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Green Urban Design: A Practical Approach for Enhancing Urban Areas

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Abstract

The challenges of Egypt's urban areas require new innovative solutions to deal with their rapid growth, inefficient land use and environmental degradation. In this paper, Green Urban Design (GUD) is considered as a comprehensive framework that merges urban design with landscape architecture to promote sustainability, green infrastructure, and socio-cultural inclusivity. The Green Urban Design Approach (GUDA) integrates compact planning, sustainable mobility, and climate adaptive strategies. It aims to create better urban environments by means of ecological, social, and spatial dimensions in a combined approach, To develop this approach, a structured methodology was adopted, consisting of three major stages: a theoretical study, an analytical study, and a practical study through assessment of Heliopolis and Al-Jasmin Neighbourhoods in Egypt, analysis and findings suggest GUDA's capacity to increase liveability, lower environmental footprint and promote cohesive integrated green urban development as a scalable model for greener, healthier urban areas in line with global sustainability goals.

Keywords: Climate adaptation, Green Urban Design, Landscape Architecture, Sustainability, Urban areas, Urban Development.

1. Introduction

Egypt encounters various challenges within its urban environment, like concentrated mobility, inadequate transport systems and abandoned infrastructure which have resulted as issues through urbanization. Also, Egyptian urban areas are noted to have informal settlements, which lack minimum facilities, services and planning [1]; alongside urban sprawl, a lack of effective sewerage systems, and a lack of green spaces, which all impair the performance of the urban areas and make them weaker and less resilient [2].

In addition, ecosystems are also subjected to significant stress. Urbanization leads to loss of land for agriculture, threatening food security [3]. Inadequacies in waste management combined with water scarcity and pollution being the world's worst for particulate matter reduce ecological well-being as well as initiatives toward sustainability [4], [5]. Besides, the high-density urban zones and slums create urban social problems because the residents experience economic inequality in addition to poorer access to the basic services. This causes the quality of life (QL) to decline and improve economic inequalities among the residents [6]. Moreover, to develop social relations within the community, the lack of public places and stakeholder engagement are ongoing problems, even though inadequate or improper maintenance of facilities becomes an obstacle to community unity [7].

This research considers the efforts made to break such challenges, the interventions that have been done on the ground, and the outcomes that have resulted. It also emphasizes the ongoing need for context-based and innovative solutions capable of breaking down embedded constraints. Based on the integration of landscape and urban design principles, the study emphasizes the possibilities of having greener, inclusive, and sustainable urban areas. These efforts not only meet present demands but also future ones.

2. Materials and Methods

A qualitative and comparative research method was adopted, combining theoretical analysis, case study research, and evaluation of international and national benchmarks. The method investigates the integration of urban and landscape design, examines international case studies, and applies the proposed framework to local case studies.

● **Stage One: Theoretical Study:** The stage was a literature review in order to establish a base knowledge of principles, elements, and processes of green urban and landscape design. With emphasis with their integration through green urbanism. Historical evolution of Egyptian cities was also researched to identify dominant challenges and gaps.

● **Stage Two: Analytical Study:** This phase studied international case studies to establish the best practices of green urban design. Green urban design strategies were also compared with international and local benchmarks to find a baseline for evaluating their effect.

● **Stage Three: Practical Study:** Applied the proposed framework in practice with local case studies (Heliopolis and Al Jasmin), to identify the usability of the framework in the Egyptian context. The process identified the usability of the framework, uncovered its weaknesses, and presented recommendations. In addition, the Z-Score method was employed to statistically audit the results and objectively analyse the data, thereby possessing a balanced and quantitative assessment of the framework's performance.

3. Disconnection Between Urban and Landscape Design in Egypt

Egypt's urban areas demonstrate a fragmented relationship between landscape and urban design disciplines. Over the years, various initiatives have been undertaken to shape urban development, from decentralization through the new cities like New Administrative Capital and 6th of October City [8]; informal settlements' upgrading like Manshiyat Naser [9]; increasing mobility through projects like Cairo Metro expansion, Monorail and Rod El Farag Axis [10]; and housing projects like Dar Misr and Asmarat [11,12]. In parallel, landscape works have progressed independently, for example, green infrastructure in the Green River project, green buildings in New Alamein [8,13], sustainable water management in riverfront developments and in the 1.5 million Feddan project, and desert greenery through xeriscaping in New Alamein [14], and public parks developments like Al-Azhar Park [15].

Despite these efforts, there is still a clear disconnect between urban and landscape design across the planning and implementation phases. This results in spatial discontinuity, weakened environmental performance, and lost opportunities for creating cohesive, livable urban areas. Figure 1 illustrates the separate paths of both design processes, showing the lack of integration or collaboration between them.

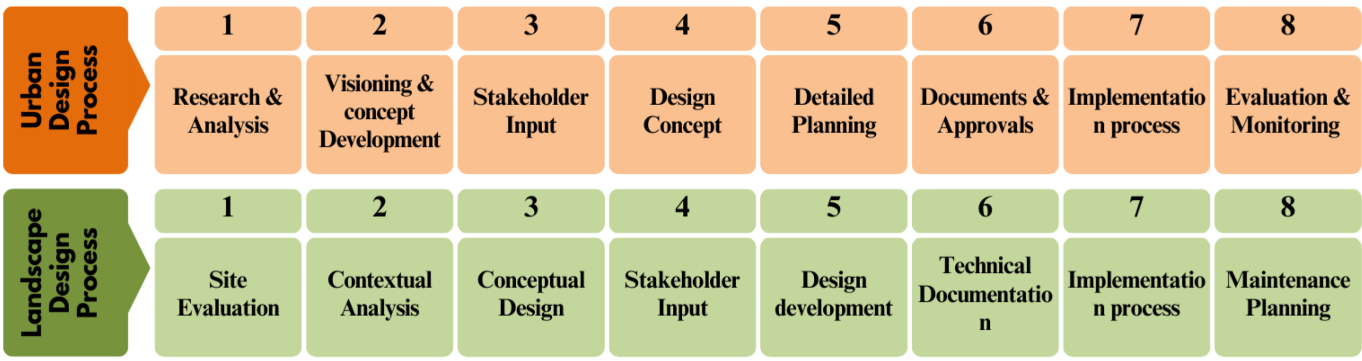


Fig. 1: Urban and Landscape Design Process in Egypt.
Source: Authors based on [8:10, 12:14].

