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# Upgrading informal areas through sustainable urban development principles



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## Abstract

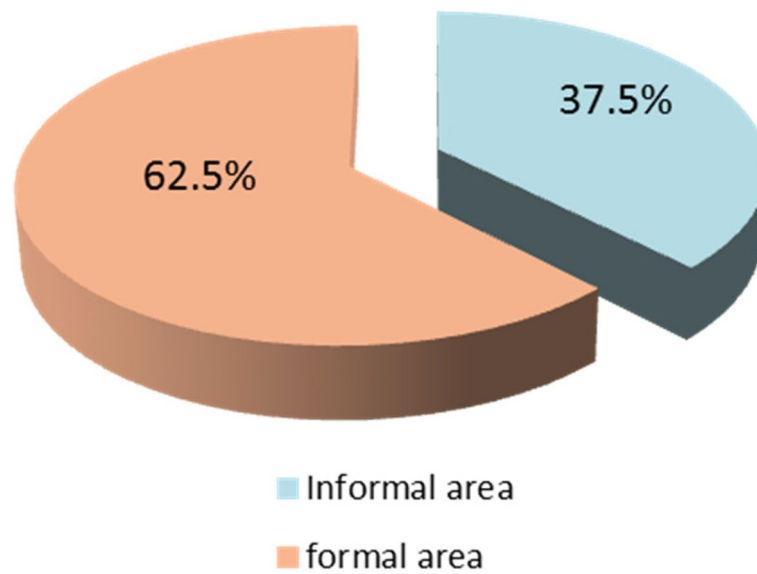
Informal areas are considered one of the biggest urban problems worldwide; it was estimated in 2018 that 29% of the world's urban population lived in informal areas (The world bank, Population living in slums, 2022). This research aimed to identify a set of criteria and principles that are the basis for sustainable development in informal areas to achieve a better quality of life for the community. After conducting a literature review of the sustainable development principles, indices, and sustainable development interventions within informal areas, the research links them to set informal areas' sustainable development principles. Then, by relying on the experts' questionnaires and their analysis through SPSS, the researchers utilized the experts' input to define each principle's relative weight. Additionally, the research applied the extracted principles to the Boulaq El Dakrou case study to assess the sustainability of previous developments undertaken in the area with community participation.

**Keywords:** Informal areas, Urban upgrading, Sustainable development principles, Statistical analysis, Boulaq El Dakrou

## Introduction

There was a significant increase in urbanization between 1995 and 2015. Increasing urbanization and poverty resulted in the emergence of informal areas. Additionally, there is a direct correlation between the rise in urbanization and the increase in informal areas [1]. According to the UN-Habitat Regional Office for the Arab States, more than half of the Arab region population lives in cities and human settlements; 32.47% represents the percentage of the slum population in the Arab states. By 2050, more than 70% of the Arab population will be urban [2].

Informal areas are among the biggest problems in Egyptian urbanism. The percentage of informal urban areas is 37.5% of the total urban area. Informal areas are divided into unplanned areas (97.1%), including informal areas constructed on agricultural land and informal areas built on desert land, and unsafe areas (2.9%), including four levels according to the degree of risk, as shown in Fig. 1 [3].



**Fig. 1** The chart illustrates the percentage of formal and informal settlements in urban areas in Egypt [3]

The term “unplanned areas” refers to regions developed to counteract the laws and regulations governing planning and construction and is determined by the general strategic plan adopted for the city or village. As a result, informal areas have several problems that need to be discussed and resolved [4].

The three branches of sustainable development (environmental, social, and economic) that address the needs of the present generation without affecting the future generation’s capabilities to meet their own needs and aspirations can be used to overcome the challenges of informal areas. However, although several sustainable urban development theories and principles exist, they are mostly tailored to formally planned areas and seldom address the peculiarities of informal areas’ characteristics and needs. Hence, there is a current gap in addressing sustainable urban development within urban informalities, and there is a particular need to develop a checklist to evaluate and propose solutions. This paper uses Egypt as a case study of informal urbanism in the Global South.

The urgent needs of residents of informal areas impose significant pressure on decision-makers to focus on meeting these needs without considering the comprehensiveness of solutions that address all aspects of the area’s development. Thus, the adoption of principles of sustainable urban development tailored to the characteristics of informal areas is necessary.

This paper proposes sustainable development principles responsive to the characteristics of informal areas. First, the study investigates several sustainable development-related concepts, principles, theories, indices, and checklists and critically assesses previous sustainable development interventions within informal areas. Second, the paper validates the extracted principles through an expert questionnaire and defines the relative weight of each principle. Finally, this paper applies this outcome to a case study to assess the previous development efforts undertaken in the past couple of decades.

## Methods

This study has five parts. The first part is a literature review of sustainable development theories, principles, and indices for informal areas, including past attempts. The second part is a comparative analysis of sustainable development theories, principles, and indices.

The third part involved a questionnaire for sustainable urban development experts to improve those principles. The validity and significance of the principles were determined via SPSS analysis. The questionnaire was answered by approximately 50 urban development experts, including district and governorate engineers, university professors, experts from the German International Development Agency GIZ, Housing and Building Research Center (HBRC) researchers, and engineers with experience in developing informal areas. The percentage of experts aged between 40 and 50 years is 25%, and the percentage of experts aged >20–30 is 75%. Additionally, 78% of those had experience ranging from 1 to 5 years, and 22% had 5 to 10 years of experience. Each expert was required to decide whether these points were appropriate for informal areas or not on a scale of 1 (least relative weight) to 5 (highest relative weight) to determine the importance and relative significance of each principle. SPSS was used for two statistical tests to validate the questionnaire and sample. The tests showed high reliability (Cronbach's alpha = 0.987) and significant results ( $F = 8.245$ , sig = 0.00).

The fourth part evaluated sustainable development projects in the informal district of Boulaq El Dakroul through observations, interviews, and questionnaires. The questionnaire was administered to 30 respondents, targeting various sectors of society and men and women of different ages. It included the main elements of the informal areas' sustainable urban development principles regarding economic, social, and environmental aspects. The percentage of people aged >20–40 years was 30%, while that aged 40–60 years was 70%, with diverse professions such as workers in workshops, youth centers, schools, libraries, health services, civil associations, and shops. The statistical analysis was conducted using the SPSS program. The reliability test with (Cronbach's alpha = 0.786 > 0.75) showed that the sample was valid at a rate of 78.6%, and the ANOVA test was used to analyze the sample variance, moreover, since ( $f = 26.379$ , sig = 0.00), meaning that  $f > 0.5$ , sig < 0.05, this means that the experiment is functional.

