SVU-International Journal of Engineering Sciences and Applications (2023) 4(2): 47-75
Print ISSN 2785-9967 | Online ISSN 2735-4571
DOI 10.21608/SVUSRC.2023.186364.1098

A Framework of EBRD Green Urbanism Program for Developing New Egyptian Cities by Using GIS and Remote Sensing (Case Study: Six October City)

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Abstract Several cities at the international and local levels have adopted the green urbanism approach to reach sustainable communities in the environmental, economic, social and institutional sectors, due to the challenges of high pollution rates and non-optimal exploitation of natural resources, energy and water, especially with the increase in urban expansion and high rates of development in many cities. The application of the green urbanism approach was based on a set of indicators which developed by a number of international programs such as LEED, BREEAM, CASBEE and the indicators of EBRD Green Cities Program. These programs targeted the transformation of existing and new urban communities into green ones to improve their performance and meet their current and future needs with least possible challenges. The EBRD green city program is considered one of the comprehensive programs that have been applied different cities around the world, and covers most green urbanism. At the local level, The Sustainable Cities Unit and the Egyptian Council of Green Building and Sustainable Cities try nowadays to develop new applicable policies, plans and indicators of green urbanism to achieve the pillars of Egypt Vision 2030 by using EBRD green city program. Therefore this paper aims to formulate suitable framework for implementing the green urbanism approach in developing new Egyptian cities by using EBRD program. This comes reviewing the previous studies, experiences and international reports on green urbanism indicators, especially EBRD program. In addition to evaluating Six October city (the first new city, which joined the EBRD Program in April 2021) according to EBRD indicators by using GIS and remote sensing technology to identify their challenges and put suitable framework to develop it into green one.

Keywords: Green urbanism– Sustainable development– EBRD program – New Egyptian cities – October city- Remote Sensing - Geographic Information system.

1. Introduction

Although the application of green urbanism is somewhat recent, its idea is considered old, through the initial human thought about the adaptation with environmental factors [1]. This appeared in using building materials from nature and the design of the buildings facades and interior spaces [2]. With the period of the industrial revolution and technological progress, the environment has been neglected and its resources are pressured, which led to the amplification of environmental problems, including the lack of energy and natural resources [3]. Therefore, the idea of green building began and appeared in Howard's writings in 1902 about garden cities, which aimed to improve the quality of life in cities and create green areas around them to reduce pollution rates, congestion and social disintegration as a result of the negative effects of the industrial revolution [4]. Then a counter trend emerged, which represented in (Cities of Tomorrow), like the ideas of Le Corbusier and Mies van Drue in 1922 [2]. This trend relied on modern construction for cities through building skyscrapers with (functional architecture) without any environmental considerations [5, 6].

As a result of neglecting the environmental dimension in these ideas, an opposite trend emerged during the forties and fifties, which called (organic architecture that merges with nature as a living organism) [7]. Some architects have adopted this trend such as the writings of the American architect Frank Lloyd Wright and his planning fo Broadacre city to correspond with the local climate and natural elements [8]. With the beginning of the sixties, the interest in protecting the environment increased as shown in some studies such as Rachel Carson' book (Silent Spring) [9], in addition to some movements such as the (Friends of the Earth, the Green Peace and the Building Biology), which indicated the importance of using environmental regulations to protect the environment from the dangers of pollution in cities [2].

Received:10 February 2023 Accepted:23 February 2023
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During the sixties and early seventies, these movements influenced the writings of many architects, such as Victor in 1963, Banham in 1965, Lewis in 1965 and Ian in 1969 [6].These writings put forward the principles of architectural designs, which compatible with the environment and climate. All the previous studies focused on green building more than green cities, to create clean, safe and environmentally compatible buildings.

In 1980, the thinking about green city in a more comprehensive way than green building, through what was set by the International Union for the Protection of the Natural Environment and the United Nations around the preserving the environment and not depleting the resources for current and future generations [10]. The concept of sustainability in cities was presented by the Brundtland conference in 1987, which indicated the importance of achieving a balance between economic, environmental and social dimensions through the management of natural resources in favor of economic growth and social prosperity [11].

In 1992, the Earth Summit was held to achieve sustainable development in cities due to the high consumption of resources, as a result of urban activities concentration that consume more energy, land and water [10]. In the late nineties, the Green Urbanism approach appeared in North America, which adheres to the green principles of Howard and Frank Lloyd Wright to re-plan some American cities though creating sufficient green spaces in gardens and around pedestrian paths and streets [12].

This approach spread in the field of sustainable urban design to meet the needs of current and future generations [13], and also in the field of urban planning through compact cities and mixed land uses concepts to save energy and water and achieve the best exploitation of resources, especially with the increasing urban growth in most world cities [14]. At the level of the Arab world, the pressure on natural resources has increased, which made the governments look for new ways to preserve and manage the environment elements, especially energy and water. A number of attempts emerged in some countries such as the green revolution in the Emirates which represented in Masdar City (the futuristic carbon-free city. in Abu Dhabi city [15]. In Egypt, the attention was paid to green urbanism through Egypt's Vision 2030 and the formation of the Supreme Council for Green Architecture to implement standards and indicators of green urbanism in Egyptian cities, whether existing or new [16].