4. Pathways to Urban–Landscape Integration

Achieving better urban areas calls for integrating landscape and urban design, which raises two important questions: what and how to integrate? The next section provides answers to both questions: it addresses "**how**" by examining Green Urbanism principles as a framework for integration, and it investigates "**what**" by identifying the quantifiable physical elements of urban and landscape design that act as tangible indicators for implementation.

4. 1 How: Green Urbanism as an Innovative approach:

Green Urbanism is the paradigm that combines urban and landscape design strategies to create compatible urban form. Developed in the early 1990s [16], it aimed to revitalize post-industrial urban cores as compact, sustainable environments. This paradigm focuses on the mitigation of greenhouse gas emissions, biodiversity, resource efficiency, and ecosystem resilience This helps solving problems of sustainability, climate change, and encouraging sustainable transport. Hence, compact city development, utilization of renewable resources, and green spaces upgrading contribute to ecological and human well-being [17,18] Besides theory, green urbanism also combines urban planners, landscape architects, and environmental scientists in an interdisciplinary manner. It unifies green infrastructure with less waste, energy, and water usage [18], ultimately bringing together environmental, social, and economic aims for sustainable, resilient cities [19].

4.1.1. Pillars and Principles of Green Urbanism:

Traditionally, green urbanism is structured around three core Pillars (Energy and Materials, Water and Biodiversity, Planning and Transportation) and a fourth one is introduced recently (Socio-cultural) to address new design challenges [20]. These pillars aim to promote healthy, Green and sustainable urban environments by combining ecological, social, structural and economic dimensions.
In this study, I have redefined and expanded these categories into six distinct classifications which closely fit the special context and challenges of Egypt. The revised framework and its guiding principles are presented as follows:

Fig. 2: Pillars and Principles of Green Urbanism
Source: Authors based on [16, 17, 19, 20].

A. Sustainable Urban Planning: The focus of this pillar is on creating efficient and context sensitive urban environments. Its main objectives are maximizing density, retrofitting existing districts, and climate adaptation. Rapid urbanization challenges are addressed by special strategies tailored for developing cities [16]. Key principles include:

- **Density and Retrofitting:** Optimizing density and retrofitting infrastructure for resilience and efficiency help to reduce sprawl [16,21].
- **Climate and Context:** Passive strategies, such as solar design and natural ventilation, should be used to design urban spaces that adapt to local climates [22].
- **Livability and Health:** Create mixed use urban areas which combine housing, commerce and recreation [22].
- **Special Strategies for Developing Cities**: Strategies put into practice that foster fair growth and local employment opportunities creation [16].

B. Transportation & Networks: This pillar encourages sustainable mobility and public spaces. In order to reduce emissions and improve urban livability, it promotes walking, cycling and public transport [23], Key principles include:

- **Sustainable Transport:** Build effective public transportation hubs and networks, and bikeway infrastructure [16].
- **Public Spaces:** Pedestrian friendly zones and vibrant communal areas developed as conducive to facilitate social interaction and heightening of the community bond [16].

C. Infrastructure: Sustainable infrastructure development in this category is promoted by resource efficiency and integration with renewable energy. The essence of this is to minimize the environmental impact through innovative technological solutions [24]. Key principles include:

- **Zero Waste Concept:** Waste reduction, recycling and composting methods must be adopted according to circular economy principles [16].
- **Local Materials:** Locally sourced, low energy materials are used to minimize environmental footprint [16,24].
- **Renewable Energy:** implementation of solar power and wind energy and decentralized energy systems will lead to zero $CO2$ emissions [24].

D. Socio-Cultural: This pillar focuses on social inclusion, cultural preservation and community well-being. It seeks to establish the livable, healthy urban environment, which considers the cultural heritage [16,24]. Key principles include:

- **Cultural Heritage:** Promote local identity and preserve historical sites [24].
- **Governance and Leadership:** The establishment of inclusive policies and stakeholder's engagement leads to effective leadership [22].
- **Education and Research:** Allocate resources to trainings and research initiatives to improve people's awareness about the sustainability practices [16].
- **Local Food Systems:** To secure food availability and decrease ecological impacts the implementation of urban agricultural activities combined with local food distribution networks should be supported [16].

E. Water and Biodiversity: This pillar gives a focus on water management that is efficient, and biodiversity conservation efforts. The purpose is to support natural ecosystems as well as urban resilience [23,24]. Key principles include:

- **Water Management:** Adopt technologies such as rainwater harvesting, greywater reuse, and stormwater capture systems [24].

F. Resilient, Climate-Adaptive Design In this pillar the urban areas have the guarantee that they will be ready to respond to future environmental problems and will be able to withstand climate change. Biodiversity and green architecture are incorporated to urban planning techniques [16,22]. Key principles include:

- **Green Buildings and Districts:** Build using energy efficient building techniques, natural lighting and ventilation [16].
- **Landscape, Gardens, and Biodiversity:** The development of urban green areas, In order to enhance recreation, biodiversity protection and air quality [22].

4. 2 What: Elements Shaping a Better Urban Areas:

Converting visions into action requires specifying measurable elements of landscape and urban design. These physical parameters are required to facilitate systematic evaluation and successful integration into sustainable environments [25]. The necessity of isolating and defining the important measurable elements thus ensued in establishing the Green Urban Design Approach (GUDA) for the Egyptian context.