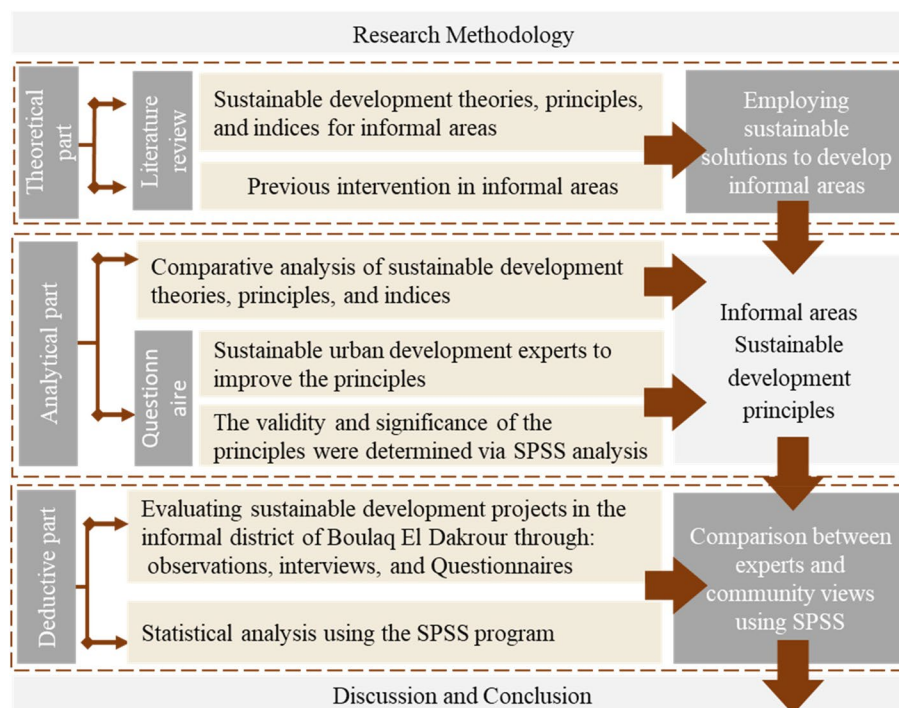
The fifth part compares experts' and community views on discussing the sustainability of Boulaq El Dakroul, as shown in Fig. 2 below.

## Reaching sustainable development in informal areas

The literature review began by illustrating sustainable development principles and indices suitable for informal areas and then discussing previous informal areas' sustainable development interventions.

## Sustainable development principles and indices for informal areas

Many sustainable development principles and theories have emerged that address the three pillars of sustainable development (economic, social, and environmental). However, these theories need to account for informal areas because of their unique nature and the need for different development approaches. Therefore, this research establishes

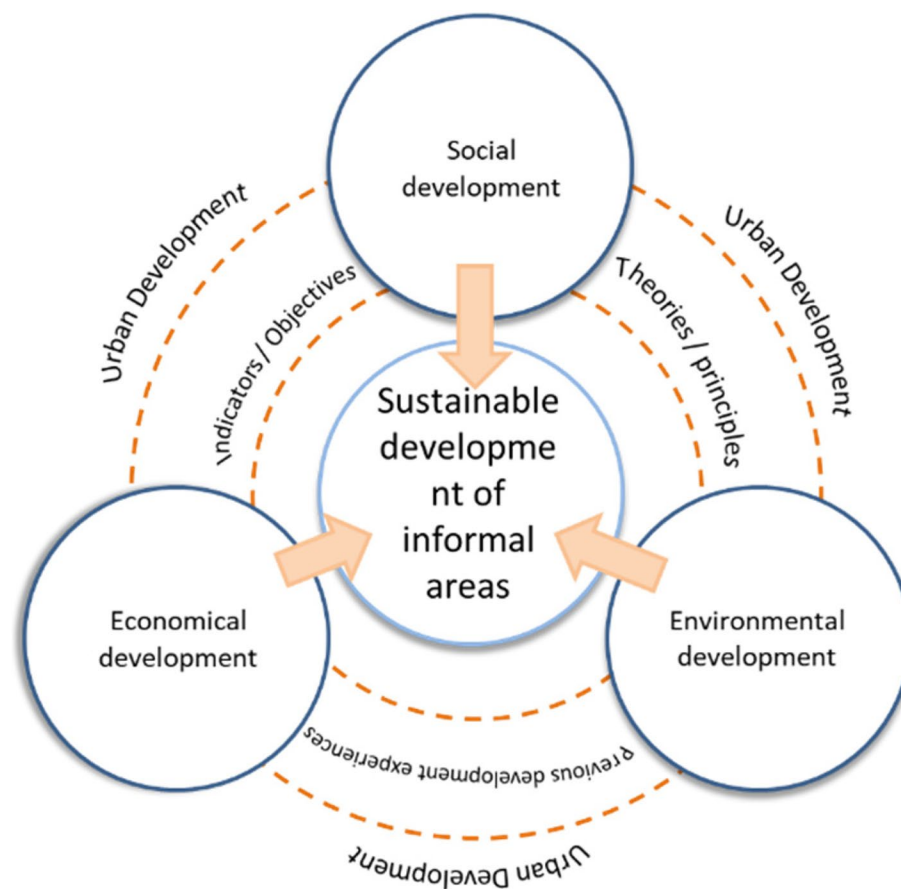


**Fig. 2** Research methodology

guidelines and standards for the sustainable urban development of informal areas by examining sustainable urban principles (smart growth, new urbanism, sustainable urbanism, transit-oriented development, and the new urban agenda) and sustainable development principles (eco-village principles, and sustainable development goals); as well as sustainable development rating systems and checklists that apply these theories (e.g., LEED for neighborhood, the Green city index, the city prosperity index, and the UK government sustainability checklist), as shown in Fig. 3.

### ***Sustainable urban development theories***

Urban development theories emphasize the importance of creating walkable and sustainable communities, including smart growth, new urbanism, sustainable urbanism, transit-oriented development, and eco-village principles. Smart growth principles include mixing land uses, compact building design, offering various housing options, and encouraging public participation in development decisions [5]. New urbanism promotes walkability, mixed usage, and green transportation [6]. Sustainable urbanism emphasizes transit-served urbanization with high-performance buildings and infrastructure [7]. The transit-oriented design incorporates walkability, a central train station, and reduced parking [8]. Eco-village principles prioritize a diverse social makeup, public realms for pedestrians, and frequent community participation in planning and design. These principles also emphasize the importance of ecological soundness, compatibility with morality, and energy efficiency [9]. However, the differences between these theories are shown in Table 1, highlighting their unique priorities and approaches.



**Fig. 3** Sustainable development of informal areas. Source: author

### ***Sustainable development principles***

SDGs and the new urban agenda promote sustainable development principles for informal areas. SDGs include reducing poverty, hunger, and inequalities; promoting good health, education, and sustainable communities; and addressing climate change and responsible consumption. The New Urban Agenda emphasizes urban planning, development, and management along five implementation pillars to achieve sustainable and inclusive communities and cities [10, 11].

