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Developing Sustainable Streets in Egypt in Relation to Public Needs - Case Study; Mostafa El-Nahas Axis

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***Abstract*- One of Egypt's most worked-on agendas is developing a new enhanced streets network, which directly impacts street users, city residents, and most certainly the economics of the country as a whole. Additionally, street design has an immense impact on developing livable and sustainable cities, since designing them sufficiently means that one-third of the city design is successful, with a tremendous effect on the remainder of the city, especially on already established cities and their residents. The crucial factor is to apply a comprehensive approach in planning or developing them, where all factors involved must be considered, including pedestrians, vehicles, parking slots, etc. This must be achieved without neglecting the important role of public participation in matters of concern. Thus, this study aimed at analyzing one of the newly developed streets in Nasr City, Cairo, to assess its achievement and if it needs enhancement from the public point of view. It was found that the latest development of the Mostafa El-Nahas Axis was favored by the majority of the study sample. However, some enhancements must be conducted on the detail level. For example, the study sample expressed the need for increasing plantations on the street and making it more pedestrian friendly.**

***Keywords*- Livable City, Sustainable Streets, Public Participation, Streets Planning**

I. Introduction

Since the 50s and 60s of the past century, cities' growth worldwide necessitates the need for new and wider streets, as a part of overall comprehensive transport plans. The streets are a crucial tool linking one city center with another so that cities are not subjected to a standstill [1]. This need to develop better streets to connect cities was even recognized by private companies that went on constructing and managing toll roads or turnpikes in some countries [2]. Since efficient roads can also increase the economy of the country. Hence, the comprehensive street development plans should include not only a vehicle-oriented approach, which is equivalent mainly to the ease of movement and the number of parking spaces but also a pedestrian approach, including all the factors of creating resilient streets. Unfortunately, some plans could never be implemented due to cost or environmental reasons [1].

Additionally, streets have a life span although it is difficult to estimate it due to various reasons that are hard to analyze. For example, when there are radical unexpected changes in land use it leads to huge changes in traffic volumes, needs, and patterns. However, when providing adequate maintenance, streets can live for almost 100 years, and pavement structures for around 20 to 30 years, which conserves resources immensely [3]. Furthermore, it is now well known that car emissions cause ill health, such as irritation of the eye and cardio-respiratory, acute toxic effects, cancer, and various effects on the defense system. Where motor vehicles are responsible for a lot of the carbon monoxide, lead, hydrocarbons, nitrogen oxides, oxides of Sulphur, and particulate levels with various percentages. Furthermore, the main gases leading to global warming are also generated by vehicles such as carbon dioxide (CO_2) [1]. It was found that Egypt's CO_2 emissions increased significantly over the past 50 years, from 25 to 269.5 million tons [4]. Thus, street development must always work on decreasing these emissions by firstly decreasing traffic congestion.

A previous study by Rania Moussa illustrated that the main reason for congestion in Egypt is likely the country's inadequate traffic management system. Lack of traffic signals, sporadic halts by vehicles and minivans, improper pedestrian crossings, and restricted parking availability are some indications of inadequate traffic management. It also showed that in regard to upkeep, Egyptian roads do not follow a regular maintenance plan. Where congestion wastes almost 47 billion L.E. annually, or 8 billion USD, and is predicted to rise to 105 billion L.E. by 2030 [4]. Putting into consideration that these numbers reflect the economic costs of congestion at the date of the study.

Thus, in recent years, Egypt has given special focus to developing a strong network of roads on a wide scale, that can link its new cities with its old ones. Not only that but the government has also worked on developing some main old streets in its various cities to enhance the traffic flow and decrease congestion inside the city while facilitating its connection with new cities. This policy generally has many benefits and objectives related to economic efficiency, environmental protection (sustainability), and safety which are demonstrated in Table 1.

Table I. Suggested Strategies for Various Transport Policy Objectives and Benefits [1]

Objectives / Benefits	Strategies
Economic Efficiency	• Prevent delays for cars at intersections. • Prevent delays for pedestrians when crossing roads. • Decrease time and money costs spent on journeys undertaken. • Encourage external capital to come and invest in the country. • Provide additional revenues from parking. • Decrease fuel consumption. • Ease of accessibility

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Environmental Protection (Sustainability)	• Control noise levels. • Decrease vibration. • Decrease levels of different local pollutants (CO, HCs, NOx, and particles). • Prevent visual intrusion. • Enhance landscape quality. • Decrease CO_2 emissions.
Safety	• Decrease accidents. • Prevent insecurity.

Finally, public participation from the beginning in decisions that will affect their lives and well-being, in matters of relevance, became crucial to the success of any development and decreasing the opposition towards it. This was acknowledged by the Egyptian Ministry of Housing, Utilities, and Urban Communities (MHUUC), in its latest guide for creating detailed plans, 2018 [5]. Thus, the research will study one newly developed street and assess it from the public point of view in relation to their needs. Additionally, it will provide some strategies and solutions to enhance its success rate and sustainability.

II. Research Objectives and Methodology

The research aspires to illustrate the importance of designing and developing livable and sustainable streets in Egypt for functional, environmental, and economical benefits. Thus, the study will first discuss the guidelines for developing a livable and sustainable street using the deductive analytical approach.

Additionally, it focuses on the effect of developing livable streets in an already established city. Hence, and for many other reasons, Mostafa El-Nahas Axis in Nasr City, Cairo, one of the latest developed streets during the time of the study, was used as the research case study. The street under study was monitored and observed for a period of around 10 years while using photo documentation whenever possible.

Furthermore, the study strives to demonstrate the importance of public participation in the process of developing where they live and what matters to them. Thus, it started by assessing the users of the street opinions on the street developments and using the results as the base for the proposed enhancement provided in the last part of the research. The public opinions assessment was conducted in two stages; Stage one was in 2013 when an anonymous short interview for more than 60 taxi drivers and a few residents took place with a single aim of how they saw the development the street was undergoing at the time and what they needed. The second stage was in 2022 when an electronic questionnaire was published on multiple platforms to assess the street's latest development. The questionnaire assessed only the users of the street's opinions, with the majority being residents. Using the quantitative analytical approach, the case study sample feedback was analyzed. Through it, the study provided some solutions and strategies to better enhance street development, making it more sustainable and livable from the public point of view.

The questionnaire conducted in the paper was based on anonymous voluntary participation, where only consented participants completed the requested survey and approved of using their opinions in academic research. Thus, there are no ethical issues applied to this research.

III. Livable & Sustainable Streets' Design Guidelines

Cities nowadays are striving to create livable and sustainable streets. That is because this can enhance wise development while creating stronger local economies. In other words, cities will be more economically competitive [6]. Additionally, economic assessments became major contributors in relation to selecting new or improved streets. In Britain, for example, economic assessments are entwined with twelve environmental aspects to create their assessment framework. The twelve elements include pedestrians; vehicle users; cyclists; equestrians; air quality; traffic noise and vibration; water quality and drainage; disruption due to construction; land use; ecology and nature conservation; geology and soils; landscape effects; cultural heritage and community effects; and policies and plans [1].

Various studies in the past discussed how to create livable and sustainable streets. Some perceived streets' main function is only to accommodate the movement of car traffic and is lined with buildings, whether they are private or public spaces [7]. However, it was found that the key element in achieving livable and sustainable streets is to design them putting all potential users and factors into consideration. This includes designing the streets for the old and young, pedestrians and walkers, people using wheelchairs and canes, bicyclists, public transportation riders, and vehicle drivers. Furthermore, the design should extend to include all the streets' elements, such as; sidewalks; bike and bus lanes; transit stops; pedestrians' crossing points; median islands; etc. [6]. Fortunately, one application can work toward achieving various goals. For example, traffic calming techniques can reduce car speed, moderate traffic volumes, simultaneously decrease noise and air pollution; and provide safe areas for pedestrians to cross the streets [8]. Tables 2 and 3 demonstrate the main guidelines that a street and sidewalk design must satisfy in order to be comprehensively livable and sustainable.

Finally, streets have multiple classifications, for example, they are classified according to the primary function of each route. Where freeways enhance movement and provide total control over accessibility. Local streets on the other hand support property access and not traffic movement. As for arterial and collector streets, they must serve both property access in addition to traffic movement [3]. Another classification of the streets divided them according to their order and made them into three types; high, middle, and low-order streets. Every street type has its own optimum design speed, ceiling speed, decision/sight distance, passing sight distance, lane width, etc. [8]. Where speed is considered one of the most important factors when working on streets. It directly affects the easiness of moving people and goods and simultaneously transportation costs [3].

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Table 2. Sustainable Street Design Requirements and Planning Guidelines [1], [3], [6], & [8].