Physical and measurable features through urban design parameters shape the functional and spatial city structure. Parameters include **building metrics** (walls, facades, orientation, height, roofs), **street geometry**

(hierarchy, width, sidewalks, cycle tracks), **public realm** (public squares, pocket parks, shared streets), and **land use patterns** (density, mixed-use ratio, urban block parameters) [25, 26, 27].
Landscape design elements introduce ecological and climatic services for urban areas via measurable parameters. They include **vegetation systems** (canopy tree cover, diversity of plant species), **water features** (bioswales, ponds, irrigation), **habitat corridors**, **landform alteration** (hills, slopes), **soil treatments**, and **green features** (green roofs, windbreaks) [27].

4. 3 Practices to better Egyptian urban areas:

The following table summarizes how these elements can be strategically integrated through Green Urbanism approaches to tackle critical urban challenges in Egypt.

Table 1: Practices to better Egyptian urban areas.
Source: authors based on [8,10:12,16:19,44]

Egyptian Challenges	Green urbanism Strategies	Urban Design Element	Landscape Design Element
Sustainable Urban Planning and design			
-Rapid Urbanization -Inefficient Land Use - Urban Sprawl	Compact Urban Areas	Urban Layout	Green Spaces, Parks
	Promote Mixed-Use Development	Flexible Building Designs	Green Courtyards
		Walkable Sidewalks	Green Spaces and Corridors
	Green Urban Layouts	Public squares, Plazas	Soft scaping, Plantings
		Railways, Transportations Routes	Green corridors and Pocket parks
		Internal courtyards & atriums	Plants and water features
		Land-use planning process	Urban tree canopies
Sustainable Transportation and Networks			
- Traffic Congestion - High CO_2 Emissions - Lack of Public Transport	Permeable Networks	Street patterns and interconnected pathways	Street trees, plantings
	Enhance Green Public Transport	Public transport hubs and pedestrian access	Shaded areas, vegetation in and around hubs
	Create Walkable Streets	Pedestrian-friendly sidewalks and bike lanes	Shade-providing trees, green buffers
Infrastructure Development			
-Air Quality - Lack of Green Spaces - Stormwater Management	Green Infrastructure	Roofs, Walls, Facades	Native Plants, Vegetation Patches and Rain gardens
		Permeable Pavements	
	Waste Management Systems	Recycling stations	Composting Areas and Green buffers
		waste collection points	
Socio-cultural Development			
-Environmental Awareness - Social Inequality - Public Participation	Engage Communities	Participatory public spaces	Green spaces and garden elements
		Local engagement spaces	
	Provide Affordable Housing	Inclusive housing developments	Shared green courtyards, community parks
Water Management Efficiency and Biodiversity			
- Water Scarcity - Flooding - Poor Water Management	Conserve Water Smartly	Rainwater harvesting systems, efficient irrigation	Xeriscaping, drought-tolerant plants
	Flood-Resilient Spaces	Permeable pavements, flood zoning	Retention ponds, constructed wetlands
	Biodiversity Conservation	planning and zoning Process	Natural habitats and green belts
Resilient and Climate adaptive Design			
- Extreme Heat - Urban Heat Island Effect - Climate Change	Passive Cooling	Wind catchers	Shading structures, vegetation
		Buildings Orientation	
		Naturally ventilated buildings	
	Establish Ecological Corridors	Urban ecological networks	Native vegetation, biodiversity pathways
	Reduce Heat Islands	Cool and Shaded pavements, Roofs	Shade-providing trees, green roofs

Through an enhanced knowledge of the concepts, pillars, and strategies of Green Urbanism, it is revealed how it could be employed to address Egypt's urban issues. The successful execution of urban and landscape design dimensions, buttressed by these strategies, is what makes sustainable solutions feasible. The next section summarizes contemporary evaluation frameworks, defines their limitations, and proposes a complete framework of the Green Urban Design Approach (GUDA) specific for the Egyptian environment.

5. Composing (GUDA) Framework:

5.1. Previous Assessment Programs:

Many methods evaluating urban areas, all with differing scales that can be applied, but none encompass the union of urban and landscape design. Every program concentrates on separate problems while lacking a complete strategy that accounts for its connection with built environments and green infrastructure. Following are the main initiatives along with primary areas of focus:

- **LEED for Neighbourhood Development (LEED ND)** evaluates walkability, mixed use, and stormwater management. While it acknowledges some landscape elements, it lacks a structured method of including urban and landscape design [28].
- **BEAM Plus:** aims at building-level sustainability through materials, energy, and water use. It fails to capture planning at the neighbourhood level and green spatial connectivity [29].
- **City Prosperity Index (CPI) and EBRD Green Cities:** give precedence to infrastructure, economy, and quality of life but their parameters have strayed away from ecosystem services and included resilience planning [30,31].
- **ESTIDAMA:** provides strong benchmarks on energy and water efficiency. But it fails to give justice to the spatial coordination among urban form and landscape systems [32].
- **Green Pyramid Rating System (GPRS):** Egypt's national system, emphasizes energy, water, and materials at the building scale, with minimal application for neighbourhood-scale integration of green or synergy of urban landscape [33].

While these tools offer useful indicators, they do not accommodate full integration between landscape and urban design. Egypt requires a framework that is contextual to its environmental, climatic, and social conditions to achieve liveable and resilient urban areas.

5.2. The key aspects of The Assessment Criteria for GUDA:

Previous benchmark studies established main evaluation criteria for the GUDA Framework, categorized into three main groups: nature, humans, and the built environment. Quantitative indicators within each group measure integration between urban and landscape design. Six main points were selected from these case studies and applications based on three main justifications:

1- Measurable and previously have been experimented against older evaluation systems.
2- Encourage integration between urban and landscape design.
3- Suit Egypt's urban and environmental context.

The following figure (3) illustrates the classification and selecting process of the six major facets in the GUDA Framework based on this criterion.