### ***Urban development indices and checklists***

The Indices and checklists for sustainable urban development include the LEED for Neighborhood, the City Prosperity Index, the Green City Index, and the UK government Sustainability Checklist. LEED for the neighborhood [12] focuses on green infrastructure and buildings, smart locations and connectivity, and neighborhood patterns and design. The city prosperity index [13] has five dimensions: productivity, infrastructural growth, lifestyle enhancement, social inclusion, equity, and environmental sustainability. Moreover, the Green City Index [14] is the third most common index concerning CO<sub>2</sub> emissions, energy, land use, transportation, water, waste, sanitation, air quality, and environmental governance. The last one is the UK government sustainability checklist [9],

**Table 1** Sustainable urban development theories comparison

Principles	Smart growth	New urbanism	Sustainable urbanism	transit-oriented design	Eco-village principles
Mixed land uses	√	√		√	√
Take advantage of compact building design	√	√	√	√	
Provide a variety of housing options and choices	√	√			√
Create walkable areas	√	√	√	√	√
Enhance friendly communities	√	√			√
Protect open space, agriculture, natural beauty, and vital environmental areas	√	√	√		√
Direct development toward existing communities	√				
Provide a diverse range of transportation options	√	√	√	√	√
Create development decisions that are predictable, equitable, and cost-effective	√				
Encourage public participation in development decisions	√				√
Connectivity		√	√		
Quality urban design and architecture		√			√
Sustainability		√	√		√
Quality of life		√			
High-performance infrastructure			√		

Source: author

which investigates economic sustainability, natural resources, social sustainability, and the local environment.

Collecting these indices, principles, and lists helps form sustainable development principles for informal areas, as shown in Table 2.

**Previous approaches in informal areas of sustainable development**

First, Law 119 for 2008 replaced the terms slums, informal settlements, and Ashwa’iyyat with unplanned areas and since 2008, the term “unsafe areas” has been used to address the conflicting definitions and names of the informal areas that have affected the statistical analysis of the ISDF [15].

The evolution of Egypt’s informal settlement upgrading strategies, such as contemporary participatory development practices and housing policies that provide affordable housing to the urban poor, should be mapped. Additionally, practical approaches have been adopted for informal settlement upgrading and addressing settlement-specific problems, such as inadequate housing, lack of infrastructure or services, poor accessibility, severe environmental degradation, and urban poverty. However, more consideration should be given to land regularization and the legalization of tenure, nontraditional community finance schemes, integration with housing markets, and land supply [16]. Figure 4 shows the state policy in dealing with informal areas’ timelines.

**Table 2** Sustainable development principles for informal areas

	Economic sustainability	Principles and Previous Development	CPI	LEED	Green city index	UK checklist	Par 30
	Basic needs						8.6
1	Eliminating poverty and hunger	√					2.9
2	The community's capability to meet its fundamental requirements, including housing, food, and other necessities	√					2.9
3	Providing secure tenure (rent or property documents)	√					2.8
	Work						8.6
4	Eliminating unemployment and providing a variety of job opportunities that are easily accessible with good local training services	√				√	2.6
5	Contributing to economic recovery by encouraging local offices/workshops and crafts, working from home/office					√	2.7
6	Encouraging small projects	√					3
	Productivity						12.8
7	Promoting local production of local food and other, and reinvesting in local communities			√		√	2.6
8	Providing adequate public spaces for trading, with intensifying urban assembly points and corridors to maximize the benefit of focus while providing suitable quality commercial/institutional spaces		√				2.4
9	Provide effective transport systems for people and goods		√				2.7
10	Encouraging multi-axis urban growth allows for synergy between major cities and smaller towns		√				2.5
11	Promoting the diversity of land use to strengthen economic bloc and land development and transform it into a source of revenue		√				2.5
	Social sustainability	Principles and Previous Dev	CPI	LEED	Green city index	UK checklist	Par 30
	Health						4.6
12	Provide adequate public infrastructure and facilities for health					√	1.6

**Table 2** (continued)

13	A pollution-free environment that facilitates the exercise of health activities and mental health	√				1.5
14	Improve health status		√			1.5
	Education					5.9
15	Provide public infrastructure and adequate facilities for education	√				1.5
16	Elimination of illiteracy	√				1.5
17	Achieve universal education	√				1.4
18	Increase community awareness and culture		√			1.5
	Community safety					4
19	Provide security systems and increase the sense of security and belonging to the community				√	1.5
20	Social balance at the neighborhood level	√	√			1.2
21	The design provides (multiuse neighborhood centers-edge-open areas)	√		√		1.3
	Equality and freedom of choice					8.3
22	Access to permanent housing and diverse services for all community categories	√			√	1.4
23	Providing diverse income-generating communities and diversifying affordable housing options		√	√	√	1.4
24	Provide public infrastructure and adequate facilities such as civic centers, libraries, sports facilities, commercial areas, open areas, entertainment areas, and others		√			1.5
25	A continuous and open society			√		1.2
26	Social justice, inclusion, and promotion of gender equality and the empowerment of women	√	√			1.3
27	Easy access to all facilities on foot or using public transportation, increasing mobility, and paying particular attention to the requirements of children and the disabled		√	√	√	1.5
	Participation					7.1
28	Enhancing community participation in the various stages of development processes (in terms of effort, money, decision-making, etc.)	√				1.5



**Table 2** (continued)

29	Participation of government agencies	√						1.4
30	Participation in nongovernmental organizations	√						1.6
31	Participation of financiers	√						1.5
32	Develop a global partnership	√						1.2
	Environmental sustainability		Principles and Previous Dev	CPI	LEED	Green city index	UK checklist	Par 30
	Natural resources							3.5
33	Ensuring fresh air and nonpolluted water while reducing pollution, CO2 emissions, and toxic gases and reducing thermal islands	√		√	√	√	√	0.8
34	Climate stability and adaptation to climate change			√			√	0.7
35	Maximizing the site's natural advantages (sunlight, water bodies, wind, etc.)			√				0.7
36	Developing a plan to restore ecosystems and conserve biodiversity			√				0.6
37	Environmental management, environmental monitoring, and public participation in environmental decision-making					√		0.7
	Buildings and infrastructure							3.1
38	Valid Construction and sanitary buildings	√						0.8
39	Reusing existing buildings and maintaining and adapting to historical resources				√			0.8
40	Supporting densities through the development of integrated infrastructure			√				0.8
41	Enhancing flexibility in exterior and interior design	√						0.8
	Water							3.6
42	Securing access to water with local sources of drinking water and water demand management	√				√	√	0.8
43	Providing water treatment surfaces with quality and water sustainability				√			0.7
44	Maintaining water efficiency in the building and landscaping				√			0.8
45	Rainwater Management	√				√	√	0.6