Streets Users' Types/ Demands	Streets' Design Requirements
Car Users (Residents/ Visitors)	• Car users must find it easy to access the street and move from one place to another. • Provide satisfying street and travel lanes widths, and numbers. • Prevent traffic jams or congestion by widening the roads or reducing the number of cars. • Build tunnels and bridges to solve traffic congestion. • Decrease accident levels, by preventing obstructions, and eliminating exceeding the specified speed. • Use appropriate traffic calming methods, to allow around 300 vehicles per hour, such as traffic signs, radars, and road bumps. • Even when preventing car horns and loud stereo sounds, vehicles still generate noise from their motors and the interaction of the car tires with the street. Thus, noise must be reduced where the noise level experienced during a 24-hour day must not exceed 65 dB. • Provide adequate lighting. • Provide all the required information such as speed, regulations, directions, etc. on oversized, retroreflective signs with suitable legibility. • Decrease the length of the trip, to decrease fuel usage. • Use appropriate street paving quality. • Median islands' dimensions and design should be suitable for safe U-turning, rotating, and crossroads without any obstruction. • Water drainage systems in the street should be adequately placed and constructed to prevent accidents. • Prevent sudden stopping of public transportation in unauthorized areas or in the middle of streets. • Provide enough parking spaces/lanes areas and numbers as in large parking areas attached to the streets or on-street parking lots, especially near commercial or mixed-use activities buildings.
Pedestrians (Residents/ Visitors)	• The preferred on-foot journey is from 1 to 3 km while the recommended distance limit for impaired people is only 50-150m/s without rest. • Provide frequent and safe crossing opportunities. Since too wide streets became hazardous and uncomfortable, especially when the cars are moving fast and can cause accidents. • Use traffic control signs for controlled and safe crossing and transit of the streets. • Road crossing speed should be around 1.2 m/s to 1.35 m/s for the mixed age group, while for a free-flow it will be around 1.6 m/s, and finally for the disabled, it will be around 0.5 m/s to decrease accident levels. • Median islands' dimensions and design should be suitable for allowing safe walking and crossing.
Bicycles & Public Transport Users (Residents/ Visitors)	• The first 14 points required for car drivers are also a requirement for public transportation users and bicyclists. • Provide a dedicated lane for public transportation, bicyclists, and emergency lanes with adequate width. • Use timely public transportation. • Provide comfortable and accessible bus stops. • Provide appropriate public transportation station areas. • Use specified routes and timings for cargo trucks.
Sustainable Demand	• Use sustainable Infrastructure (Paving/ Sewage). • Decrease Carbon Footprint by decreasing vehicle emissions. • Provide a stormwater management control plan. • Create a plan to use recycled waste. • Decrease traffic noise. • Decrease harmful emissions and enhance air quality by making vehicle emissions within the acceptable limit.
Economical Demand	• Estimate traffic volumes for around a 20-year design period. • Cooperation between all the different government agencies, municipalities, and all concerned parties, to finish the infrastructure before paving to save time and money and decrease construction time and discomfort for street users. • Streets should be designed to live for around 100 years and pavement for 20 to 30 years. • Promote car-sharing programs, car polling, and taxis.

Table 3. Sustainable Sidewalks Design Requirements and Planning Guidelines [3] & [6].

Streets Users' Types and Demands	Sidewalks' Design Requirements
Car Users	• They must be attractive & appealing to enhance the traveling experience. • Provide enough accessible parking lanes without affecting sidewalks' other functions. • Provide non-obstructing landscape elements and waste management methods.
Pedestrians	• They must be designed with appropriate dimensions and widths to accommodate pedestrians, landscape, hardscape, lighting, waste pins, bus stops, waiting area for transit, building entrances, etc. • Curbs must have a suitable height of about 15 cm. • Be walkable for walkers; people using wheelchairs or canes; old and young; and people with luggage. • To be safe & healthy. • Designed while considering residential, commercial, or multi-mixed activities such as shopping & touring experiences. • Accommodate enough resting seats at appropriate intervals. • Be attractive & appealing with enough greenery and plantation for shading and decreasing Co_2 levels. • Appropriately lighted with pedestrians' light signs. • Designed while including frequent ramped sidewalks for wheelchair and luggage users. • Provide pedestrian traffic signs for safe crossing of the street and to work on request.
Bicycles & Public Transport Users	• Accommodate enough accessible bus stop numbers and shaded waiting areas. • Provide satisfying sidewalk width, gathering points and focal points, and parking areas for bicycles.
Sustainable Demand	• Use sustainable systems for lighting units, plantation, pavement, finishing materials, bin wastes, etc. • Plantation and greenery are crucial not only because they are interesting to look at but also because they lower carbon dioxide footprint and enhance air quality while offering shading in hot countries. • Use sustainable plants and streetscape.
Economical Demand	• Long-term use of sidewalk elements / Streetscape which includes good seating, lighting, clear signs with local information, and other amenities that help people to gather and increase sociability. • Use durable materials while studying public needs to decrease the need for new development in a short period of time.

IV. Case Study: Mostafa El-Nahas Axis

A. *History & Basic Information*

The paper selected Mostafa El-Nahas Street/Axis as the research case study for being one of the latest streets that outwent a new development in 2020. However, this was not the only development that the street has gone through in the last 10 years. Actually, in 2013, it went from being a two-way street with a tram in the middle, which is considered

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sustainable public transportation, to being a two-way divided street with a middle two-way undivided third street for public transportation usage only. Additionally, the street is a main street that is found in Nasr City, Cairo, Egypt. With an area of around 250 km^2, Naser City is the largest neighborhood in Cairo City and is situated to the east of the Cairo Governorate [9].

As explained previously, streets have many types, and the El-Nahas axis can be considered the Boulevard type. It is a wide thoroughfare multi lanes two-way street which used to have average landscaping scenery [10]. It has mix-used activities for both vehicles and pedestrians [8]. Additionally, the latest development with its multiple connecting bridges made it a mix of minor arterial roads and collector roads, since it has direct access to buildings [5]. The axis is currently divided into three sections/streets; the first is called Ali Amin Street, the second is Mostafa El-Nahas Street, and finally, the third one is called Africa Street. Its development included another junctional street called Metwally El-Sharawi Street represented as the fourth part as demonstrated in Fig. 1.

B. Development Stages

The street went through four main development stages in the last 20 to 30 years or so of its life. This reflects an unsustainable development process due to the short intervals between them which means resources and time for new constructions were wasted. It also reflects two main factors, the absence of public participation in the process since the beginning and the lack of future estimation studies and plans. This also has its impact on the economics of the country as a whole especially if it is an ongoing pattern of development.

Stage one of the development is when the street was a two-way street with a tram (metro) in the middle of it as shown in Fig. 2 and perpendicular intersections, for the main streets with traffic lights. This stage was distinguished by using a sustainable public transportation method; the electrical tram, while there was increased congestion at the intersections, especially at certain times of the day. It is also considered the longest stage in the axis life.

Stage two of the development is when the street was a two-way street with a tram (metro) in the middle of it as shown in Fig. 2 and U-turns, with traffic lights. This stage was distinguished by using a sustainable public transportation method; the electrical tram, while there was some congestion at the U-turns especially at certain times of the day while having a safe design for rotating.

Stage three of the development is when the street was a two-way street with a third undivided street in the middle, for public transportation movement as a rapid public transport lane as shown in Fig. 3, and started in 2013. This stage was distinguished by using a fast transit lane that separated the public transportation vehicles from normal traffic on the street. However, it led to using high speed in the transport lanes that resulted in an increased level of accidents when using U-turns, or for pedestrians. It also led to multiple changes in the axis planning and its adjacent streets network over time, to try to overcome some of the problems caused.

Finally, stage four of the development is the latest state, when the street became a two-way street with multiple connecting bridges and U-turns as shown in Fig. 4. This stage is distinguished by the easiness of traffic flow. However, there is a clear lack of greenery and landscape on the street.

Figure 1. Mostafa El-Nahas Axis with its three parts and Metwally El-Sharawi Street, the fourth part [11] (Edited by the Author)

Figure 2. a) & b) The axis with a metro in its middle [12] & [13].

Figure 3. a), b), & c) Mostafa El-Nahas axis with a third undivided street in its median [14], [14], [15].

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Figure 4. a), b), & c) Sectors on Mostafa El-Nahas axis showing the bridges [16] & [17] (12/2/2023).

V. The Egyptian Society; Surveying Public Feedback

Transport planners, before the 1960s, used to believe that their knowledge and expertise alone are enough for the development of a street. However, since the 1970s this was challenged by the public, who wanted to have a stronger voice in the decisions that influenced their lives. Thus, a process was created known as public participation, in spite of it being time-consuming, however, it has many benefits. It allows planners to have a precise understanding of community needs and their acceptable alternatives. It can also decrease opposition to decisions taken since potential opponents are part of the decision-making process from its beginning. It can also offer transparency, a democratic frame of engaging people, and allows the education of all participants; the public and planners [1]. Therefore, the Egyptian Ministry of Housing, Utilities, and Urban Communities (MHUUC), in its latest guide for creating detailed plans, 2018, included public participation as one of the tools or means in the mechanisms of implementing the detailed plans

In accordance with this approach, a survey was conducted to understand the street users' feedback on the current and previous developments of the street under study. This was achieved by conducting an electronic questionnaire. The targeted study sample included residents mainly, but also, visitors participated; whether they are car drivers, public transportation users, and/or pedestrians. Ninety people volunteered to participate in the survey anonymously while agreeing on using their feedback for the research. The number was surprisingly much lower than expected, especially since as illustrated people demand on taking their opinions on matters that concern them, otherwise, they complain about it. However, when the survey was published on many multiple platforms, public and private, and left open for participation for more than 6 months in 2022, the number who agreed to answer it was less than 0.1% of the total available number.

A. Study Sample Basic Information

The study sample basic information analyses and classification were demonstrated in Table 4. It was found that the majority of the study sample were between the age of 41 and 60 with a total of 65.5% of them being direct residents on the street or Nasr city residents in general and 81.1% being car drivers. Finally, around 68.9% of the study sample witnessed the four main stages of development of the street. These variations have their influence on the results.

B. Best Vs Worst Development

The study sample was asked to state their opinion on the best and worst development conducted for the street from their point of view as illustrated in Table 5. Their feedback was most reliable since 87.8% of them witnessed the four or at least three stages of the four development stages that were conducted for the street. As shown in Fig. 5, it was found that the majority with 64.4% see the current fourth stage of the street, being one main divided street with multiple bridges, as the best stage for the street. On the other hand, the worst stage for street development from the majority's point of view was the third stage, which was one main divided street with a third undivided street in the middle for public transportation use only by 50%. This is a great indicator that current developments are consistent with the majority of the community's needs, never less putting into consideration that the sample majority are car drivers. Furthermore, it also reflects a need to enhance some strategies of the development process to increase the approval rate.

On the other hand, selecting the third stage as the worst only by 50% was lesser than expected. In a previous survey that was conducted in 2013 where more than 60 taxi drivers and a few residents were interviewed by the researcher over the period of one year. A single question was asked on how they preview the on-time development; the third stage. 100% objected to it and they were divided between turning the middle area into a parking area or widening the street. Additionally, some residents felt that there is an increased rate of accidents due to this development between vehicles and pedestrians especially at intersections. Fig. 6 demonstrates an example of a few accidents that occurred at the time.

