many reasons. At the top come the historical, social and cultural values of the district, as the historical nucleus of Assiut City, and one of the most ancient parts of it. However, recent developments were oriented toward newer districts, whilst the GEBD[1] laid far beyond policy makers' interest and awareness. Further, the district, with a density of about 440 P/Acre, was argued overpopulated and overcrowded, being marked by the shortage in major services and facilities (Mahmoud, 2007).

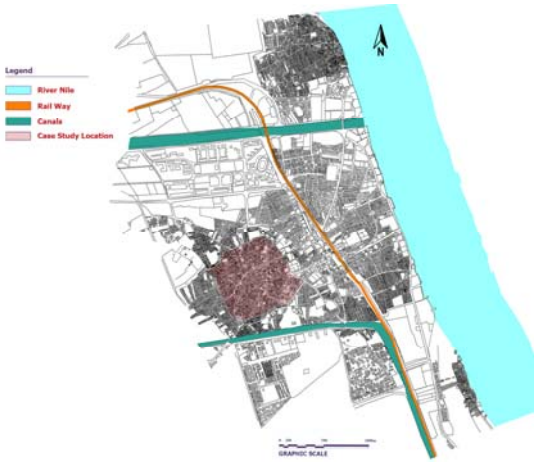
Despite the deteriorated profile of the GEBD, its compact urban form, well inter-connected street network, high percentage of deteriorated buildings (28%) that can be rebuilt according to a well prepared plan, the rising commercial investments (22.9%) mixed land use (mostly commercial in addition to 3.3% pure commercial), and the adjacency to Assiut City future land extensions represented positive indicators of the GEBD urban capabilities (Mahmoud, 2007).

4.1 Urban analysis

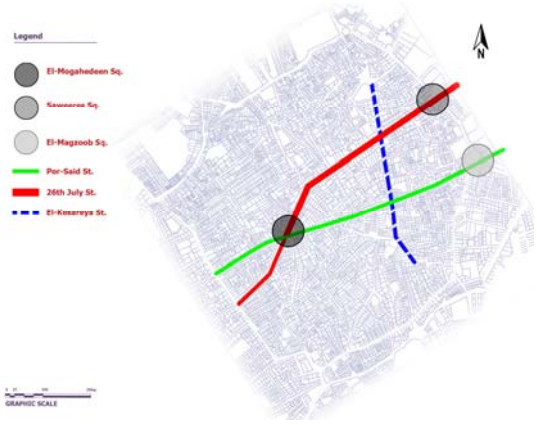
The GEBD is located in western south Assiut City – as illustrated in Figure 5(a) – with an area of 508036.07 m2, population of 53335 capita and density of about 440 P/Acre (Mahmoud, 2007). As shown in Figure 5(b), three nodes; El-Mogahedeen Sq., Saweeres Sq. and El-Magzoob Sq., and three main paths; Por-Said St., the 26th July St. and El-Kesarya St., form in their totality the basic features of the mental image. Further, the district is marked by a compact urban form, within which the street network is strongly inter-connected.

Since main streets are paved and most walkways are occupied by illegal commercial activities, the car movement takes the priority over pedestrians and cycle riders. Two main travel patterns are clear in the district: outbound during the morning, and inbound at the evening. This travel pattern is reversed during weekend and national holidays. Due to the high population, the GEBD can be considered an over-populated and over-crowded district, marked by mixed land use and dominance of commercial activities; especially alongside main roads (Mahmoud, 2007). Further, the district is marked by the shortage in services and facilities and a high percentage of deteriorated buildings (28% and most of them made of mud bricks), notably reflecting the deteriorated urban profile of the GEBD.