**Table 2** (continued)

65	Using local building materials and recycled materials					√			0.8
	Transportation								5.2
66	Improving the quality of communication and connectivity between neighborhoods and access to services while using sites that reduce transportation time (near dwelling and employment)					√			0.8
67	Providing good road networks and are well serviced by public transportation and transportation demand management					√		√	0.8
68	Constructing footpaths to reduce reliance on vehicles					√			0.8
69	Reducing parking space area					√	√		0.6
70	Providing cycling infrastructure (the road network of bicycles and parking racks)					√	√		0.7
71	Reducing traffic congestion and providing traffic facilities					√	√		0.8
72	Expanding transportation networks and setting sidewalks and shaded streets with trees on both sides					√	√	√	0.8
	Quality of life and maintenance	Principles and Previous Dev	CPI	LEED	Green city index	UK checklist			10
	Quality of life								5
73	Improving architectural and urban aesthetic quality (overall design and landscape)					√		√	2.4
74	Promoting identity, culture, and preservation of heritage					√			2.6
	Evaluation, follow-up, and maintenance								5
75	Applying availability of evaluation, follow-up, and maintenance systems for development projects	√							2.7
76	Developing a plan that includes development and orientation for expansions					√	√		2.3

Previous research has addressed the problem of informal areas and has tried to offer many recommendations and solutions to achieve actual development in such areas; some have done so by integrating sustainable urban design concepts and principles. For example, Nassar [19] suggested converting informal areas into eco-friendly



**Fig. 4** State policy in dealing with informal areas timeline. Source: author according to [17, 18]

sustainable communities by assessing local needs and potentials and three levels of sustainability: economic, social, and environmental for “Houd 10” in Alexandria.

Miguel P. Amado [20] employed a method that integrates social context analysis and a participatory design process to develop an inclusive and sustainable approach for informal settlements.

Moreover, Khalil [21] linked sustainable urbanism and sustainability in informal urban development by studying four examples, including two informal areas in Cairo (Boulaq El Dakrou and Imbaba) and two upgrading projects (Imbaba Airport and

Zeinhom). The results highlighted the importance of developing urban development theories and guidelines to address sustainability issues.

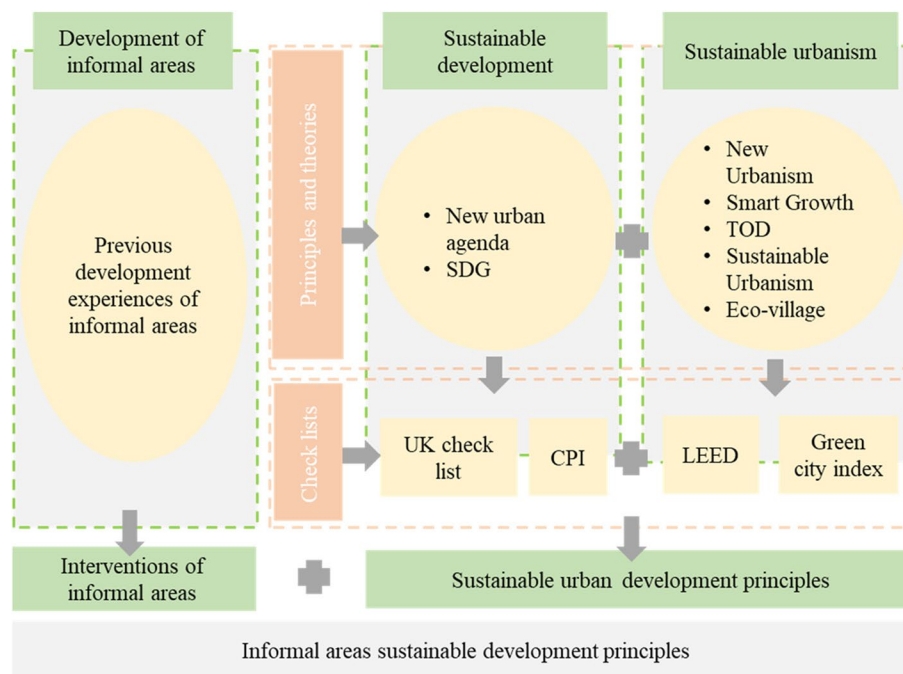
The slum in Alexandria, Egypt, known as “Ezzbet Abd El Meniem Riyadh”, embraced sustainable urban development. The study revealed that residents possess the necessary knowledge to address community issues but require guidance, training, and empowerment to create independent and repeatable solutions [22].

Interestingly, Montoya [23] created 13 indicators to evaluate the sustainability of informal settlements in 2 poverty-stricken areas of Bogota. Interviews were conducted with residents, and experts validated the findings. Khalil and Gammaz [24] analyzed informal areas’ compliance with sustainable urbanization principles and their green features, energy efficiency, and quality of life measures. These authors suggested solutions to increase resilience to climate change and improve quality of life.

Elrefaie [25] introduces a methodology for defining variables and indicators to evaluate the sustainability of informal areas. The aim is to develop a rating system called the Compass of Informal Areas Development, which is a graphical policymaking tool for urban planners and policymakers to quickly diagnose the sustainability performance of informal areas and formulate strategies accordingly, where variables related to quality of life (housing adequacy and social and economic welfare) with place value are represented graphically as a ‘diamond’ with a radar shape in four axes. The application of this developed rating tool in informal areas has provided a comprehensive picture and clear interpretation of the area’s performance.

The Government of Egypt has revised its Nationally Determined Contribution (NDC) to accelerate the transition toward a low-carbon development pathway by increasing the adoption of renewable energy, with a target of 42% installed capacity by 2030 [26]. This update aligns with Egypt’s Sustainable Development Strategy: Egypt’s Vision 2030. The NDC includes measures such as promoting renewable energy and energy efficiency in existing and new buildings [27] and The Informal Settlements Development Fund (ISDF) concentrates on developing two distinct types of areas: unsafe zones that are relocated to new housing developments, such as the Ashish area development project in Dokki District-Giza Governorate, the Maspero Triangle development project in Boulaq District, and the Al-Asmarat project in Cairo Governorate. The Fund has successfully implemented 13 unplanned area development projects in various neighborhoods, including Omraniya, Al-Haram, Al-Warraaq, Boulaq Al-Dakrou, North Giza, and Giza City. These initiatives are aligned with the city’s strategic plan and planning requirements, resulting in improved services for citizens while adhering to planning requirements and developing all existing utility networks, civil defense systems, and street lighting. As the ISDF transitions to the Urban Development Fund (UDF), it will also engage in other goals related to sustainable cities and communities (SDG 11), gender equality (SDG 5), economic growth (SDG 8), climate action (SDG 13), and partnerships (SDG 17) [28].

Comprehensive principles are needed for sustainable development in informal areas, covering economic, social, and environmental pillars. The existing development efforts are insufficient, and specialized principles are lacking. The research compared sustainable development principles, checklists, and prior projects to establish principles for informal area development, as shown in Fig. 5.



**Fig. 5** Overlapping sustainable development principles, checklists, and previous experiences of informal areas development to reach components of informal areas sustainable development

Thus, informal areas’ sustainable development principles are divided into four main categories: economic, social, and environmental sustainability; quality of life; evaluation; and maintenance. The main principles are divided into subprinciples, as follows: *economic sustainability*: basic needs, work, and productivity; *social sustainability*: health; education; community safety; equality; freedom of choice; and participation; *environmental sustainability*: natural resources; building, and infrastructure; water; sewage; waste; electricity; earth and soil; and transportation; *quality of life and maintenance*: quality of life, maintenance, evaluation and follow up, as shown in Fig. 6.