Table 4. Study Sample Basic Information Classification [18].

	Percentage / Options							
Age Range	2.2%	Under 18	35.6%	18-40	58.9%	41-60	3.3%	Over 60
Status	18.9%	Direct Resident on the Street	46.6%	Nasr City Resident	16.7%	Continuous Visitor	17.8%	Irregular Visitor
Relation to the Street	81.1%	Car Driver	0%	Motorcycle & Bicycles User	13.3%	Public Transportation User	5.6%	Pedestrian
Street Development Stages Witnessing	1.1%	One Stage	11.1%	Two Stages	18.9%	Three Stages	68.9%	Four Stages

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Table 5. Best and worst development analysis [18].

Development Stages of the Street	Best Development	Worst Development
Stage One (One main divided Street, with metro in the middle and perpendicular intersections, with traffic lights.)	16.7 %	18.9 %
Stage Two (One main divided Street, with metro in the middle and U-turns, with traffic lights.)	7.8 %	12.2 %
Stage Three (One main divided Street, with a third undivided street in the middle, for public transportation.)	11.1 %	50 %
Stage Four (One main divided Street, with multiple bridges.)	64.4 %	18.9 %

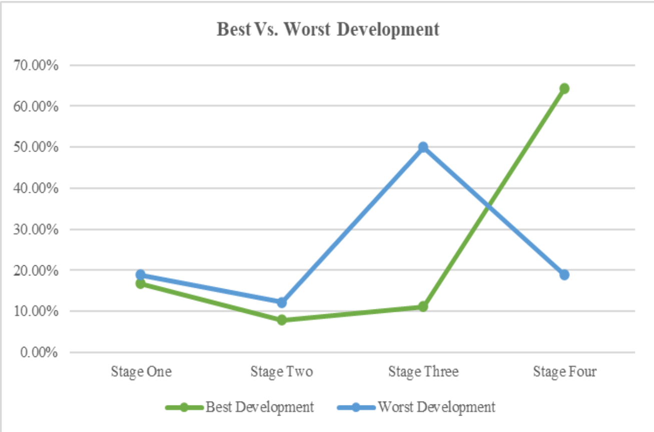

Figure 5. Shows the variations in the study sample opinions for the best and worst development of the street (By Author)

Figure 6. a), b), & c) An example of accidents at the time of the third stage development due to the transportation dedicated lane (third street), speed, and improper crossing behavior of vehicles in Mitwally El- Sharawy intersection [17] (15/10/2014, & 7/9/2017).

C. Latest Development Overall and Detailed Users' Analyses

When the sample was asked about their overall evaluation of the current fourth development of the street that the majority observed as the best stage, it was found that the overall percentage of success is 64.67%, which is consistent with the above-mentioned answer. As shown in Fig. 7, around 46% of the participants rated it between 4 (Very Good) and 5 (Distinctive), and around 21% rated it between 1 (Very bad) and 2 (Bad). Additionally, and as demonstrated in Table 6, the study sample was asked to detail their assessment of the street, in relation to four main users' categorizations; which are car drivers, public transportation, motorcycle and bicycle users, and finally pedestrian. As shown in Fig. 8, it is obvious that the study sample believes that the new development was best in achieving the car drivers' needs, with a 70% success rate, and worst for the pedestrian with a 46% success rate. The distribution is not homogeneous between the very bad and distinctive as it should be, in all categories except to some extent in the car users. Additionally, the average overall success rate for the detailed analyses shown in Table 5, was decreased by around 10% than the overall given rate in Fig. 8. Although it is a relatively high variation between the two ratios, it is acceptable, nevertheless, it reflects a need for enhancing the street on the detail level of the various categories.

D. Advantages and Disadvantages of Stage Four

In order to understand the problem on the detail level that appeared in the abovementioned section, the survey's participants were asked to state the current problems they observe in the El-Nahas axis. It was available to select more than one disadvantage according to their point of view. As demonstrated in Table 7, eight problems were agreed upon by at least 50% of the study sample. The number one problem was found to be the lack of plantation for both aesthetics and environmental values by 67.8%. This was followed by the lack of enough parking slots, the accidents caused due to the high speed, the design of U-turns and their few numbers that cause congestion, the no crossing points for the pedestrians, the lack of traffic signs for pedestrians, the sidewalk dimensions that are not suitable for the old and sick, and finally the lack of stations and waiting areas for public transportation. Additional problems were demonstrated also in Table 7 but with lesser ratios and thus importance and significance to the study sample.

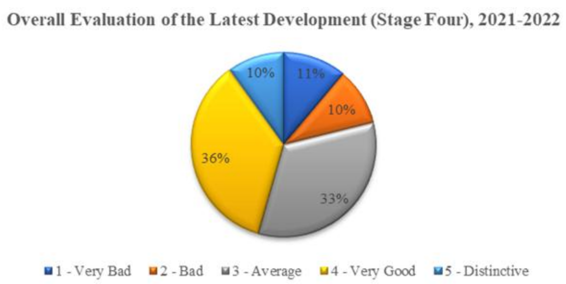

Figure 7. Shows the variations in the study sample opinions for the fourth stage development of the axis (By Author)

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Table 6. Detailed analysis results of the latest development in four categories [18].

Evaluation for the Latest development (stage four), 2021-2022	Very Bad (1)	Bad (2)	Average (3)	Very Good (4)	Distinctive (5)	Overall, Success Percentage
For car drivers' usage.	11.1%	5.6%	25.6%	40%	17.8%	**70%**
For public transportation users (stations/ stops/ waiting areas/ etc.)	18.9%	26.7%	28.9%	23.3%	2.2%	**53%**
For motorcycle & bicycle users (parks/ safe lanes/ etc.)	23.3%	23.3%	35.6%	13.3%	4.4%	**50%**
For pedestrian	36.7%	17.8%	27.8%	14.4%	3.3%	**46%**
Average	**22.50%**	**18.35%**	**29.48%**	**22.75%**	**6.93%**	**54.67%**

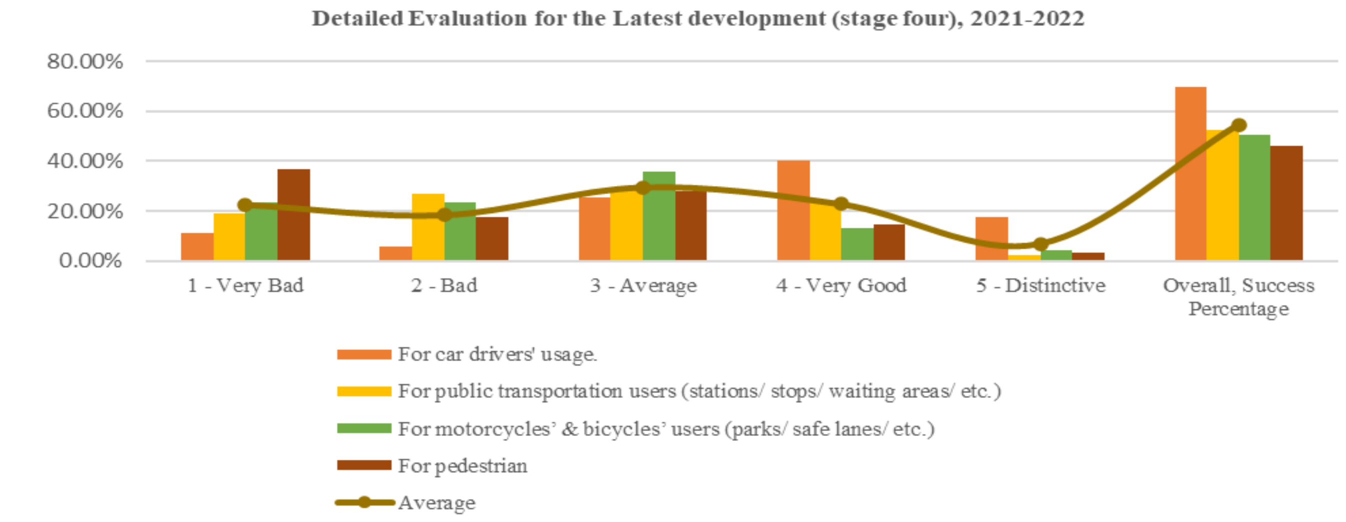

Figure 8. Shows the study sample evaluation in detail for four categorizations (By Author)

Table 7. Disadvantages/Problems in the fourth development, where the yellow color represents the most important according to the study sample and the gray is exempted [18].

Problems Offered by the Research for the Participants' Selection	Percentage	Rank
There is no plantation for both aesthetics and environmental values	67.80%	1
The available parking slots are not enough	60%	2
The high speed of the vehicles leads to accidents	58.90%	3
The U-turns are not enough and cause congestion	57.80%	4
There are no specified areas for pedestrians crossing the road	57.80%	5
There are no traffic signs for pedestrians	54.40%	6
The sidewalk dimensions are not suitable for old and sick people to use	52.20%	7
No stations and waiting areas for public transportation for people and to eliminate the sudden stopping	50%	8
No trash pins in the street	45.60%	9
There is not enough sidewalk area for pedestrians	41.10%	10
The water drains places are not suitable	34.40%	11
The design of the U-turn is not safe and causes accidents	33.30%	12
The street width is not suitable for residential area	30%	13
The traffic signs' location is not suitable	25.60%	14
The traffic signs are few	23.30%	15
Streetlights are not enough	22.20%	16
The street pavement needs enhancing	14.40%	17
There are no problems	1.10%	18
Problems Offered by the Study Sample	**Percentage**	**Rank**
The increase in the number of vehicles causes an increase in the street noise	1.10%	19
The bridges don't support pedestrians' safe movement	1.10%	20
The bridge inclination increases vehicles' speed and causes accidents since pedestrians cross the street from the start or the end of the bridge	1.10%	21
The street does not support cars or transportation	1.10%	22