Figure 5 Urban analysis of GEBD, (a) location of GEBD in Assiut City (b) nodes and paths (c) land use (d) public spaces (e) street network (see online version for colours)



(a)



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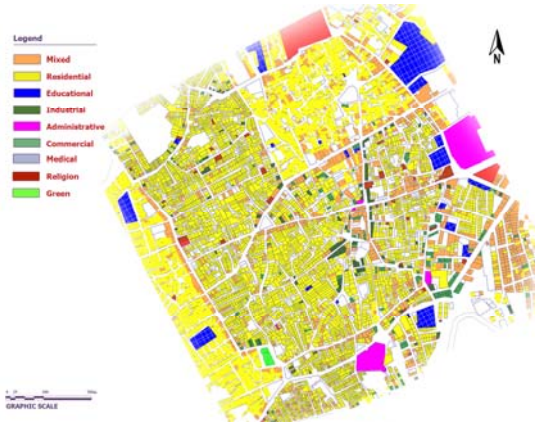
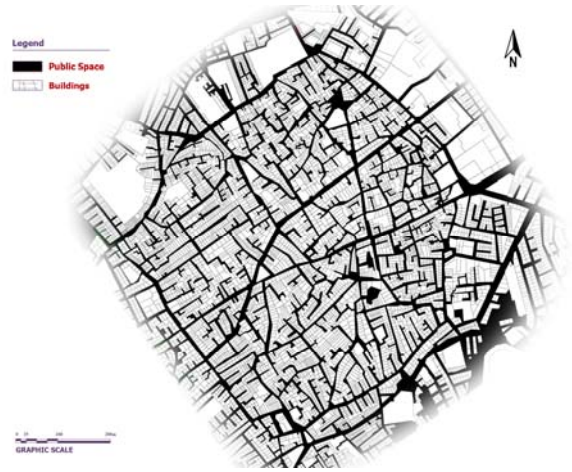


(c)

Figure 5 Urban analysis of GEBD, (a) location of GEBD in Assiut City (b) nodes and paths (c) land use (d) public spaces (e) street network (continued) (see online version for colours)



(d)

(e)

4.2 Street network: SWOT analysis

A SWOT analysis of the GEBD street network was conducted in order to identify: the attributes that would help moving towards ST (strengths), the attributes that would hinder that (weaknesses), helpful external conditions (opportunities) and harmful external ones (threats), Table 4.

Table 4 SWOT analysis of the GEBD street network

Strengths	*Weaknesses*
• Legible mental image. • Compact urban form and permeable street network would support inter-connectivity. • Main streets (arterial roads and collectors) are well paved, and the infrastructure is installed. • High percentage of public spaces (26%) supports proposing street network design alternatives. • The 26th July St. of 15m width allows two-way car movement and supports public transportation. • Private cars ownership is at minimal rates (0.006 private car/capita) when compared with the national average rate of 0.023%[2]. • Low income rates do not allow people to own private cars, encouraging walking, cycling and public transportation.	• Widths of street network do not enable safe walkways and cycling routs; mixed movement threats the safety of people (pedestrians and cycle riders). • Car movement takes the priority over walking and cycling. • No public transportation (dependence on taxis) • No central parking areas (parking takes place alongside street network). • Lack of services and facilities. • Lack of vegetation. • Due to high illiteracy rate, the issue of sharing the environmental responsibility and raising public awareness concerning ST strategic directions can be considered academic. • High rates of emissions due to deteriorated car engines owned by residents.
Opportunities	*Threats*
• The district is attached to Assiut City future land extensions; therefore, these extensions can be accessed through the GEBD.	• Low degree of governmental awareness. • Absence of NGOs and public participation. • Lack of funding resources.

4.3 Developing the GEBD street network

4.3.1 Proposed actions

In developing the GEBD street network, the proposed strategic directions appeared to fall into three main groups. The first group seemed to have no beneficial use for the development of the GEBD street network for many reasons. 'Compact urban form', 'permeable street network', 'walking-distance locations' and 'rapid connections' are already there. Further, due to the low car-ownership rate (0.006 car/capita), the notion of 'car-free life style' seems academic.

On the further side resides the second group of strategic directions including: improving fuel quality, high-tech and pollution-free car engines, low activity and e-activity modes, raising people awareness, coordination between public and private sectors, life-cycle-based decisions, fee-based parking, and less expensive, more convenient and faster public transportation, to be the issue of industrial, social and governmental bodies. In the contrary, the third group appeared to have the outward aspect of supporting the GEBD to experience a level of ST; in terms of a set of proposed actions.