## Results

This research develops a list of informal areas’ sustainable development principles and applies them to the Boulaq El Dakrouir case study, as shown below.

### Validation of informal areas’ sustainable development principles through expert opinions

Table 2 and Fig. 7 provide evidence of the results obtained from the statistical analysis of an expert’s questionnaire using the SPSS program. These results reveal the relative importance of each sustainable development principle for informal areas.

To establish a balanced assessment of sustainability, the research suggests aggregating expert opinions by determining the average response for each pillar, including economic, social, and environmental considerations. Next, to equalize the weight of these pillars with a total weight of 90%, we propose normalizing their sum to a value of 30. The remaining 10% of the evaluation will be allocated to quality of life and maintenance principles, where each principle should be given a score of 5.



Fig. 6 Informal areas of sustainable development principles

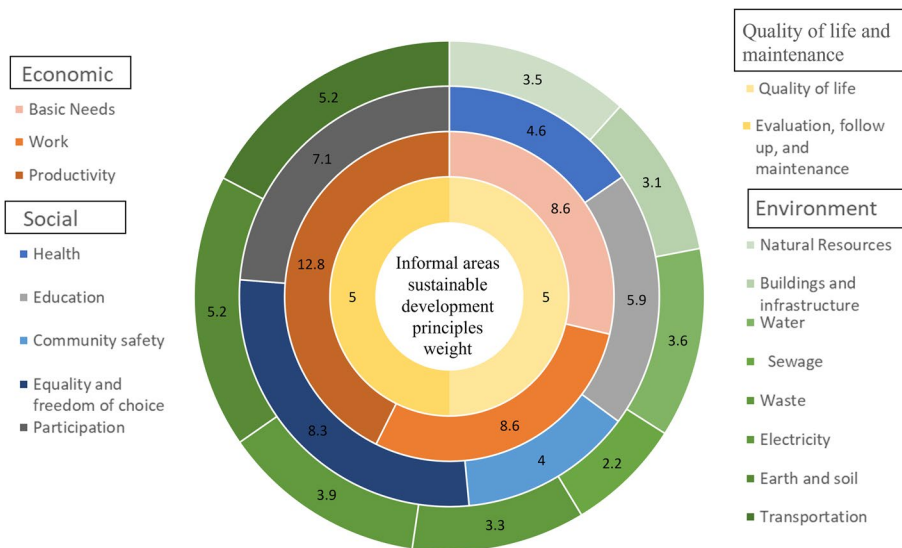


Fig. 7 Chart of informal areas sustainable development principles weight

Therefore, the criterion for assessing a project's sustainability includes a balanced consideration of economic, social, and environmental factors, each of which constitutes 30% of the overall assessment. Moreover, the quality of life and maintenance principles comprise the remaining 10% of the evaluation, further emphasizing the importance of a holistic approach to sustainability.

Additionally, the table provides a comprehensive overview and comparison of the sources attributed to each point within the sustainable development principles for informal areas. The first column outlines the principles and previous developments, followed by the four checklists mentioned, and the last column shows the relative weight of the principles.

The importance of having these relative weights also the determination of the importance of the point and the priority of applying it is to help in assess the case study area showing the percentage of achievement points in the list of sustainable development principles for informal areas like other checklists such as LEED rating system.

### **Boulaq El Dakrou case study**

Boulaq El Dakrou is one of the most common unplanned areas in the Giza Governorate. Construction started on agricultural land in 1950. Figure 8 depicts Boulaq El Dakrou, which has a population of 1.2 million and a 9-km<sup>2</sup> area (GIZ: Upgrading of Boulaq El Dakrou Governorate of Giza, 2010, unpublished).

Development in Boulaq El Dakrou began in 1998 through a development cooperation protocol between Egypt and Germany, starting with a 5 million Euro grant for infrastructure in 2003. GIZ aimed to improve the infrastructure and build trust in local administration.

The work included managing the grant of the community investment fund (CIF) (10% of the budget, € 0.5 million) and facilitating the agreement on infrastructure development projects engaging the local administration and the local popular council (LPC), and consulting of residents and other local stakeholders. However, in 2015, the Participatory Needs Assessment [30] revealed existing issues and their priorities for action, including solid waste, sewage, road conditions (unpaved streets, transportation, traffic congestion, street vendors), lack of security (harassment and drugs), drinking water, electricity, education, gas, hospitals, and pollution, as shown in Fig. 9.

### **Applying the informal areas' sustainable development principles to the development of Boulaq El Dakrou**

Applying the determined informal areas' sustainable development principles in Boulaq El Dakrou, Table 3 shows how the area performed and the sustainability of previous development interventions.

Figures 10, 11, 12, 13, 14, and 15 below show the intervention of the infrastructure and describe the façades and markets before and after the development, respectively.

When conducting a comparative analysis of experts' opinions (desired sustainable development) in expert's questionnaire illustrated above especially in Table 2 with the views of community members (the current situation in the region) in the community questionnaire, the principles of sustainable development were included and formulated in 20 questions in the community questionnaire that represent the main points in the principles of sustainable

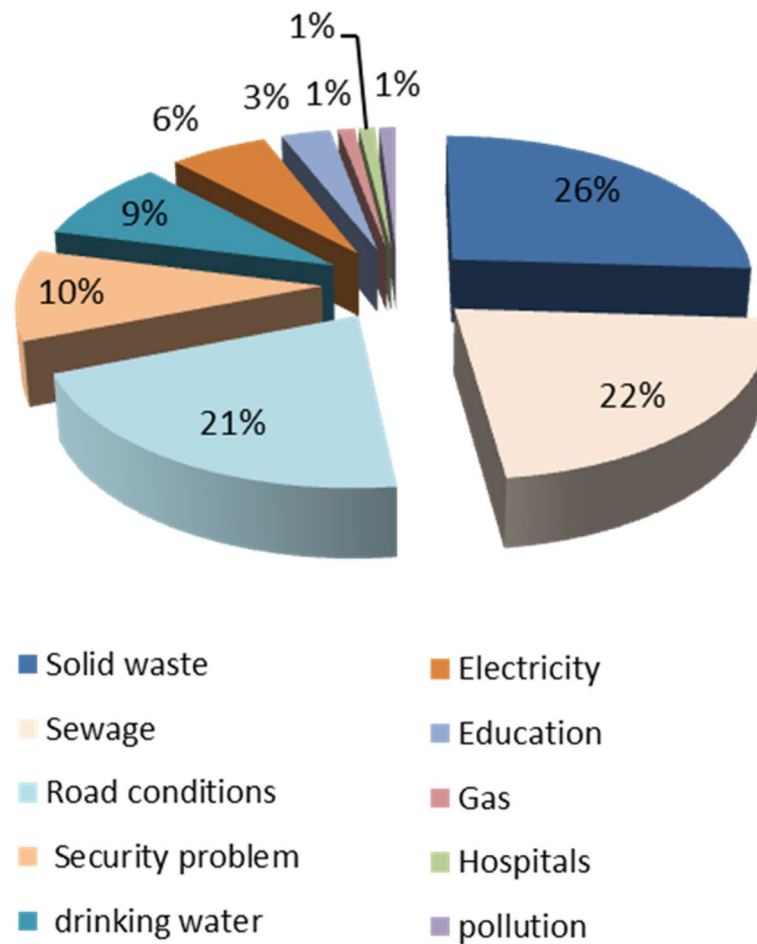




**Fig. 8** Location of Boulaq El Dakrour District in Greater Cairo. Source: author, according to Google [29]

development for informal areas. However, the researchers found that the residents agreed with the experts. The residents' opinions were about the deterioration of the area, such as decreased access to work and productivity in the area, the decline of this finding supports the experts' opinions, as they are less valuable than the experts are, so they are common in that they reflect the region's deterioration. Among the positive points from the population's point of view and the experts' opinions is the availability of secure tenure, electricity, and the ability of the community to participate, as shown in Fig. 16.