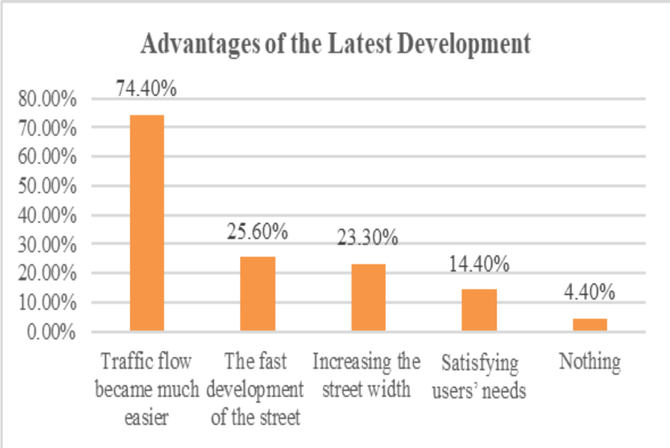

Figure 9. Advantages of the latest development percentages (By Author)

As for the advantages, four main advantages were mainly discussed by the study sample with various ratios. As shown in Fig. 9, they are that the traffic flow became much easier by 74.4%, the fast development of the street by 25.6%, increasing the street width by 23.3% and finally satisfying the users' needs by 14.4%. This reflects that the strategies created to achieve the main goal of the current development which was creating ease of flow in the street to better connect cities, decrease trip time, and reduce congestion have been effective and observed by the street users. However, it also demonstrates that the street's current width is not agreed upon by the study sample. When this is analyzed in relation to the stated problems, the reason could be due to pedestrian and/or parking problems.

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E. Accessibility and Design

Accessibility is defined as the ease of reaching different types of facilities by people in various locations, and with different methods of transport. Thus, the study sample was asked to evaluate the easiness of reaching the street from the main perpendicular streets such as; Youssef Abbas, El-Tyran, Abbas El-Akad, Makram Abeid, and Hassan El-Maemon streets. They were asked to consider factors such as easiness of traffic flow, U-turn locations, and numbers, Traffic signs, etc. They were also asked about their opinion on closing the end of Africa Street (End of Mostafa El-nahas – El-Taba area) as seen in Fig. 10, and making the U-turn from the Mitwally El- Sharawy Street intersection as shown in Fig. 11. Finally, they were asked to state how they view the crossing in Mitwally El-Sharawy Street that is used as the U-turn.

Figure 10. The end of Mostafa El-Nahas Street – El-Taba area. a) & b) Show some congestion in one of its two ways at certain times of the day. c) shows the curve design of the end (using an orange shape) that requires editing, since it causes congestion [16] & [17] (9/3/2023).

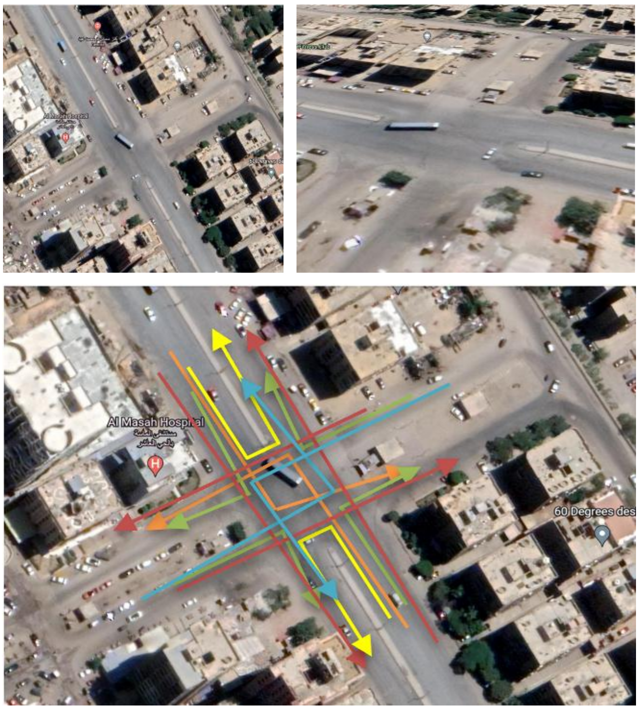
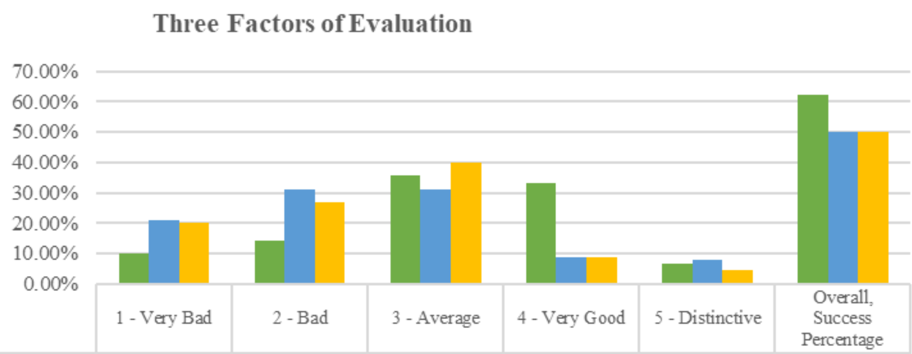


Figure 11. a) & b) The intersection for crossing in MitwallyEl-Sharawy Street and c) shows the vehicular conflict points at a typical four-way intersection [16] (Edited by the Author).

As shown in Fig. 12, the study sample considered that reaching the street from the other perpendicular main streets is successful by 62%, which reflects a slight problem in the numbers and locations of the U-turns in the perpendicular streets, that influenced the ease in accessing the street. This will be further discussed in the enhancement section. Additionally, some traffic signs' locations in the perpendicular streets also need to be located further in the street to allow a better flow of traffic. As illustrated in Fig. 13, the traffic signs are so close when turning to access the perpendicular streets, thus, when there is some traffic congestion, it affects the flow in the main street beside the bridge and simultaneously blocks the U-turning from under the bridge.



	1 - Very Bad	2 - Bad	3 - Average	4 - Very Good	5 - Distinctive	Overall, Success Percentage
Easiness in accessing	10.00%	14.40%	35.60%	33.30%	6.70%	62%
Closing affrica street	21.10%	31.10%	31.10%	8.90%	7.80%	50%
The Crossing of MitwallyEl- Sharawy street	20.00%	26.70%	40.00%	8.90%	4.40%	50%

Figure 12. The study sample evaluation in regard to the easiness of accessing the street, closing its end, and the crossing of Mitwally El-Sharawy Street (By Author)

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Figure 13. a) & b) the location of the traffic signs that decrease the level of easiness in accessing the axis [17] (26/4/2023).

In regard to closing the end of the axis, it had only a 50% success rate, which means the participants were displeased with it to some extent. This could be due to the long distance they have to cover for making a U-Turn which increases the trip time and consumes more fuel. Additionally, its curve design allowed wrong parking and/or waiting scenarios, especially from public transportation drivers such as toktoks and microbuses as shown in Fig. 14. Additionally, there is still congestion happening on one of the two ways; the way from Mitwally El-Sharawy Street to Mostafa El-Nahas axis at various times of the day as shown in Fig. 10 & Fig. 14.

Finally, again the sample gave a success rate of 50% for the crossing in Mitwally El- Sharawy Street, this could be due to the absence of a middle roundabout in the four intersections, with an absence of traffic signs as shown in Fig. 15, which led to accidents. However, while working on the research the local administration acknowledged the problem and first used fences as a roundabout, then totally closed the square and provided U-turns as shown in Fig. 16. This was a sufficient solution; however, it would have been preferable for residents and users to maintain the four-way intersection while creating a roundabout for rotating and U-turning while putting traffic signs and radars. In addition, opening a U-turn in the El-Taba area in order to decrease the trip distance will be needed. Especially, since the current U-turns are not leveled appropriately, causing some discomfort when used, however, they were perfectly located.

Figure 14. a), b), & c) End of Mostafa El-Nahas – El-Taba area at different timings and dates, showing various levels of traffic and unauthorized road occupancy [17] (6/5/2022,16/7/2022, & 12/2/2023).

Figure 15. a), b), & c) The four-way right-angled intersection in MitwallyEl- Sharawy street where vehicles cross without any order due to its open space design, and the absence of a roundabout, which led to many accidents [17] (6/5/2022 & 16/7/2022).

Figure 16. The official measures taken in rectifying the intersection problem were done on two levels. a) & b) it first used metal fences as a roundabout then c) closing the intersection totally and opening U-turns in other locations [17] (16/9/2022, 12/2/2023, & 12/2/2023).

F. Under Bridges Usage

Furthermore, the participants were asked how they want the areas under the bridges to be used. Surprisingly, 65.6% wanted it to turn into green areas, while 50% wanted it to be parking areas, and only 21.1% wanted it to turn into entertaining areas and cafes. Finally, only 7.8% wanted it to be public stations for transportation, and other options with lesser percentages were also mentioned in Table 8. As illustrated in Fig. 17, the development went for options two and three. Making these spaces parking areas is a great option since a significant part of the traffic is caused due to vehicles searching for parking slots. Nevertheless, putting in

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mind that lack of parking is also a measure for controlling car use, but when providing sufficient alternatives to car usage. This will improve the environmental quality and increase safety. However, it will aggravate users who need to park near their destination causing accessibility problems. Thus, off-street parking is usually best combined with sufficient on-street parking in a comprehensive development [1]. However, this means alternative measures still must be conducted to satisfy the majority's needs in providing green areas and landscapes.

G. Plantation and Recycling Wastes

The study sample was asked if they want to plant fruitful plants that can be eaten. As demonstrated in Fig. 18, around 57.8% agreed while only 21.1% refused. Also, they were asked about their opinion on developing a system for recycling waste management and 97.8% agreed on it. This reflects the public awareness of related environmental issues.

Table 8. Disadvantages/Problems in the fourth development [18].