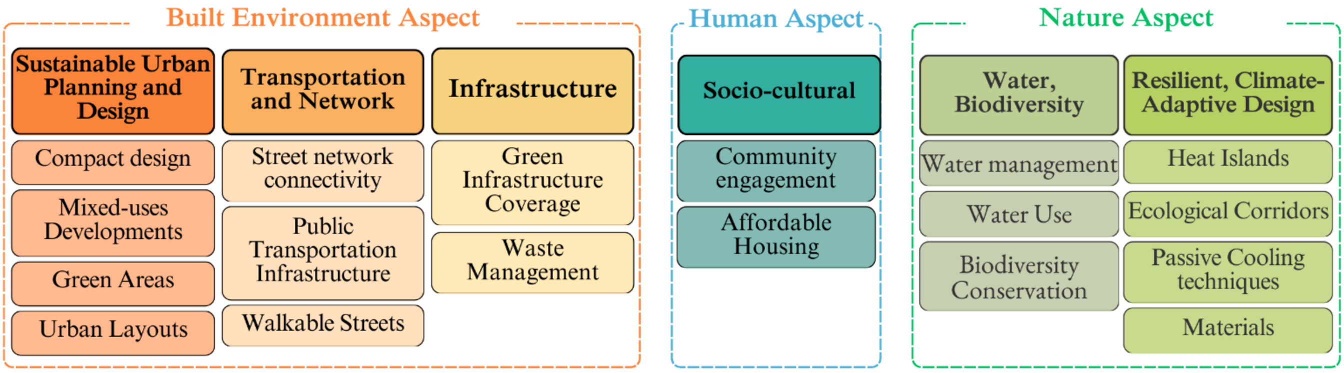


Fig. 3: The Main Key aspects for the GUDA Framework
Source: Authors based on [28:38].

5.3. Proposed GUDA Framework:

Table (3) outlines the GUDA Framework, presenting the six selected factors with their benchmark, these indicators offer a physical and spatial basis for measuring urban and landscape integration, representing an achievable, context-sensitive intervention derived from international and local programs.

Table 2: Practices to better Egyptian urban areas.
Source: authors based on [28:38, 44].

	Sub-Category	Measurable indicator	Description	Benchmark			Ref.
				High	Medium	Low	
1- Sustainable Urban Planning and Design	Compact Design	Residential density	Number of residential units per acre of land. (units/acre)	> 63	20-63	< 20	[28]
	Mixed Uses-Developments	Service Accessibility	walking access (within 400 m) to the number of existing land uses	>12 uses	8-12 uses	< 7 uses	[28]
		Multi-function Spaces	Frequency of use and satisfaction with multi-function spaces	High	Moderate	Low	[32]
	Green Areas	Green Space Coverage	The amount of permanent green space per capita (in m²/person)	> 10 m2	7-10 m2	< 7 m2	[30,31]
		Tree canopy density	Percentage of urban area covered by tree canopy	> 30%	15-30%	< 15%	[28]
		Green space accessibility	Percentage of the population living within a 10-min. walk of a green space	> 70%	50-70%	< 50%	[29]
	Urban Layout	Block Size	Average block area in square meters (m^2)	<15,000	15,000-30,000	>30,000	[34]
		Building street ratio	Building Height to Street Width Ratio (H:W)	<1:1	1:1 - 3:1	>3:1	[28,43]
		Public-facing building entries	the number of public-facing openings (doors & active windows) per 100 meters of street frontage.	>10	5-10	< 5	[28,35]
		Building setbacks	Minimum distance between sidewalks and buildings	> 3.5 M	2-3 M	< 2 M	[28,29, 36]
		Solar Orientation	Percentage of building façade area facing North and North-East	>70%	50-70%	< 50%	[28,32]
2- Transportation	Street network connectivity	Street Intersections	Number of intersections per square km	>100	50-100	<50	[35]
		Street Network Ratio (SNR)	The ratio of the total street area to the total land area	>15%	15% - 25%	>25%	[28]
	Public Transportation	TOD	Location within walking distance of high-quality transit service	600 m of high-quality transit	1000 m of high-quality transit	Not within walking distance	[28]

	Sub-Category	Measurable indicator	Description	Benchmark			Ref.
				High	Medium	Low	
	Infrastructure	Low Carbon Transport	Cycling accessibility network and availability of bicycle parking Within 400 m of networks	Yes	Partially Yes	No	[28]
	Walkable Streets	Pedestrian network integration	Integration of pedestrian access points with the surrounding network	Integrated	Partially	Not integrated	[28,29]
		Pedestrian infrastructure	Width of pedestrian routes	> 3 m	2-3 m	< 2 m	[28,35]
		Continuity of Pedestrian pathways	measures interruptions in pedestrian routes by physical barriers. (% obstructed Path/100 m)	<20%	20-50%	>50%	[32,35]
3- Infrastructure	Green Infrastructure Coverage	Green Roof coverage	Percentage of building's roof, facades and walls are covered by greenery	>20%	20-10%	< 10%	[28,32, 37]
		Sidewalk coverage	Percentage of streets with sidewalks on both sides	> 80%	50-80%	< 50%	[29,38]
	Waste Management	Integrated waste management plan	Presence of a comprehensive plan for waste management	A plan with clear targets	A partial plan with some targets	No formal plan or outdated plan	[38]
		Waste processing facilities	Availability of facilities for waste processing	Yes	Partially Yes	No	[38]
4- Socio-cultural	Community engagement	Community satisfaction	Community feedback is reviewed, analysed, and acted upon.	Reviewed & acted upon with follow-up actions	Reviewed but limited follow-up actions	Feedback not reviewed or acted upon	[38]
	Affordable Housing	Percentage of Affordable Units	Percentage of housing units designated as affordable	>30%	10-30%	<10%	[36]
5- Water, Biodiversity	Water management	Stormwater Management	Percentage of permeable & vegetated surfaces for runoff reduction	> 50%	30-50%	< 30%	[28,32]
	Water Use	Water Efficiency	Use native or drought-resistant plants to reduce water demand (suitable for Egypt's arid climate).	> 75%	50-75%	< 50%	[28,31]
	Biodiversity	Conservation	Avoid construction in sensitive ecosystems (wetlands, water bodies) and maintain natural buffers with species protection plans.	Yes	Partially Yes	No	[30,32]
6- Resilient, Climate-Adaptive Design	Heat Islands	Heat Islands Mitigation	Ensure ≥50% of hardscapes (roads, parking, sidewalks) use cool/reflective, permeable, or vegetated surfaces.	Yes	Partially Yes	No	[28,37]
	Ecological Corridors	Presence of ecological corridors	The existence of connected green spaces and natural habitats	Well-connected	Partially connect	Limited or no green spaces	[32]
	Materials	% Of recycled or local materials	Proportion of construction materials obtained from recycled or local sources	>20%	10-20%	< 10%	[28]
	Passive Cooling Strategies	Shading & Ventilation Design	Percentage of streets/public spaces using shading (trees, pergolas) and natural ventilation (wind corridors).	> 70%	40-70%	<40%	[28,32]