The development that took place was limited and at intervals, and there needs to be follow-up. The problems in the region also increase, such as sewage and waste problems, security issues, education, health, and others, so sustainable development must be made to achieve a better standard of living and improve the quality of life.



**Fig. 9** The Priority of the problems in Boulaq El Dakroul for the population [30]

**Discussion**

Therefore, there was a case of deterioration in Boulaq El Dakroul, which required development and maintenance since the previous action was limited to spaced intervals and had no follow-up. Additionally, the problems in Boulaq are increasing, such as sanitation and waste problems, lack of security, unemployment, poor education, lack of healthcare, and other issues. However, on the other hand, there is the availability of secure tenure, electricity, and the ability of society to participate in the development process. Thus, the development of Boulaq should pursue more comprehensive sustainable development to achieve a better quality of life. The Boulaq case has shown the benefits of applying the proposed informal area’s sustainable development principles, highlighting the weaknesses and opportunities through the SPSS analysis of community responses to the interviews and questionnaire.

The case study has shown the applicability of the proposed principles, found relevant information, and related to real issues identified by the questionnaire respondents. However, not all the principles were equally easy to apply. For example, some data, such as information about promoting local food production and reinvesting in

**Table 3** Sustainable development principles assessment for Boulaq El Dakroul

Economic sustainability		
Basic needs		
1	Eliminating poverty and hunger	The percentage of the poor in the region is 27.41% <sup>a</sup>
2	Providing basic needs of food, drink, housing, and others	The residents built their own houses and connected the infrastructure services <sup>a</sup>
3	Providing security of tenure (rent or property documents)	Security of tenure is available in the form of rent or ownership
Work		
4	Eliminating unemployment and providing a variety of job opportunities that are easily accessible with good local training services	The unemployment rate is high among the youth and females, where the number of workers in the region is estimated at 43,837, the number of unemployed persons is estimated at 5995, there is a shortage of job opportunities, and they are available only for skilled workers <sup>a</sup>
5	Contributing to economic recovery by encouraging local offices/workshops and crafts, working from home/office	There are many workshops throughout the region <sup>a</sup>
6	Encouraging small projects	There are many shops, and GIZ gives funding and support for small and medium projects <sup>b</sup>
Productivity		
7	Promoting local production of food and other goods/services and reinvesting in local communities	Not available
8	Providing adequate public spaces for trading, whether individual or institutional, intensifying urban assembly points and corridors to maximize the benefit of such trading spaces	GIZ <sup>b</sup> developed 60 fruit units and 114 vegetable units. There are also unique spaces available for fruit and vegetable markets <sup>a</sup>
9	Providing effective transport systems for people and goods	Available but not sufficient
10	Promote multi-axis urban development, allowing for synergies between centers and subcenters	None
11	Promoting the diversity of land use to strengthen economic bloc and land development and convert it to a source of income	Various land use: residential, commercial, and workshops
Social sustainability		
Health		
12	Providing adequate public infrastructure and facilities for healthcare	Twenty-two private health units, eight public health units, 117 private physicians, and 272 pharmacies provide health services <sup>a</sup> . GIZ has established a health office providing vaccinations and contraceptives <sup>b</sup>
13	Providing a pollution-free environment that facilitates the exercise of physical and mental health activities	There has been a rise in the frequency of gastrointestinal and allergic reactions due to sewage problems and dust spread in the unpaved streets and garbage piles <sup>a</sup>
14	Improving health status	There is a low health status
Education		
15	Providing public infrastructure and adequate facilities for education	GIZ has made improvements to schools <sup>b</sup> . However, there still needs to be secondary schools in the region, and the quality of education could be better
16	Eliminating illiteracy	A proportion of the population is illiterate
17	Providing adequate education opportunities	Deteriorated education inside the region and the high costs of private lessons <sup>b</sup>
18	Increasing community awareness and culture	GIZ has implemented more than 20 projects for local initiatives by NGOs, conducted many interviews with community members, and planned workshops to activate new types of participation and interaction <sup>b</sup>

**Table 3** (continued)

	Community safety	
19	Providing security systems increases the sense of security and belonging	Frequent quarrels and acts of violence and a high rate of addiction and drug trafficking are recorded, as there are no police stations in the region <sup>a</sup>
20	Achieving Social balance at the neighborhood level	not available
21	Providing multi-use neighborhood centers and open areas	GIZ has made improvements to public spaces (green areas—seats) <sup>b</sup>
	Equality and freedom of choice	
22	Facilitating access to permanent housing and diverse services for all community categories	GIZ has built six youth centers with sports courts, changing rooms, and a gym. It built the first fire station, renovated an ambulance unit, constructed a new one, and provided different administrative services (Post Office-Official Registry Office-Community Service Center) <sup>b</sup>  There are nine youth centers and entertainment services that are not open to the public, but there are amusement parks and one youth center that are open to the public <sup>a</sup>
23	Providing diverse income-generating communities and diversifying affordable housing options	There is less access to housing, and services could be better
24	Providing public infrastructure and adequate facilities such as civic centers, libraries, sports facilities, commercial areas, open areas, entertainment areas, and others	Residential options could be better, and there is an increase in rental rates There is a range of different housing levels suitable for other classes, from craft working class to university professors <sup>c</sup>
25	Securing a continuous and open society	There are solid human relations among the population <sup>a</sup>
26	Maintaining social justice and promoting gender equality and empowerment of women	It is not safe for women to go out due to harassment and lack of safety and security <sup>a</sup>
27	Providing easy access to all facilities on foot or using public transportation, paying Special attention to the requirements of children and the disabled, and improving mobility	Not all utilities are easily accessible
	Participation	
28	Enhancing community participation in the various stages of development processes (in terms of effort, funding, decision-making, etc.)	GIZ had partnerships with some community members (youth-women) and selected seven community members to lead seven committees, each consisting of 200 active members, creating new forms of cooperation, and providing advisory services <sup>b</sup>
29	Participation of government agencies	GIZ contacted the neighborhood and the government <sup>b</sup>
30	Participation in nongovernmental organizations	GIZ organized 150 local NGOs under one Board of Trustees <sup>b</sup> There are 183 NGOs <sup>a</sup>
31	Participation of financiers	Successful cooperation with some private companies (RWE-Mobinil) <sup>b</sup>
32	Develop a global partnership	GIZ <sup>b</sup>
	Environmental sustainability	
	Natural Resources	
33	Ensuring fresh air and clean water while reducing pollution, CO2 emissions, and toxic gases and reducing thermal islands	Some areas have air, water, and acoustic pollution <sup>a</sup>
34	Maintaining climate stability and adaptation to climate change	Unstable climate
35	Maximizing benefits from natural resources (sunlight, water bodies, wind, etc.)	The nature of the informal areas reduces the ventilation and the adequate entry of sunlight and then increases the humidity and increases the sense of cold, especially in winter <sup>a</sup>
36	Developing a plan to restore ecosystems and conserve biodiversity	None