Areas under bridges usage Offered by the study	Percentage	Rank
Green Areas	65.60%	1
Parking areas for cars and bicycles	50.00%	2
Entertaining areas and Cafes	21.10%	3
Stations for public transportation	7.80%	4
Areas under bridges usage added by the participants	**Percentage**	**Rank**
Planting fruits and vegetables and selling them	2.20%	1
Increasing greenery	1.10%	2
All the usage offered except the stations for public transport	1.10%	3
Dividing the usage since they are 4 bridges	1.10%	4

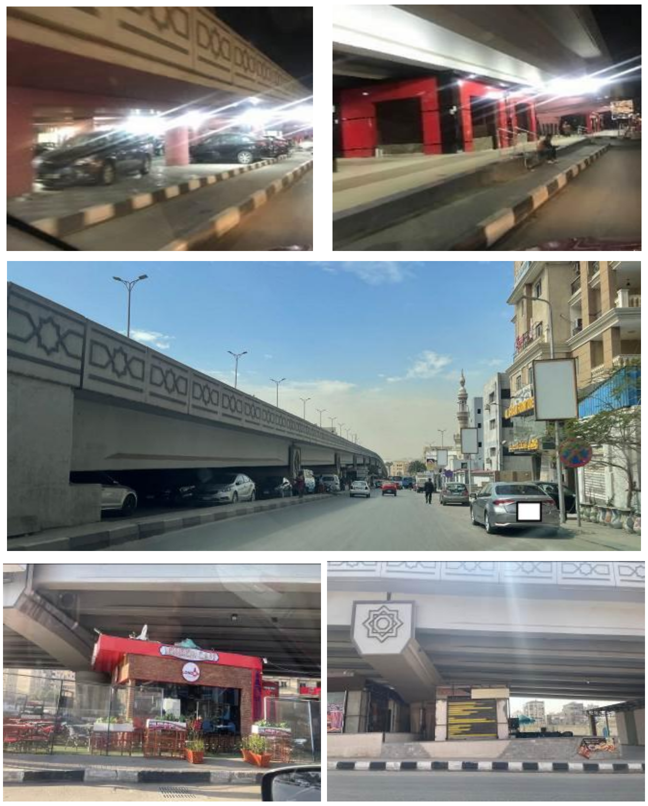

Figure 17. a), b), c), d), & e) Areas under bridges were used as parking and entertaining areas [17] (16/9/2022 & 9/3/2023).

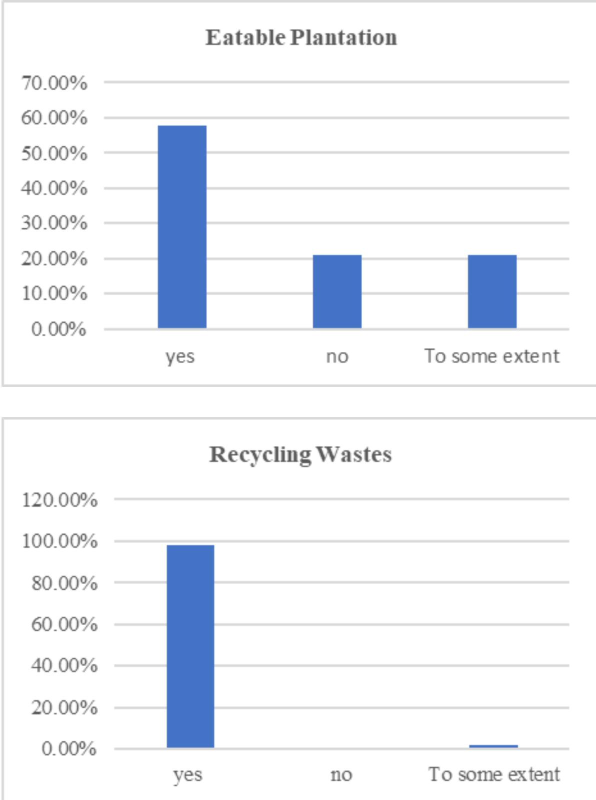

Figure 18. a) & b) the results of using eatable plants and recycling waste systems on the street (By Author)

H. Additional Feedback

In this part of the questionnaire, the study sample emphasized some opinions about what they wanted and sure they are relevant to the decrease in their satisfaction percentage. For example, they demanded that their opinion must be seriously listened to when any development is going to happen in their neighborhood. Additionally, they wanted to replant the areas that the trees were cut from and increase the plantation in various areas to decrease air temperature and increase aesthetics. Some stated the need for more street bumps while others expressed their annoyance with current speed bump locations, especially at night when the vision is not clear as shown in Fig. 27. c), while both wanted to put traffic signs to avoid accidents. Furthermore, some explained their refusal for turning the areas under the bridges into cafes because it increases the noise and causes congestion, so it is best to be parking areas or kids' areas, or open gyms. They also expressed the need to change the parking system in the streets from being parallel to being perpendicular to offer enough parking slots. This should be accompanied by the continuous maintenance of the street and sidewalks to preserve the current development. They also stated the need for creating lanes for bicycles and increasing the U-turns and making them safe. Others, expressed their current concern for pedestrians especially the old and children since the medians and sidewalk areas have been decreased or have unauthorized occupancies from the shops which lead pedestrians to walk on the street. And finally, they requested to add pedestrian signs for the safe crossing of the street that works on the request of the users.

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VI. Mostafa El-Nahas Axis Enhancement Solutions

In this part, the study will strive to illustrate some strategies and solutions for Mostafa El-Nahas Axis that can enhance its efficiency from the users' point of view to increase its livability and sustainability. Hence, the main top problems mentioned by the study sample will be discussed in this section while giving some alternative solutions.

A. Plantation & Landscape

Plantation and landscape of the streetscape are crucial factors in creating livable and sustainable streets. As demonstrated by the study sample they are much needed for their aesthetics and environmental values. Greenery can increase the aesthetics of the neighborhood, create various visual experiences for the residents and visitors in relation to the selected types, and give the district its character [3]. Additionally, they can provide shading [19], and food, regulate noise, be used for erosion-control purposes, and decrease carbon dioxide levels [3] since they act as fresh air generators [19]. However, the location and type of plantings [3], turf, shrubs, and trees [7], should be considered carefully, since plantings, especially in narrow medians, can cause maintenance activities problems [3]. Additionally, trees in the median can act as visual obstructions [3], if not carefully, located, especially when vehicle drivers turn, and mainly at intersections [7]. Therefore, in medians, all plantings and landscaping features must be obliging with the AASHTO Roadside Design Guide [3], since as mentioned they are considered roadside obstacles [7]. On the other hand, the landscape at the side of the road helps in improving how drivers behave and perceive their surroundings [20]. However, a study by Rehan in 2012, stated that the majority of Egyptian streets don't have attractive streetscapes, which has a negative impact on how people behave and the aesthetics of the built environment, degrading the image of most Egyptian cities [21]. Therefore, it is crucial that the primary responsibility of landscape and streetscape architects and developers is to aid in balancing functional, engineering, and safety standards and needs with aesthetic and environmental considerations [20].

Many solutions can be used in the El-Nahas axis to enhance its streetscapes, in regard to its plantations such as using green walls on bridges in addition to greening its medians and under bridges. Although this application is still not widely used, however, turning bridges into vertical walls can be an answer to the scarcity of space and the need for greenery in the streets. Various examples worldwide in France, India, Mexico, and Vancouver are shown in Fig. 19, where green walls are used on the bridge body or its pillars. Currently, Prefabricated Green Wall Structures that are easy to install are available with fabric grow pages and use a micro-irrigation system as illustrated in Fig. 20. Where micro-irrigation is a low-volume, low-pressure irrigation technique that can reduce the need for water, fertilizer, and labor [22].

Figure 19. a) At Aix-en-Provence, France, a living wall covers a bridge, which is considered an escape from the concrete jungle [23]

Figure 19. b) A vertical garden on the pillars at a bridge close to COEP in Pune, India [24], c) Bangalore, India, gets its first vertical garden on flyover pillars in an attempt to reduce pollution [25]

Figure 19. d) A busy highway in Mexico City has 1,000 pillars covered with vertical gardens and below bridges planting [26]

Figure 19. e) The biggest green wall in North America was finished in Vancouver, in Surrey British Columbia. It is a double-sided, 10,150 square-foot green wall made up of 50,000 individual plants, the majority of which are indigenous to British Columbia [27]

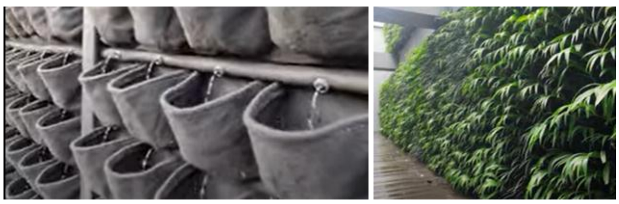

Figure 20. a) & b) Prefabricated Green Wall Structures and pages with a micro-irrigation system [28]

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Additionally planting the median of the street is a much-preferred solution as done in other streets in Nasr City, like the extension of Abbas El-Akad Street as shown in Fig. 31, or in a section of Dr. Abd Allah El-Araby Street and Dr. Abd El-Aziz El-Shennawy Street as illustrated in Fig. 21. Where when trees are unavailable, palms are planted in addition to strips of flower beds. Although, some will not consider their design as being the optimum, however, they made a step toward enhancing their street landscape.

As for the sidewalks, some parts of the axis currently have trees on them as shown in Fig. 22. However, a comprehensive streetscape design for the sidewalks is urgently needed. The Axis has an average sidewalk width of 4 m, and as illustrated in the guide for creating detailed plans by the Egyptian MHUUC, flower beds can be used on all sidewalk widths, while agriculture strips with widths from less than 60 cm to more than 90 cm must be on sidewalks from 1.5 m to 6m. As for shrubs and palms they can be used when the sidewalk width is between 1.5 m and 6 m, and finally, trees can only be used when the sidewalk width is between 3m to 6m [5]. Landscape designs, in general, should be conducted to allow for a clear and safe pedestrian walking experience and also facilitate maintenance activities, hence, a planted strip between the sidewalk and the traveled-way curb could be used of a minimum of 0.6 m in width [3]. Additionally, Plants must not be located in a position where they could block a sign. At crossroads, they must be chosen and maintained to allow for unobstructed viewing in all directions. And the mature height or spread of trees shouldn't be planted in areas where they would obstruct utilities or encroach on traffic lanes [20]. Finally, drought-tolerant plants are recommended for use in flower beds like Wedelia (sphagneticola trilobata) and Carpobrotus edulis [29] shown in Fig. 23, in addition to the Low water demand plants such as Dodonaea viscosa while using low flow irrigation system [9]. A proposal for a sector of street landscape enhancement solutions is presented in the study in Fig. 25.