6. Practical Application of the GUDA Framework:

This section applies the GUDA framework to assess selected Egyptian neighborhoods. Comparing GUDA results with previous evaluations highlights the framework's applicability to Egypt's urban context.

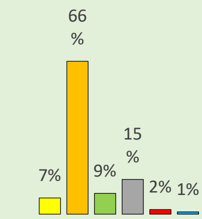
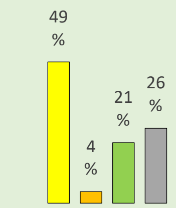
6.1. Selection of The Study Area:

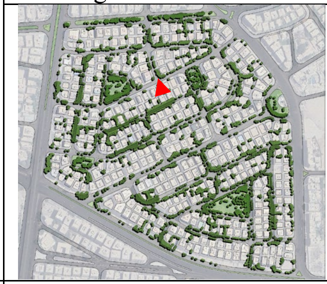
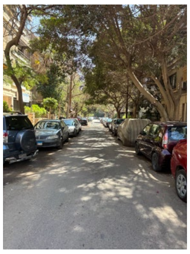
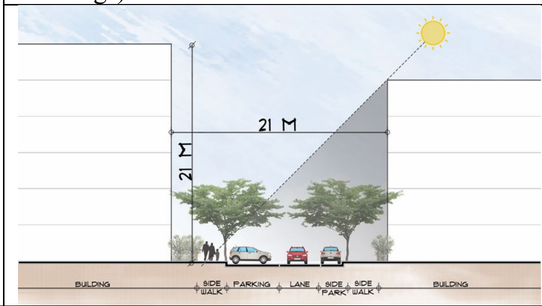
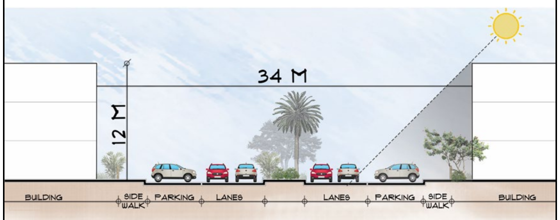
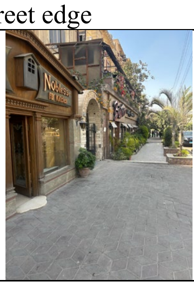
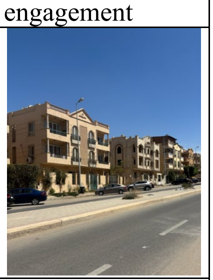
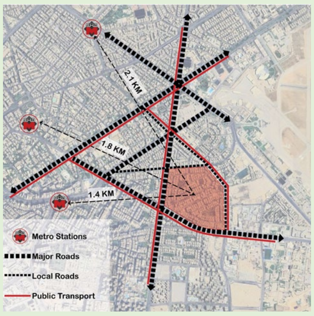
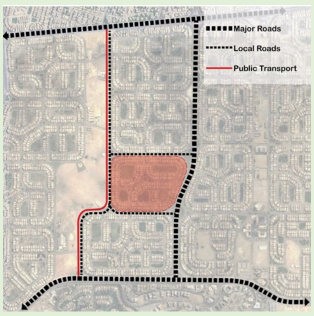
A review of previous assessments of Egyptian urban areas revealed several commonly studied neighborhoods, including Al-Rehab city [39], Nasr city, Heliopolis, Al-jasmin [40], 5th settlement [41], Al-sadat city [42], 6th October city [43]. Based on this review, two neighborhoods (Heliopolis, Al-jasmin) were selected using the following criteria:

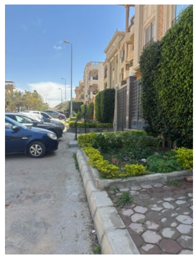
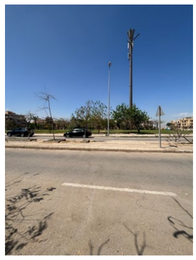
1. Represent average residential size and population.
2. Have existing evaluations to compare to.
3. Illustrate previous attempts at integrating urban and landscape design.
4. Possess similar socioeconomic characteristics.
5. Provide stable and accessible data and are public property, not private or gated ones.

The selected Heliopolis study area excluded recently altered areas with highways and bridge interchanges (i.e., El-Galaa Bridge, Triumph Square) in order to study its original urban fabric. Even though such altered areas currently suffer from connectivity and walkability challenges, our case study was for a stable unchanged area to study embedded urban-landscape design. Applying this model to altered areas would yield drastically different results, particularly in street patterns and mobility. Table 3 explore practical application for the proposed framework and the final outcomes will be compared with previous research in both locations, to verify the efficiency and reliability of the framework.