Table 5 Proposed actions (see online version for colours)

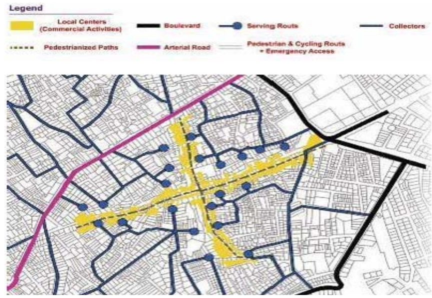
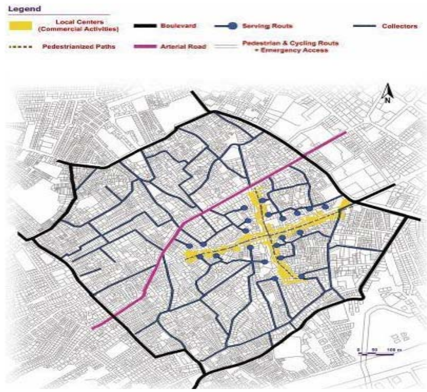
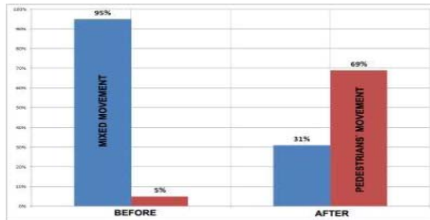
Strategic directions	*Proposed actions*	*Maps and illustrations*
Pedestriansed local centres	• In Por-Said St. and El-Kesarya St. (local center), movement is limited to pedestrians with emergency access. As shown in the map, the commercial activities can be served by dead-end serving routs (cul-de-sac routs).	
Restricted car movement Pedestrians rather than cars Safe routs	• Car movement in the local centre is already restricted according to the previously proposed action. • To promote the priority of pedestrians over car movement, the street network is refined in terms of assigning only 31% of the network for mixed movement (instead of 95%), while 69% of the network is limited to pedestrians, cycle riders and emergency access (compared with 5% before refinement). The issue is to reassign priorities and support safety. • Pedestrians' primary flow runs along Por-Said St. and El-Kesarya St. in the centre of GEBD supporting pedestrians' safety, while pedestrians' secondary flow moves alongside street network feeding the entire district.	 

Table 5 Proposed actions (continued) (see online version for colours)

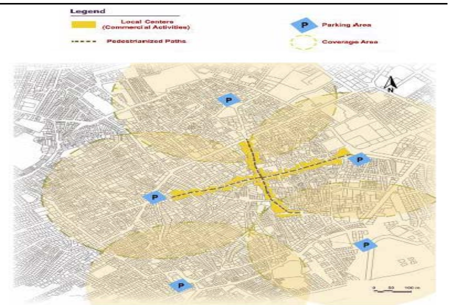
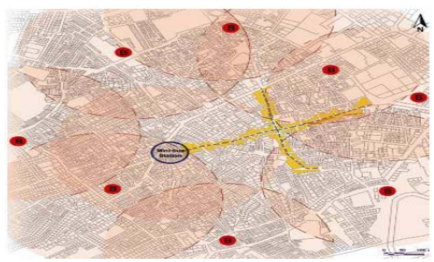
Strategic directions	*Proposed actions*	*Maps and illustrations*
Limited parking areas	• Five locations are argued to have the urban capabilities (within walking distance to the local centre, commercial activities, key locations, key-gateways and piazzas) to be exploited as central parking areas. • These locations are proposed to be fee-based, minimising transportation demands and encouraging walking and cycling.	
Public transportation oriented development	• Public transportation network is developed, serving the entire district, supporting connectivity, strengthening the connections to vicinity and taking the priority over private car and taxi-based transportation. • The mini-bus station is located in El-Mogahedeen sq. in the GEBD key-location.	
Direct high-quality pedestrian and cycling links to public transportation	• Eight mini-bus stops are proposed in order to cover the entire district within a maximum walking distance of 300 m. • Mini-bus stops are located alongside main roads and streets to support direct pedestrian and cycling links to public transportation.	
Cycling facilities	• Cycling storages and facilities are installed; attached to Mini-bus Station and stops.	