Figure 21. a) & b) Some streets in Nasr City planted their medians and can be used in the El-Nahas Axis as well [17] (9/3/2023).

Figure 22. a) & b) Some parts of the street sidewalks with the landscape, however, it is not enough to give the street the required visual and environmental effect [17] (9/3/2023).

Figure 23. a) On the left, Sphagneticola Trilobata, and b) on the right, Carpobrotus Edulis examples of plants that can be used in flower beds and can work toward decreasing water needed for irrigation [30] & [31]

B. *Parking Slots*

To create a livable street, proper parking areas should be provided for both residents and users. This requires that adequate information should be available about the amount, location, and duration of parking to better manage the parking areas. The parking problem tends to come from the lack of off-street parking areas in many inner-city [1]. Although the current Mostafa El-Nahas development provided some areas under the bridges to be parking spaces, in addition to on-street parallel parking along most of the axis, the problem is still ongoing from the study sample's point of view. They expressed the continuous lack of enough parking slots. This led to illegal parking behavior on the street. This behavior was observed on some parts along the axis more than others. For example, in the first sector of the axis, Ali Amin Street, this behavior was lesser than in the second sector of the axis which is Mostafa El-Nahas Street. This was related to firstly the availability of more off-street parking areas as illustrated in Fig. 24, and secondly the type and number of commercial services and multi-use areas in the Ali Amin sector. Thirdly, it is also related to the buildings' height, layout design, and the number of units, since it affects the number of parking slots needed by the residents and their visitors. Fourthly, providing enough garages for residents to park and use.

This problem, the lack of enough parking slots, can be solved along the axis by ensuring firstly that all private parking areas and garages are used for that purpose and not turned into other functions, especially commercial ones. Where local government must enforce this through the law and issuing fines. Secondly, turning the parallel parking regulation into perpendicular or angled parking, especially where multi-functional activities are available; will increase the number of parking slots to be doubled. Thirdly, providing additional parking areas, maybe through turning all under-bridges areas into parking spaces and eliminating the cafes and shops, that require in themselves additional parking slots. This is crucial since providing additional parking areas contributes to economic enhancement by reducing the need to look for parking spaces [1]. Thus, the Egyptian guide for creating detailed plans demonstrated how to design the parking areas and calculate the parking numbers needed [5]. Generally, the on-street parking lanes

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are around 2.5 m in width, with a maximum width of around 3.1 m and a minimum of around 2.1 m [8]. Finally, Fig. 25 demonstrates the current in comparison to the proposed parking regulations for part of the axis, where there is an urgent need for more parking slots.

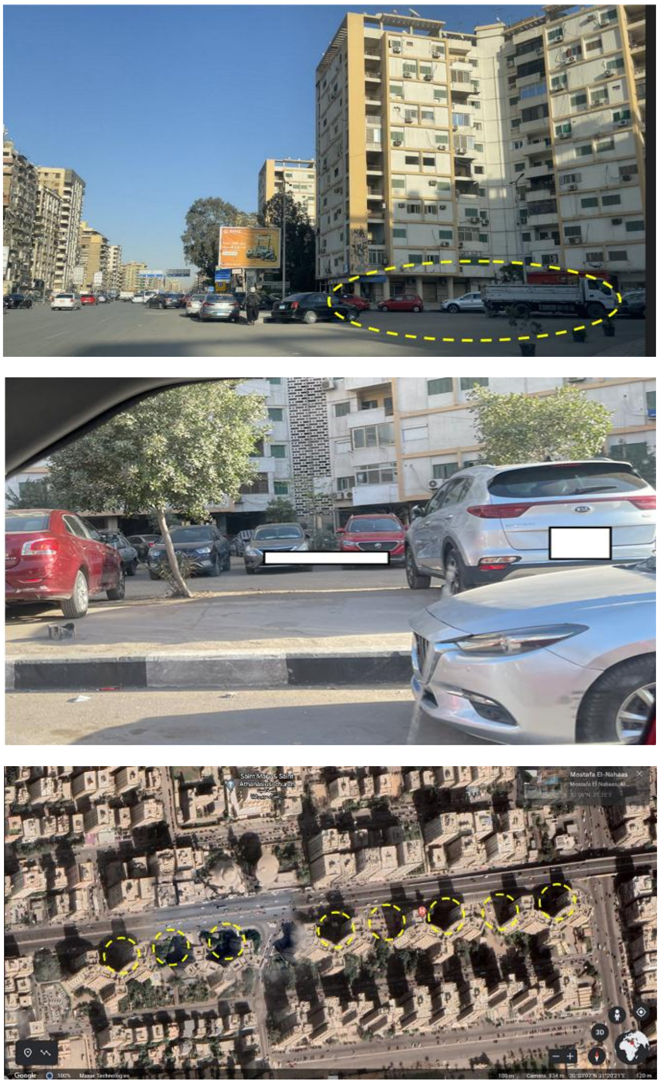

Figure 24. a), b), & c) Example of off-street parking areas along Ali Amin Street which led to lesser illegal parking behavior marked using yellow shapes in a) and c) [16] & [17] (9/3/2023).

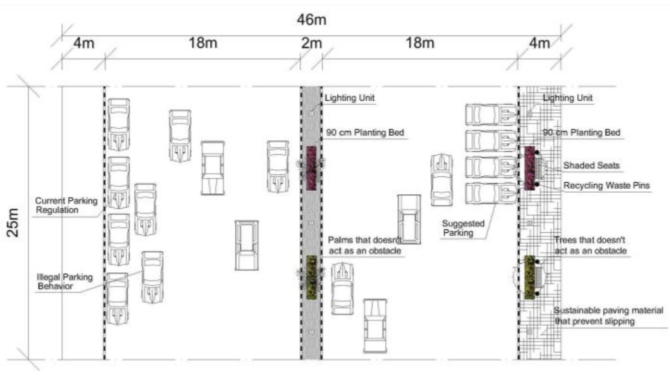

Figure 25. On the left current situation and on the right and the middle is the proposed one for the landscape and parking. It was made using mean dimensions calculated with the help of Google map scale and through actual measuring from the street

C. *Vehicles' Speed*

The latest development widened the axis to improve traffic flow and reduce congestion [1], and allow for shorter trips between cities. Unfortunately, this had its dark effect; which is speeding vehicles, especially since it is mainly a residential area. As shown in Fig. 26, accidents happened. Where, in Egypt in 2005, driver behavior accounted for 72% of accident causes, followed by the technical status of vehicles (22%), weather (4%), and road conditions (2%) [20]. This requires an urgent need for public education to change their attitudes [1]. Until that happens, local administration took charge and imposed firm speed control/reduction on the axis while working on the study. As demonstrated in Fig. 27, traffic signs, radars, cameras, and street bumps were used on the whole axis while specifying the speed to be 60 km/h. All necessary informative signs were used. This strategy had a fast effect on controlling the vehicles' speed, especially speeding cars. However, people felt constrained between the reached easiness of flow on the axis that allows them to use more speed effortlessly, and the specified street speed being only 60 km/h.

When analyzing street speed design, it was found that high-order streets which carry high volumes of traffic and/or accommodate high levels of economic activities have design speeds from 60 to 80 km/h which is the safe speed for vehicles. And the ceiling speed which is the speed near schools, old-age homes, etc. is from 50 to 60 km/h. On the other hand, middle-order streets which serve mainly as links between high and low-order streets have design speeds from 40 to 60 km/h and ceiling speeds from 30 to 50 km/h [8].

Furthermore, according to the Egyptian Code for Urban and Rural Roads Work in its third part about the Geometrical Design of the Roads [33], the main divided straight roads which carry high volumes of traffic [8], and all intersections are high-level have design speeds from 70 to 90 km/h [33]. While the Subsidiary divided straight roads which serve primarily as links [8] between main and local roads have design speeds from 50 to 70 km/h [33].

This clearly demonstrates that selecting 60 km/h is a logical speed for the Mostafa El-Nahas axis in spite of the objections. Since, although it is an essential main road, however, it is still in a residential area with mixed-use and commercial activities such as supermarkets, restaurants, a school, clinics, various shops, etc. Nevertheless, it could be studied to increase the speed to 70 km/h if efficient measures are taken to ensure pedestrians' safety and ease of movement.

Figure 26. a) & b) An example of accidents happened due to speed [32].

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Figure 27. a), b), & c) Photos show the various speed control measures taken on the axis in night view, where street bumps need to be more obvious maybe by using reflective color on them [17] (12/2/2023).

D. U-Turns

According to the study sample, the U-turn numbers are not enough and cause congestion, which will simultaneously increase the trip distances and in total increase fuel consumption which is not an aimed goal of Egypt's developments. When studying the U-turns problem, it was divided into firstly the ones on the El-Nahas axis and secondly, the ones on the perpendicular streets network to access the El-Nahas axis.

Firstly, in Mostafa El-Nahas Axis which now has 5 bridges, the best U-turn location is under the bridges which is the current case as shown in Fig. 28. It is wide enough and allows for vehicles' safe U-turning but shops under the bridges and lack of enough parking slots could lead to illegal parking behavior in the rotating space. This simultaneously can cause congestion and uneasiness when large vehicles or buses are U-turning. Thus, it is again not favored to turn under bridges into shops and cafes on this axis, at least without further analyses of their consequences on the street and its users.