Table 3: Practical application for the proposed framework.
Source: authors based on site visits and observations.

	Measurable Indicators	Heliopolis Neighborhood (1920)	Al-Jasmin Neighborhood (1995)
General Data and Info	Base map		
	Area	84 Acre (0.35 km^2)	92 Acre (0.38 km^2)
	Buildings, Units	380 Buildings, 6880 Units	266 Buildings, 2120 Units
	Demographics	High- and Mid-Income Groups	High Income Groups
	Urban Form	Fine Grained Urban form	Super Block Urban form
1. Sustainable Urban Planning and	Characteristics and Land use Map	 	 
		Compact, mixed-use layout (50%+), supporting walkability. El-Horeya Street retains some greenery and pedestrian access.	Low-density and sprawling, with large blocks, poor accessibility, sparse greenery, and minimal pedestrian activity.
	Res. density	82 units/Acre	23 units/Acre
	Service Accessibility	Easy walking access to more than 23Basic and Secondary Services within 400 m. (75% of streets are Mixed use)	Limited access to services, with about 8 uses within 400 m, as non-residential buildings don't exceed 1%. (5% of the streets are Mixed use)

	Measurable Indicators	Heliopolis Neighborhood (1920)	Al-Jasmin Neighborhood (1995)
	Multi-function Spaces	Moderate satisfaction with frequent use.	Moderate satisfaction with infrequent use.
	Green Space Coverage	1.5 m^2/ capita.	9.5 m^2/ capita.
	Tree canopy density	19%, concentrated along streets and near building entrances. 	8%, concentrated in sparse and wide green areas. 
	Green space accessibility	100% of residents live within 400 meters of green spaces.	100% of residents live within 400 meters of green spaces.
	Block Size	10,200 m^2	44,500 m^2
	Building street ratio	1:1 (14-21 m street width with 4-6 floor old-buildings) 	1:3 (21-34 m wide streets with ground + 2-floor buildings) 
	Public-facing building entries	16 public-facing entries per 100 m Includes shopfronts, garage doors, windows, and building entrances - all activating the street edge 	only 6-8 public-facing entries per 100 m, primarily gated residential entrances set back from sidewalks, limiting street engagement 
	Building setbacks	3.5 m setbacks	4 m Setbacks
	Solar Orientation	57% of buildings face North/North-East	55% of buildings face North/North-East
2. Transportation and	Characteristics and Mobility Map	 A connected street grid, served by metro and buses, supporting mobility and transit-oriented development. Walkability is decent, but car use remains high.	 A disconnected looped layout with few intersections, minimal public transport, and no metro, making it car-dependent and largely unwalkable.

	Measurable Indicators	Heliopolis Neighborhood (1920)		Al-Jasmin Neighborhood (1995)	
	Street Intersections	70 intersection/ km^2		25 intersection/ km^2	
	Street Network Ratio (SNR)	15%, reflecting a balanced urban layout.		26%, indicating excessive land allocation to streets.	
	Transportation Accessibility	Served by three metro stations—Koleyet El Banat, El Ahram, and Haroun, and a dense public transportation network, enhancing accessibility and connectivity.		despite the presence of a few public transportation lines, there is no high-quality transit service, and the area remains heavily reliant on private vehicles for mobility.	
	Low carbon transport	Partially available		Not available	
	Pedestrian network integration	Partial connectivity with surrounding networks		Complete lack of integration	
	Pedestrian Infrastructure	2.5 - 4 m sidewalk		2-2.5 m sidewalk with some obstacles (Planters, Side Parking)	
	Continuity of Pedestrian pathways	60%, with occasional garage entrances and planters causing minor disruptions		20%, severely interrupted by private parking and extensive sidewalk planters	
3. Infrastructure	Characteristics	Pedestrian areas have green coverage, but green roofs/walls are rare. Waste management relies on traditional methods without recycling.		Lacks green roofs, walls, and shaded walkways. Uses organized waste collection and recycling systems.	
	Buildings Coverage (Roofs, Walls)	Minimal implementation, don't exceed 5%		Minimal implementation, don't exceed 5%	
	Sidewalk coverage	Moderate shading, reaching around 70% of pathways		Largely bare, with only about 20% coverage	
	Waste management plan	Traditional methods with no targets		Comprehensive plan with clear targets, timelines, and stakeholder involvement	
	Waste processing facilities	No		Partially Yes	
Socio-cultural	Characteristics	Moderate satisfaction with high social interaction among residents, but without formal channels for development input and remains affordable only to mid/high-income groups.		High satisfaction (basically wealth-based) with moderate social interaction, since it is a gated community where owner associations control everything and exclude the poorer residents by means of unaffordable housing.	
	Community satisfaction	Feedback was reviewed and but limited follow-up actions		Feedback reviewed and acted upon with follow-up actions	
	Percentage of Affordable Units	Serves ~30% of residents (mid-to-high-income brackets).		Caters to <10% of residents, with limited affordability.	
5. Water, Biodiversity	Characteristics	No stormwater drainage system, occasional flooding. With water-loving trees, the rest are drought-resistant natives. Urban biodiversity maintained in green spaces (birds, cats, dogs).		Simple stormwater collection but liable to waterlogging. Native plants used, but no effort at serious biodiversity conservation	
	Stormwater Management	Weak drainage (15%) with frequent flooding		Relatively functional system (75% efficiency) though still prone to occasional waterlogging	
	Water Efficiency	70%, Shows strong use of native and drought-resistant plants, though opportunities remain to expand sustainable green coverage.		60%, Moderate adoption of native/drought-resistant species, but still insufficient for the area's climatic needs.	
	Biodiversity Conservation	Partial efforts only		Completely lacking	
6.	Characteristics	Demonstrates building heat resilience by shaded promenades and adaptive urban green		Suffers from heat mitigation neglect, with asphalt-dominated surfaces and lacking green	

Measurable Indicators	Heliopolis Neighborhood (1920)		Al-Jasmin Neighborhood (1995)	
	infrastructure, though challenges persist in connecting ecological networks.		corridors intensifying urban heat.	
Heat Islands Mitigation	Moderate heat island mitigation due to tree canopy and green spaces.		Poor heat island mitigation with limited greenery and high heat retention.	
Presence of ecological corridors	Existed and well connected		Limited	
% Of recycled or local materials	Limited use of recycled or local materials, around 20%.		Minimal use of recycled or local materials, less than 10%.	
Shading & Ventilation Design	Shaded areas around 65%		Shaded areas around 30%	

6.2. Research Findings and Discussion:

To enable proper comparison of the two case studies, the data were normalized using the Z-score method, which calculates how far each value is from the mean. This statistical technique reduces bias and provides accurate and reliable assessment on diverse indicators.