**Table 3** (continued)

37	Environmental management, environmental monitoring, and public participation in environmental decision-making Buildings and infrastructure	None
38	Constructing valid and sanitary buildings	GIZ has rehabilitated 15 houses <sup>b</sup>
39	Reuse existing buildings and maintain and adapt to historical resources	Not available
40	Supporting densities through the development of integrated infrastructure	Infrastructure is unable to support high densities
41	Supporting flexibility in exterior and interior design Water	Not available
42	Facilitating access to water with local drinking water sources and managing water demand	GIZ has improved water services <sup>b</sup> There are two water stations. Additionally, there is worn out water network, and sometimes there is polluted water and an increase in the percentage of chlorine <sup>a</sup>
43	Providing high-quality water treatment surfaces and water sustainability	None
44	Ensuring water efficiency in the building and landscaping	None
45	Considering rainwater Management	None
46	Adopting a system for leakage and recycling of water Sewage	None
47	Improving sanitation services	GIZ has improved the sewer service and replaced the old network However, one of the most serious issues is a rash of sewage in some neighborhoods since the canal's filling caused a rise in groundwater level <sup>a</sup>
48	Providing local wastewater treatment surfaces, reuse of groundwater	None
49	Presenting sewage and recycling management Waste	There are three sewage stations <sup>a</sup>
50	Reducing waste	GIZ did a cleanup campaign*but it was not enough, as waste is still existing in some streets <sup>a</sup>
51	Constructing solid waste management infrastructure	None
52	Improving methods of collection, disposal, recycling, and use of wastes	Lack of waste collection services, insufficient garbage boxes, and burning of waste increase waste and pollution rates. Additionally, the spread of stables in front of houses and so the spread of insects <sup>a</sup>
53	Adopting organic waste recycling programs and utilizing it as a local fertilizer Electricity	None
54	Providing electricity	There are two power stations and two natural gas stations, and there is a rise in electricity prices in many houses due to the lack of independent meters, and some families must get electricity illegally <sup>a</sup>
55	Ensuring energy efficiency in buildings, infrastructure, and site	None
56	Using clean and renewable energy and reducing nonrenewable energy usage	None
57	Adopting passive urban design to reduce carbon emissions	None
58	Using environmentally friendly technology Earth and soil	None

**Table 3** (continued)

59	Planning for urban densities to reduce land use, energy consumption, and environmental footprint of settlements	High densities
60	Reducing urban crawl	Fully occupied area
61	Conservation and management of long-term preservation of housing, agricultural lands, and water bodies	There are buildings constructed on agricultural land
62	Using innovative and easy ways to access sites	Featured location
63	Protecting steep slopes and avoiding floods and high-risk areas	Safe location and less risky areas
64	Developing the previously used sites (brownfield), preventing pollution resulting from it, and restoring agricultural land and water bodies	None
65	Using local and recycled building materials Transportation	None
66	Improving the quality of communication and connectivity between neighborhoods and Providing services that reduce transportation time (near dwelling and employment)	There is a pedestrian bridge connecting the area to the surrounding regions <sup>c</sup> The transportation network from and to the site is good <sup>a</sup>
67	Providing and managing good road networks and efficient public transportation	GIZ has improved the transportation and traffic systems and covered 320 m of Al-Zomor Canal for Environmental Development and Transport <sup>b</sup> Streets within the area are narrow and allow only the passage of tuk-tuk <sup>a</sup>
68	Increasing streets designed for pedestrians	Narrow streets do not allow traffic, while streets designed for pedestrians enhance walking and cycling and reduce reliance on vehicles <sup>a</sup>
69	Reducing parking spaces	There are two parking spaces-4 minibus parking spaces <sup>a</sup>
70	Providing cycling infrastructure (the road network of bicycles and parking racks)	None
71	Reducing traffic congestion and increasing traffic facilities	Traffic jams, haphazard microbus and tuk-tuk parking, and street vendors encroaching on streets from both sides of the market may be found on the region's edges <sup>a</sup>
72	Expanding transportation networks by setting sidewalks and shaded streets with trees on both sides	GIZ planted trees, sidewalks, and 500 lighting units on 50 streets <sup>b</sup> However, lighting poles are only available in some areas, and the existing floodlights are not maintained
	Quality of life	
73	Improving architectural and urban aesthetic quality (overall design and vision (	GIZ colored the facades <sup>b</sup>
74	Promoting identity, culture, and preservation of heritage Evaluation, follow-up, and maintenance	None
75	Evaluating, following up, and maintaining development projects	None
76	Adopting a plan that includes development and orientation for expansions	None

<sup>a</sup> [30]<sup>b</sup> Unpublished reports from GIZ, 2017<sup>c</sup> [31]

local communities, were unavailable. Although there is no local production, there may be some unannounced local production. In addition, achieving social balance at the neighborhood level was difficult to assess because data about income in the community was not available.



**Fig. 10** Taraat Al-Zumar market before development [31]



**Fig. 11** Taraat Al-Zumar market after development [31]

Moreover, supporting flexibility in exterior and interior design was difficult to assess, as additional studies are needed to reach within the appartements. Additionally, some principles were not applicable, such as developing a plan to restore ecosystems and conserve biodiversity; adopting a system for leakage and recycling of water; adopting organic waste recycling programs and utilizing them as a local fertilizer; ensuring energy efficiency in buildings, infrastructure, and sites; providing cycling infrastructure; and evaluating, following up, and maintaining development projects. While providing adequate public infrastructure and facilities for healthcare and education were easy to reach from the Participatory Development Programme and GIZ reports, other data were



**Fig. 12** Building facades before development [32]



**Fig. 13** Building facades after development [32]

collected through site visits regarding being built on agricultural land and having high densities, as shown in Table 3.

As mentioned, experts verified the sustainable development principles of the developed informal areas, as shown in the SPSS results of the questionnaires. They did not exclude any point in the principles, but they assigned each different relative weight, as discussed in Table 3 above. As a result, informal area sustainable development principles support the decision-making process to evaluate and guide the implementation priorities of the informal areas' sustainable development.