Moreover, the distances between the bridges are different and concurrently are the consecutive U-turns distances. As shown in Fig. 29, the first part of the axis between the two bridges is around 1.095 Km, and the second part is divided into two parts by 3 bridges with around 0.741 Km and 1.079 Km for each, while the third part between 2 bridges is around 1.661 Km and 0.49 Km. This made it necessary that the longer section in part 3 of the axis provides an additional U-turn option. The best location in relation to street network planning and distance is identified in Fig. 29 by the red circles. This location was previously a four-way intersection that rarely caused congestion problems. Hence, it would be ideal to reopen the four-way intersection, with a roundabout and maintain using the control systems such as traffic signs, radars, cameras, and street bumps as shown in Fig. 30 - a). This solution will make the U-turning distances in this part to be 1.126 Km and 0.536 Km which is near the other distances numbers. The second-best solution is reopening it only for U-turning as demonstrated in Fig. 30 - b). And in that case, another more suitable location for only a U-turning is proposed using a green circle as shown in Fig. 29. This location provides at least two options that will allow for U-turning with an adequate distance division of about 0.7 Km as a minimum and 0.9 Km as a maximum for each section.

Figure 28. a) & b) Safe U-turning under the bridges while there is an unauthorized parking behavior near the shops [17] (9/3/2023 & 26/4/2023).

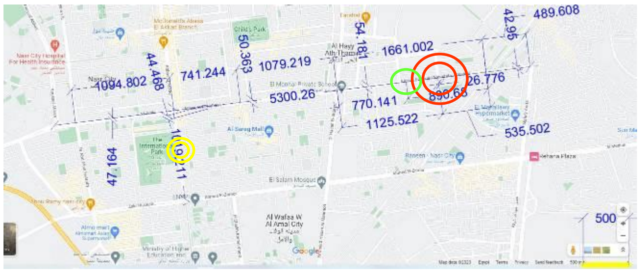

Figure 29. Approximate Dimensions in meters for Mostafa El-Nahas, and U-turns using Google Maps scale and the AutoCAD software. The location of the proposed U-turn opening on it in red and green while on Abbas extension is in yellow [11] (Edited by the Author)

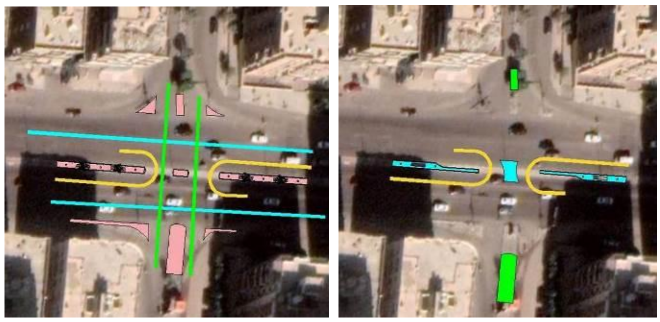

Figure 30. The two proposed solutions by the research; a) on the left is reopening a four-way intersection and b) on the right is opening just a U-turn [16] (Edited by the Author)

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Secondly, is the problem of the U-turns found in the perpendicular streets network to access Mostafa El-Nahas. For example, when studying Abbas El-Akad Street it was found that if a car user entered the street from El-Nasr Road he will find only two U-turns till he reaches its end at its intersection with Ahmed El-Zomor. And he can only use the last one to access the El-Nahas axis shown in Fig. 31. When calculating the distance from the El-Nahas axis to the U-turn, it was found that it is around 1 km, which seems appropriate relative to the above-mentioned distances. However, when realizing that the car driver has to take it going then come back to access the street, that makes the distance around 2 km which is a lot in inner cities. Hence, an intermediate U-turn has to be opened as proposed in Fig. 29 by the yellow circles. And although distances covered for U-turning in the El-Tyran extension (Dr. Abd Allah El-Hady), Makarm and Dr. Hassan El-Shareef Streets are not the main issues, congestion at them as shown in Fig. 32 is what necessitates the location of another U-turn before current ones if possible.

Medians are crucial for a variety of reasons, including separating opposing traffic, providing a recovery area for out-of-control vehicles, providing a stopping area in an emergency, reducing headlight glare, allowing space for speed changes and storing left- and U-turning vehicles, and providing width for future lanes. The possibility of open green space and the ability to manage the position of intersection traffic conflicts are two additional advantages of a median in an urban setting [3]. Additionally, U-turn lanes are used for safe and quick turning. It allows the maneuver to be made via the median. However, due to many circumstances, the median width is reduced. Thus, the design criteria must take into consideration the new limitations [34]. Therefore, great consideration must be given to designing U-turns and medians, and one of its safest design solutions with the current limitations is proposed in Fig. 30. b). However, in the future, it is recommended to not create medians in a street such as El-Nahas with less than 3 m in width, which is currently around 2 m, or its accessing roads to allow for safe U-turning unlike some cases now as shown in Fig. 33 that used movable metal fences to help in safe turning. The need for increasing the median dimensions will be further discussed in the pedestrians' next section.

Figure 31. The Extension of Abbas El-Akad Street with its only U-turn to access Mostafa El-Nahas Street [17] (9/3/2023).

Figure 32. Congestion due to U-turning in El-Tyran extension Street (Dr. Abd Allah El-Hady) [17] (9/3/2023).

Figure 33. Using movable metal fences to allow safe U-turning to El-Nahas Street from El-Tyran extension Street since the median design, and dimension are not adequate [17] (9/3/2023).

E. Pedestrians

According to a study on Egyptian urban communities, whether in inner cities or suburbs, pedestrians were found to prefer to travel along particular paths because of the presence of beautiful landscape characteristics. The findings also indicated that discomfort, a lack of safety, and an unappealing or boring landscape dissuade individuals from walking. Thus, intervention with creative ideas is needed to upgrade the state of the sidewalks [35] as previously discussed in the plantation and landscape section.

Additionally, pedestrians love to use the shortest path while feeling safe. Where they cannot walk over 1.5 km to work or over 1.0 km to take a bus, while almost 80% of their trips will be less than 1.0 km. Furthermore, they need median islands of enough width that act as a refuge when crossing. However, as abovementioned, economic considerations frequently restrict the available median width [3]. This may be why the study sample was displeased with the current development for not providing specified areas for pedestrians crossing the road with traffic signs and sufficient medians. This is a simple issue to solve if appropriate intervals of safe crossings at particular locations [3] are provided with a minimum of 4 m width [5]. Additionally, appropriate pedestrian traffic signs must be used that accommodate lower walking speeds people whether old or

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disabled, where a normal walking speed of 1.2 m/s is used in the Manual on Uniform Traffic Control Devices (MUTCD) [3]. Additionally, the Egyptian guide stated that the least minimum width of the median is 3.6 m for main and secondary arterial roads and 0.6 m for collector roads and bridges [5]. Another study stated that a median cannot be narrower than 3.0 m or it will not provide pedestrians with any sense of safety and security. Actually, a median lesser than 1.5 m in width is considered physically dangerous to pedestrians and must not be conducted when pedestrian traffic is encountered [8]. This means the current median in Mostafa El-Nahas with its almost 2 m in width needs to be increased to at least 3 m to sustain the multi-mixed functions on the street and accommodate the pedestrians, car drivers, and streetscape needs.

As for sidewalk widths, in residential areas in large cities, 2.4 m is considered an appropriate minimum width [3]. And as illustrated by the Egyptian guide, it varies from a minimum of 1.5 m to 2.5 m, with at least 3.5 m width in a commercial area [5]. Where they should be designed to accommodate enough space for walking pedestrians, landscape design and aesthetic vegetation, building entrances, street hardware, public transportation stops, and waiting areas, enough storage area for pedestrians waiting to cross, to serve as a buffer strip, and to accommodate persons with disabilities [3]. The current sidewalk width of El-Nahas Street is not consistent along the whole axis, however, when measured in various areas it exceeded 3.5 m with an approximate 4 m in the measured area. This is considered an appropriate dimension; however, the local authority must ensure there are no occupations and encroachments on the sidewalk that prevent its appropriate use by pedestrians. Moreover, an anti-slip material with a rough texture should be used to finish the walking surface while providing maintenance for the needed parts to facilitate walkability as illustrated in Fig. 34 [19]. Finally, CamToPlan mobile application was used for median and sidewalk measuring.

As for the curbs, they should be no more than 15 cm in height [5]. The study sample considered the current sidewalk dimensions are not suitable for old and sick people to use and that is because when measured they ranged from 20 to 22 cm as shown in Fig. 34. Yes, it is understandable that the higher the pedestrian path the more sense of security the pedestrians will have, for being more distant from the vehicle path. Nonetheless, that height should not exceed the human capacity for vertical movement [19]. Hence, this needs urgent measures in future developments, however, currently redesigning where pedestrians will use the curbs while moving is a must, by providing ramps and steps.

Safety is a must for pedestrians, and one of its factors is providing adequate lighting. Simultaneously, it is crucial to decrease the amount of electricity used for street lighting. Both can be achieved by utilizing the ideal combination of photovoltaic, and high-efficiency LED which will provide economic and environmental benefits. Additionally, solar trees that resemble a typical tree but have glass photovoltaic panels in the shape of branches and tiers that may be positioned to offer shade as well as shown in Fig. 35 are another great option to use.

Figure 34. a), b), c), & d) Sidewalks and curbs various photos showing their current state, height, finishes, and unauthorized occupations marked using yellow shapes [17] (26/4/2023).

Figure 35. a), b), c), & d) Various examples of solar trees used in the streets [37] & [38]

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Solar trees, not only provide sustainable lighting, and give a distinctive character to the city, but they also can provide more covered spaces for pedestrians, leading to less exposure to dangerous UV rays and allowing people to spend more time outside while feeling more comfortable [36]. Finally, the municipality of cities, especially in developed nations, must give significant attention to identifying the criteria for developing walkable urban settings for pedestrians [19].