Table 5 Proposed actions (continued) (see online version for colours)

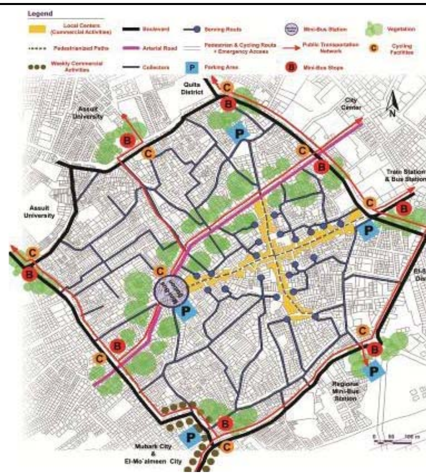
Strategic directions	*Proposed actions*	*Maps and illustrations*
Vegetation	• Green street concept is adopted, and vegetation is proposed alongside the public transportation main path and close to Mini-bus stops. The issue is to minimise the impact of fuel emissions.	
Environmentally responsible and attractive access choices	• An end to the dominance of mixed movement type is proposed; pursuing various movement types and attractive accessibility choices.	

Figure 6 Strategic plan of the GEBD street network (see online version for colours)

4.3.2 Strategic plan

The proposed actions were put together under one roof to form in their totality the proposed strategic plan, Figure 6. The plan can be summarised as follows:

- a public transportation network is proposed to take the priority over private car and taxi-based movement (a Mini-bus station and eight Mini-bus stops)
- to support walking, the local centre, where most commercial activities take place, is to be pedestrianised with emergency access and serving routes
- existing street network is to redesigned to minimise car movement, encourage walking and cycling and support pedestrians' safety

- five fee-based central parking areas are proposed to cover the GEBD area in order to minimise the transportation demand, reduce parking footprint and encourage walking, cycling and dependence on public transportation
- to support cycling, storages and facilities are to be installed adjacent to Mini-bus Station and stops
- adopting the green street concept, vegetation is proposed alongside the public transportation spine and close to Mini-bus stops to minimise the impact of fuel emissions
- being influenced by the social and cultural values, the proposed actions are revised, taking the mental image (i.e., nodes, paths, compact pattern) of the district into consideration.

5 Discussion of results and conclusions

- In the paper, it was argued that due to the varying environmental, social and economic conditions between and within countries there would be no silver bullet solution to achieve ST, opening the door for local efforts to integrate theoretical guiding principles closely together with the pressing local context. The scope of the paper was extended to provide a strategic plan to develop the GEBD to investigate the applicability of the worked out strategic directions.
- The paper managed to induce taxonomy of ST indicators, as they were derived from the literature, to fall into 11 key-attributes, which can be considered a concrete base on which a coherent profile of ST can be sketched.
- The paper argued that achieving any attribute of ST would influence and be influenced by achieving other attributes, providing the paper with the motive to induct an in-depth analysis in order to identify the interrelationships among ST indicators.
- The in-depth analysis showed ST indicators to have various relative weights due to the various correlation values (from +78 to –21) they have.
- Also, the analysis showed that more dependence on public transportation together with restricting car movement can be considered the most influential strategic directions to support achieving ST. On the contrary, the excessive parking areas are to maximise transportation demand; negatively influencing the achievement of ST.
- The paper managed to issue 24 strategic directions to achieve ST.
- After analysing the GBED profile (urban analysis and street network SWOT analysis), the strategic directions to ST were integrated with the local context providing the research with solid ground on which appropriate actions were proposed and a strategic plan was developed.

In this paper, the GEBD was given the opportunity to experience a level of sustainability in transportation, adopting the concept of *'think globally and act locally'*. As a result, a specific strategic plan was proposed based on studying the application possibilities of

24 strategic directions. In conclusion, the research appeared to bridge the gap between theory and practise in terms of investigating the potentials of ST as a theoretical issue, to develop an existing district with a relatively pressing local profile.

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Notes

1 More than 80% of GEBD population have a monthly income less than 250 L.E. compared with the national average income of 737.3 L.E.

2 A study conducted by the Ministry of Transport in Egypt concluded that the private car ownership rate in the Greater Cairo Region is increasing annually (17%); showing the private car-based travels to take the priority over public transportation.