The Z-score is calculated using the formula:

$$Z = \frac{X - \mu}{\sigma}$$

where X is the observed value, μ is the mean of all values, and σ is the standard deviation. The Z-score of 0 means that the value is equal to the mean, representing an average performance. The negative Z-score means a value below the mean, representing weaker performance, and the positive Z-score means a value above the mean, representing stronger performance [44]. Table (4) presents the Z-score values calculated for each indicator across both case studies.

Table 4: Z-score values for each indicator across both case studies
Source: authors based on [44].

Indicator		Actual Value		The mean	standard deviation	Z Score	
		Heliopolis	Al-Jasmin			Heliopolis	Al-Jasmin
Sustainable urban design	Residential density	82	23	41.5	24.75	1.64	-0.75
	Service Accessibility	23	8	9.67	3.79	3.52	-0.44
	Multi-function Spaces	2	2	2	0.82	0.00	0.00
	Green Space Coverage	1.5	9.5	8.5	2.96	-2.36	0.34
	Tree canopy density	19%	8%	21.67	8.96	-0.30	-1.53
	Green space accessibility	100%	100%	58.33	14.43	2.89	2.89
	Block Size	10,200	44,500	22,500	10,206	1.21	-2.16
	BH/SW Ratio	1:1	1:3	2.17	1.48	-0.79	-1.23
	Public-facing building entries	16	8	7.83	3.4	2.40	0.05
	Building setbacks	3	4	2.67	1.03	0.32	1.29
	Solar Orientation	57	55	60	12.25	-0.24	-0.41
Sustainable urban planning and design Sum (z- score)						8.28	-1.95
Transportation and Network	Street Intersections	70	25	75	28.87	-0.17	-1.73
	Street Network Ratio (SNR)	15	26	20	5.59	0.89	-1.07
	Transportation Accessibility	3	1	2	0.82	1.22	-1.22

Indicator		Actual Value		The mean	standard deviation	Z Score	
		Heliopolis	Al-Jasmin			Heliopolis	Al-Jasmin
	Low Carbon Transport	2	1	2	0.82	0.00	-1.22
	Pedestrian network integration	2	1	2	0.82	0.00	-1.22
	Pedestrian infrastructure	3.5	2.5	2.5	0.82	1.22	0.00
	Continuity of Pedestrian pathways	60	20	35	16.33	1.53	-0.92
Transportation and Network Sum (z- score)						4.69	-7.38
Infrastructure	Building's coverage (roofs, Walls)	5	5	15	6.12	-1.63	-1.63
	Sidewalk coverage	70	20	63.33	18.93	0.35	-2.29
	Integrated waste management plan	1	3	2	0.82	-1.22	1.22
	Waste processing facilities	1	3	2	0.82	-1.22	1.22
Infrastructure Sum (z- score)						-3.72	-1.48
Socio-cultural	Community satisfaction	1	3	2	0.82	-1.22	1.22
	Percentage of Affordable Units	30	10	20	12.5	0.00	-0.82
Socio-cultural Sum (z- score)						-1.22	0.40
Water and Biodiversity	Stormwater Management	15	75	40	12.25	-2.04	2.86
	Water Efficiency	70	60	62.5	14.43	0.52	-0.17
	Conservation	2	1	2	0.82	0.00	-1.22
Water and Biodiversity Sum (z- score)						-1.52	1.46
Resilient and Climate-Adaptive Design	Heat Islands Mitigation	2	1	2	0.82	0.00	-1.22
	Presence of ecological corridors	3	1	2	0.82	1.22	-1.22
	% of recycled or locally sourced materials	20	10	40	12.25	-1.63	-2.45
	Shading & Ventilation Design	65	30	55	16.33	0.61	-1.53
Resilient and Climate-Adaptive Design Sum (z- score)						0.20	-6.42

As illustrated in Figure (4), Heliopolis leads in Sustainable Urban Design, Transportation and Network, and Resilient and Climate-Adaptive Design when compared across all six major dimensions. Al-Jasmin, however, leads by a narrow margin in Infrastructure, Socio-Cultural, and Water and Biodiversity. These are illustrated in Figure (5) to take into further consideration.

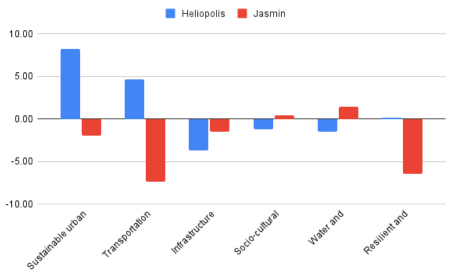
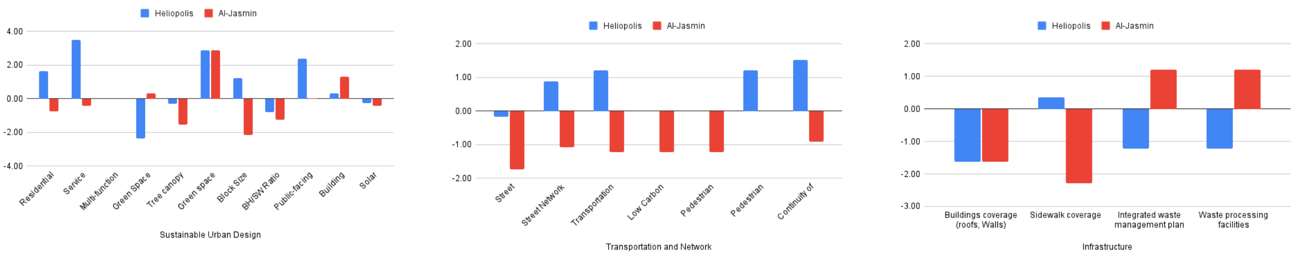


Fig. 4: overall Z-score comparison across the six main dimensions.
Source: Authors.