F. Public Transportation

The lack of stations and waiting areas for public transportation for people to use and the sudden stopping of public transportation is how the study sample perceived the current state of El-Nahas Street. This will lead to congestion and accidents for cars and public transportation users. When analyzing the street, this was discovered to be a fact, where almost few bus-stops with a waiting area were located in a sector of the axis from old development and not the latest one as shown in Fig. 36. They are also aesthetically not fulfilling, thus need further development in number and design. Again, local authorities have to take fast action toward this to enhance the state and use of public transportation. Where bus stops should typically be 300–500 meters apart in metropolitan settings, and they should ideally be no farther than a five-minute walk from any given residence in a residential area [1]. It is also important to take into account where to locate bus loading and unloading areas, taxi stops, and parking spaces designated for people with disabilities [3].

Figure 36. A bus stop is currently found in part of the street from the third development stage [17] (9/3/2023).

For example, currently, the loading and unloading of buses and micro-buses could take place at the beginning or end of the bridges. Or they could obstruct vehicles from entering adjacent streets. Additionally, buses and/or trucks should travel in the adjacent lanes [8], which is not the current case. All of these problems could be eliminated and solved if local authorities apply a comprehensive public transportation plan. In this plan, whether it is for a new street or improvements to existing ones, it should not be based on current traffic volumes only, public transportation included, but also on future estimated traffic volumes, especially for the geometric design. Since streets are intended to accommodate the traffic flow that is likely to happen within the design life [3].

Finally, when comparing this development with the third stage development that was considered generally the worst, however, it succeeded along the dimension of public transportation strategies since it focused solely on enhancing them along the axis. The concept of this development was about providing dedicated lanes for public transportation such as buses, mini-buses, and micro-buses only. Additionally, it provided stops with shaded waiting areas for users along the axis. Although they were not aesthetically fulfilling, however, they succeeded functionally as shown in Fig. 37. These strategies were abounded by the latest development up till now. However, the third stage of development failed greatly in decreasing congestion as shown in Fig. 38 which is a succeeding aim in the current development.

Figure 37. a) & b) Bus stop shaded area examples at the third development stage [17] (11/11/2014 & 11/8/2016).

Figure 38. a), b), & c) Examples of congestion during the third stage development at various times [17] (11/9/2014, 28/9/2014, & 15/10/2014).

VII. CONCLUSION

One of Egypt's agendas during the past years has been developing a strong streets network, that decreases congestion, better links the cities; old and new, and hence, improves the country's economics. Simultaneously, decreasing congestion reduces the levels of vehicle emissions and their contribution to global warming that is endangering the planet. And, the goal of the study was to work in accordance with this agenda to ensure the development of sustainable livable streets in Egypt. This was

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achieved throughout analyzing one of the currently developed streets and understanding its level of achievement and how it can be enhanced sustainability and be more livable.

It was found that in order to create sustainable livable streets some general design requirements and planning guidelines must be followed for the streets and their sidewalks. The research divided those requirements into three categories that include car users, pedestrians, bicycles, and public transport users, whether they were residents or visitors. In addition to demonstrating the sustainable and economic demands for both the roads and their sidewalks in two separate categories. The requirements could seem many but they were simple and some can satisfy more than one need. And thus, can turn the image of the cities greatly; functionally, environmentally, economically, and aesthetically as well.

And since public participation became a must in any successful development. It was even included as part of the process in the Egyptian guide for creating detailed plans, in its latest version in 2018. Thus, the research preferred to analyze the street under study throughout users' feedback. Where public opinions were assessed by conducting a questionnaire in 2022. During working on collecting answers to the questionnaire, it was observed that whenever the percentage of residents who participated changed in relation to visitors, there was a clear variation in the results. Thus, in future studies, it is advised to create separate questionnaires for each category to analyze their feedback.

The research selected Mostafa El-Nahas Axis in Nasr City, Cairo, Egypt, which was newly developed in 2020, as the research case study. This is a very important road in the area and to the research for multiple reasons that were discussed. The most important one is that this axis previously had one of the most sustainable public transportation methods which is the tram. Where worldwide, environmentalists are trying to encourage such methods of transport and not eliminate them. However, at these stages of street life, congestion has been a major problem, especially with the increase in Nasr City's population and becoming a portal to New Cairo and beyond. However, when the tram was eliminated and the street was developed to have dedicated lanes for public transportation as a two-way undivided street in the middle of the main street, it was considered by the public as the worst development stage the street faced, where around 50% of the study sample supported that opinion. That is because this stage only focused on the public transportation category, neglecting both car drivers and pedestrians' needs. Thus, traffic congestion maintained being a problem with an obviously increased level of accidents, for vehicles and pedestrians.

On the other hand, the latest development stage under study now was considered the best by the majority, 64.4%, of the study sample, which was very optimistic, that developers are going on the right track to provide what the public needs. The questionnaire results showed their approval of the latest development with 64.67% for the overall street percentage of success. Where 74.4%, of the sample, felt the easiness in the traffic flow that occurred. These numbers could be viewed by some as only sufficient but not enough. However, the research observes them as promising and can be easily increased to more than 90% if some enhancement solutions are conducted on the street.

When analyzing the study sample feedback about the current advantages and disadvantages and what they see as needed in their additional feedback, it was concluded that the current problems are on the detail levels of the street, mainly for pedestrians followed by public transportation users. Since when they evaluated the latest development in relation to four detailed categorizations; the car drivers' category success was evaluated by 70%, public transportation users by 53%, motorcycle & bicycle users by 50%, and finally pedestrians by 46%. Additionally, there was a major aesthetic and environmental problem observed due to the lack of adequate landscape and plantation.

Therefore, the main problems viewed by not less than 50% of the study sample were discussed, and some strategies were offered, in order to increase their approval level. Not only that but these solutions will definitely turn the conducted street development into being more sustainable and livable development. Yes, it might not deal with all the parameters in the proposed guidelines in the first part of the research, but they are very effective and crucial ones. And they can be a step towards more sustainable streets and cities in Egypt. The main enhancement categorizations that were found and discussed are; Plantation and Landscape, Parking Slots, Vehicles' Speed, U-Turns, Pedestrians, and Public Transportation. The overall proposed solutions were:

- Planting sufficient and efficient landscape and greenery on the axis medians, sidewalks, and under-bridges for functional, aesthetical, and environmental needs. It is also advised to use drought-tolerant plants like Wedelia, Carpobrotus edulis, etc. in order to decrease water consumption while using a low-flow irrigation system. Additionally, it is proposed to use Vertical green walls on the bridges as the case in some bridges in France, India, Mexico, and Vancouver.
- Providing enough on-street and off-street parking slots to eliminate illegal parking behavior and decrease unnecessary trips. That can be achieved throughout changing the current parking regulation from being parallel to angled or perpendicular. And transferring all under-bridges areas for parking and eliminating the cafes there. Additionally, the local government must ensure that all private garages are not used for any other functions, especially commercial.
- Controlling vehicles' speed to prevent accidents, nevertheless, at the same time not hinders car users. That was achieved by using traffic signs, radars, cameras, and street bumps. However, the location of some radars and cameras can be altered and street bumps can be made more obvious at night. It is also advised to conduct a study on the appropriate design speed that can be used and whether or not it can be increased, but after implementing some measurements to ensure pedestrians' safety and walkability in the street.

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- Designing U-Turns that are sufficient in number and allow safe rotating to prevent congestion as illustrated in Fig. 30 and create adequate trip length. This can be achieved throughout increasing the median width by a minimum of 3 m. And ensuring that the U-turning does not exceed a certain trip distance.
- Creating a livable pedestrian experience, with a special focus on medians and sidewalks dimensions and finishings to allow safe and enjoyable walkability. Additionally, safe crossing and movement plans from one point to the other must be developed using pedestrian traffic signs, solar trees, etc. in adequate positions. Moreover, curbs' height must be decreased to reach 15 cm to be comfortable in use, especially for the old and handicapped.
- Developing public transportation plan that sustains locating public transportation stops, taxi stops, shaded waiting areas, etc. Stops must be placed within specified intervals and not be an obstacle to buildings entrances and pedestrians' walking lanes.

Furthermore, the study agreed on planting fruitful plants that can be eaten on the streets by around 57.8%, while only 21.1% refused. And in a world that is going for self-sufficient buildings, and even cities, and where there is a food problem, this is an approach that needs to be considered carefully and encouraged by local governments, especially in developed countries. Additionally, they agreed on using a system for recycling waste management by 97.8%. This reflects the public awareness of related environmental issues, which needs to be encouraged by the government and private sectors by supplying the needed tools and equipment to facilitate waste recycling.

Finally, to create sustainable streets, they must be made to last for around 100 years with pavement structures from 20 to 30 years, with appropriate maintenance. However, that was not the state of street development in Egypt. For example, El-Nahas Axis was developed many times in a very short period, around 30 years. This is considered a real waste of resources, time, and money. Thus, the local government must work on solving this issue by studying its multiple reasons and eliminating them, to go toward creating sustainable streets.

VIII. Recommendations

- Developers and local authorities must start to consider seriously the needs of the environment, pedestrians, and public transportation users in any future street development if they want to satisfy the public and the sustainable streets goals.
- Although the current developments in Egypt seem to adopt the notion of closing intersections and converting them into U-turns, however, local government and developers must realize that two- and four-way intersections could be more beneficial and appropriate in certain cases. Thus, it is recommended to use an integration of both in the country's development agenda depending on the most efficient for the street under development and not as an overall strategy for all and every street. This, in addition to controlling wrong users' behaviors by applying firm regulations and fines.
- The Egyptian Ministry of Housing, Utilities, and Urban Communities (MHUUC) has to create an updated version of the guide for creating detailed plans, with its latest version in 2018, and sustain more local and international new developments' standards, especially on the level of the details. Since there is an emerging need for national standards in some areas, such as some needed dimensions and numbers when designing U-turns for example. It could also be more comprehensive by implementing and upgrading some factors found in the Egyptian Code for Urban and Rural Roads Work in its third part about the Geometrical Design of the Roads with its latest version in 2008.
- The local government has to make working with this guide mandatory, for public and private sectors.

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