**Fig. 14** Infrastructure interventions: improving the sewage network [31]



**Fig. 15** Infrastructure interventions: New pedestrian bridge [31]

The proposed principles cover all pillars of sustainability, filling the gap identified earlier in the literature; Khalil [21] selected principles from urban development theories to help develop informal areas sustainably, but they were not comprehensive. Furthermore, it complements the QOL index for unsafe areas developed by Abdel-Moneim et al. [33], as the currently proposed principles cover informal areas (unplanned areas) with different characteristics.

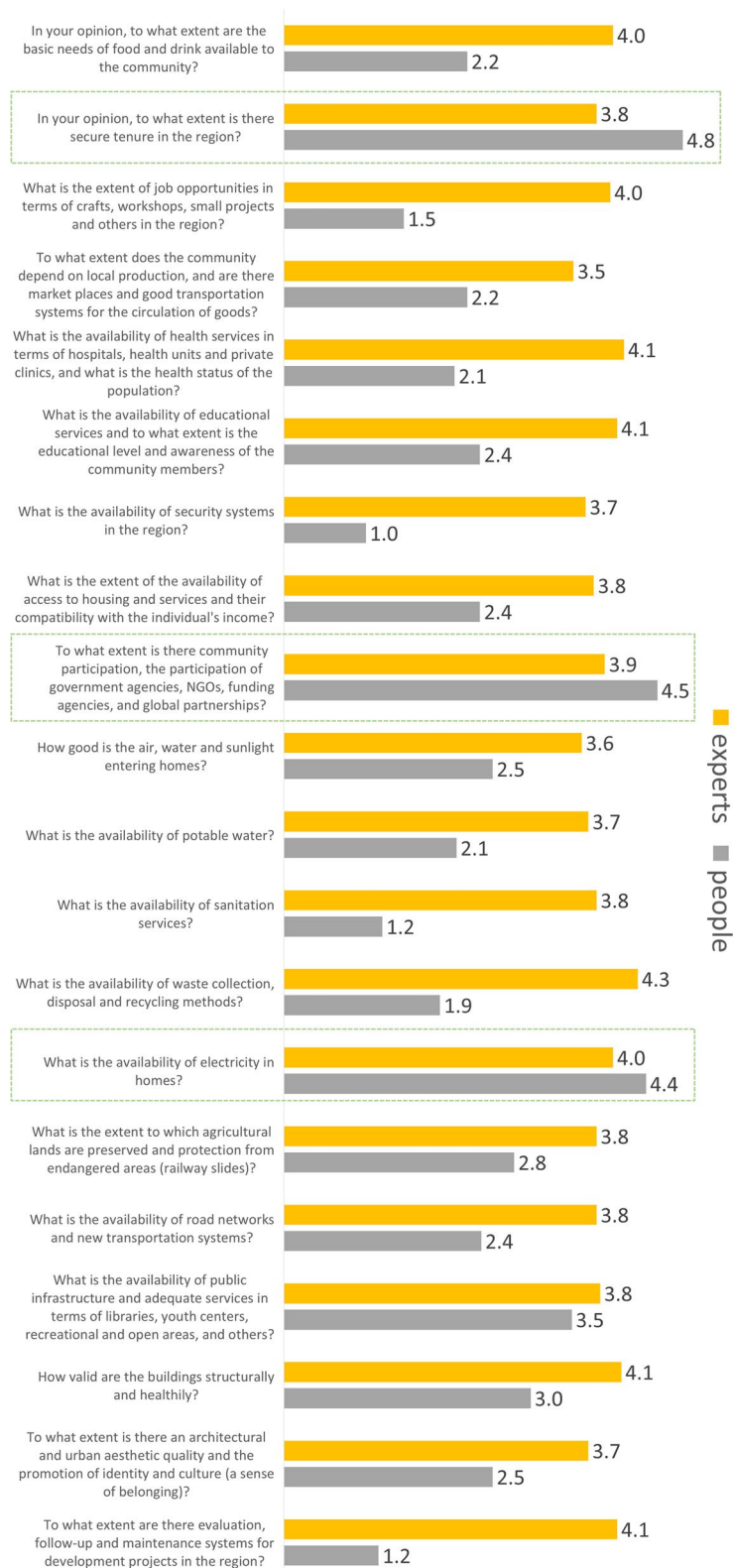


Fig. 16 Analysis of the positive and negative points in the Boulaq El Dakroul area. Source: the researcher

## Conclusions

Informal areas represent a major problem in Egyptian urbanism; the previous development projects did not fulfill the residents' needs or ensure the sustainability of their efforts. Therefore, sustainable urban development principles must be revised, especially for informal areas. So, the research tried to fill this gap by providing informal areas with sustainable development principles. The informal area's sustainable development principles can be reached by integrating urban development principles and checklists while considering the special conditions and problems of informal areas.

These principles also help the decision-making process guide the implementation priorities in the sustainable development of informal areas. Hence, they can be included in governmental urban development plans and in the work of other agencies concerned with developing informal areas such as UN-Habitat and others.

The research applied these principles to the Boulaq El Dakrou case study and concluded that the development made is not sustainable and the region needs comprehensive sustainable development to achieve a better quality of life.

The study has potential limitations that could affect its generalizability, representativeness, and reliability. Firstly, the studies can be applied to other informal areas worldwide but require different relative weights suitable for their context. Secondly, the sample size of 50 urban development experts may not fully represent diverse perspectives and expertise in informal areas. Thirdly, the study heavily relied on expert opinions, which could be subjective and biased. Lastly, the study only assessed the sustainability of previous development efforts in Boulaq El Dakrou over a specific timeframe, and its long-term impacts and outcomes require further investigation.

The future research direction aims to utilize the principles of sustainable development in informal areas through the implementation of Geographic Information Systems (GIS) programs. By integrating GIS and parametric urban design programs, a parametric model will be developed to assess and enhance informal areas in a sustainable manner. This model will provide decision-makers with insights into appropriate interventions for development.

## Abbreviations

SPSS	Statistical Package for Social Sciences
GIZ	The German International Development Agency
HBRC	Housing and Building Research Center
SDGs	Sustainable Development Goals
LEED	Leadership in Energy and Environmental Design
UK	The United Kingdom
CPI	City Prosperity Index
ISDF	Informal Settlements Development Fund
CIF	Community investment fund
LPC	Local Popular Council
NGOs	Nongovernmental organizations
NDC	The Government of Egypt has revised its Nationally Determined Contribution
GIS	Geographic Information Systems

## Acknowledgements

I am grateful to my professors, family, friends, and colleagues for their support and recognition.

## Authors' contributions

MG, AA, and HK participated in all the paper sections. All the authors have read and approved the manuscript.

## Funding

Not applicable.

## Availability of data and materials

Data availability at any request.

## Declarations

### Competing interests

The authors declare that they have no competing interests.

Received: 29 March 2023 Accepted: 15 January 2024

Published online: 05 March 2024

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