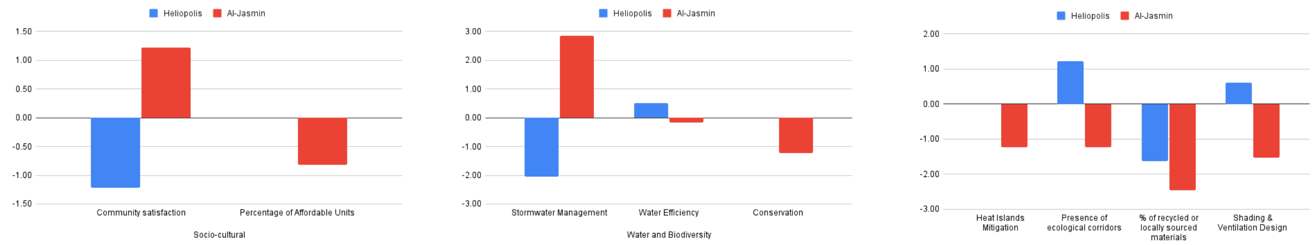
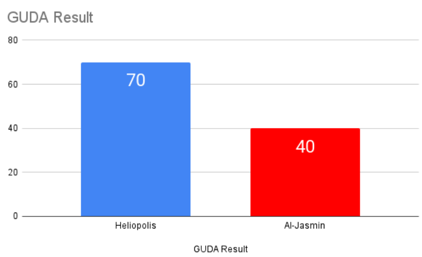


Fig. 5: Detailed comparison across the six main dimensions.
Source: Authors.

1- Sustainable urban design: Heliopolis is clearly demonstrated to integrate effective sustainable planning with its walkable, mixed urban form and public spaces, decreased urban sprawl, and enhanced accessibility. Yet Al-Jasmin's low density and inaccessibility of services equate to inefficient land use and limited environmental and social returns.
2- Transportation and Network: Heliopolis' dense intersection coverage and pedestrian network enable sustainable mobility and urban linkages. Al-Jasmin, by contrast, lacks a connected street network and reliable transit system, which increases its dependency on private cars and decreases accessibility.
3- Infrastructure: Heliopolis is supported by wide sidewalk cover and partially-structured waste management enabling urban resilience and environmental quality. Al-Jasmin, however, is plagued by infrastructure shortages, particularly pedestrian mobility and waste systems, compromising its urban performance.
4- Socio-Cultural: Al-Jasmin excels in achieving greater levels of community satisfaction. Heliopolis, while advanced otherwise, requires more efforts in promoting public participation and low-cost living conditions.
5- Water and Biodiversity: Al-Jasmin is relatively superior in stormwater management by possessing efficient drainage systems with less flood hazard and encouraging water preservation. In comparison, Heliopolis lacks effective water management, therefore it limits environmental sustainability.
6- Resilient and climate adaptive design: Heliopolis integrates ecological corridors, shading and ventilation provisions that enhance climate adaptation and thermal comfort. Al-Jasmin does not have much of this aspect, with hardly any climate-responsive design and hardly any green elements to mitigate urban heat.

7. Conclusion and Recommendations:

Figure (6) illustrates the clear gap in performance between the two case studies, with Heliopolis achieving 70% compliance with the GUDA framework, while Al-Jasmin reached only 40%. This noticeable disparity reflects the varying capacities of different urban areas to meet sustainability benchmarks. More importantly, the results align with several previous academic studies that emphasize similar shortcomings in modern developments and the relative strength of historically integrated neighborhoods. This consistency with prior findings strengthens the credibility of the GUDA framework and confirms its relevance as a valid tool for evaluating the integration of green urban and landscape design principles across diverse urban environments.



7.1. Final Comments:

- **Adopt integrated urban planning:** Urban development has to be guided by an integrated framework balancing environmental, social, and economic aspects, with sustainability design principles integrated right from the early planning stages.
- **Strengthen institutional tools:** One of the biggest challenges in applying the framework was the lack of data and monitoring instruments. An organized institutional framework for gathering data, monitoring performance, and ensuring compliance with sustainability is crucial.
- **Promote community awareness and participation:** Involvement of residents in planning and decision-making promotes community ownership and ensures sustainability projects are more accepted and maintained.
- **Prioritize sustainability in urban policy:** Urban policies must go beyond aesthetics and efficiency in construction to actively promote carbon reduction, livability, and social and spatial equity.
- **Recommendations for improving Heliopolis:**

– Enhance green and blue infrastructure via stormwater collection facilities and rooftop greenery.
– Enhance biodiversity by green space extension and linking.
– Adopt high-tech water management technology and sponsor urban greening.

- **Recommendations for improving Al-Jasmin:**

– Promote higher residential density and mixed-use development to make urban form more active and efficient.
– Increase public transport connectivity and upgrade streets to support walkability and cycling.
– Enforce stricter environmental building regulations and apply passive climate measures such as shading and natural ventilation.

- **Future application of the GUDA framework:** GUDA framework can be applied to more diverse urban areas across Egypt. The indicators would have to be locally modified to acknowledge regional differences, thereby making the framework more scalable and applicable.

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