With the spread of green urbanism internationally, many systems and programs were formed that set its principles and controls to transform cities into sustainable green ones. The most famous of these systems are BREEAM, SBTOOL, LEED, Green Globes, BEAM, Green star, CASBEE and EBRD green city [17].

Focusing on the EBRD green city program, it is one of the comprehensive systems for implementing the concept of green urbanism. It began its work in 2012 and issued a number of reports in 2016, 2018 and 2022 to introduce a framework, principles and indicators for green cities [18]. These principles cover many sectors such as (air , energy , water , transportation, building ,solid waste , land use .. etc.). This program has been applied internationally in about 48 cities until August 2022, among these cities (Amman - Almaty - Ankara - Ganja - Istanbul) by financing their proposed projects to address the environmental challenges they face [19]. In 2019, the Ministry of Housing contracted in 2019 with the European green city Program (EBRD) to apply its indicators in some existing cities such as Cairo and Alexandria. And in 2021, Six October city became the first member from the new Egyptian cities in this program [20]. Therefore, the New Urban Communities Authority recently seeks to develop policies and applicable rules to apply EBRD program in line with new Egyptian cities characteristics and their environmental issues, and this is what the research paper aims at.

2. **Materials and Methods**

2.1. Research Objectives

According to the recent membership of the 6th of October City in the comprehensive green cities program of EBRD in 2021 (the first membership for a new Egyptian city), in addition to the recent aspirations of the Ministry of Housing to develop appropriate policies and mechanisms to implement the green urbanism approach in the new Egyptian cities, the paper aims to formulate suitable framework for implementing the principles of green urbanism which proposed by the EBRD program, to transform new Egyptian cities into green cities. This framework includes (steps of implementing green urbanism approach- the suitable indicators for characteristics of the new Egyptian cities- required strategies for dealing with priority environmental challenges- responsible authorities). This framework can be used in evaluating or planning new cities in the future to create environmentally compatible green communities.

2.2. Methodology

The following figure No 1 shows the used methodological framework to achieve the main research objectives.

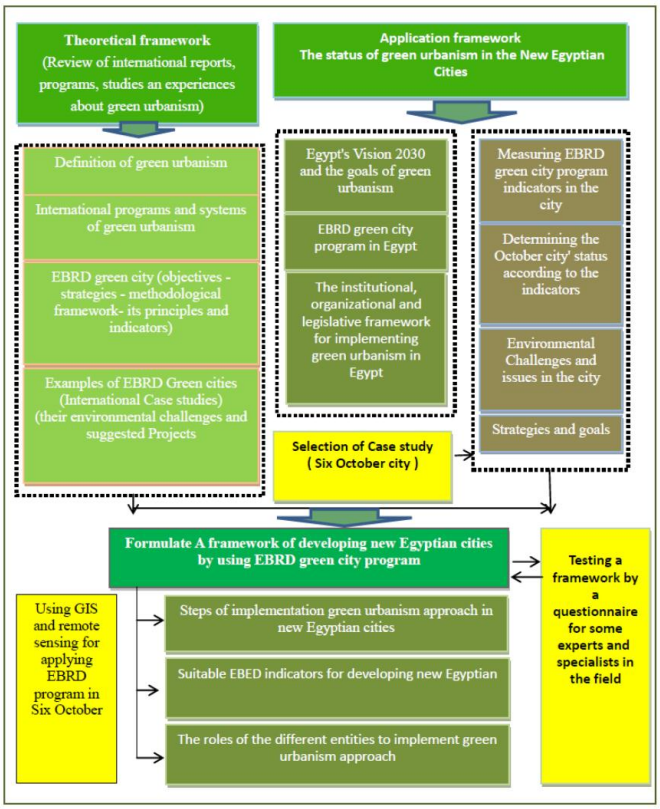

Fig. 1. Methodological framework of the study (Author)

3. Literature Review

The theoretical framework and literature review covers the concept of green urbanism, as well as the programs for defining the characteristics and dimensions of green urbanism in general, focusing on EBRD program in particular. In the part of EBRD program analysis, its principles, objectives and indicators are explained, beside the analysis of international experiences related to program member cities to benefit from their results in developing new Egyptian case by using this program.

3.1. Defining Green urbanism approach

There are many concepts, dimensions, and terms related to green urbanism, which presented by studies, international reports and some organizations. The first term focused on climate dimension (*green climate urbanism*), which is defined as a model for a city that takes into account the climatic conditions (wind - solar radiation - humidity - heat..) in its designs to reach a city with the least environmental footprint [21]. The term was developed in the fifties to include standards of the lowest carbon emissions, which called (*Zero Carbon urbanism*) to reduce the pollution rate; due to human practices and industrial activities that have caused environmental problems [22]. In the early sixties, the term (*Green energy*) was used through using the renewable energy sources such as solar energy, wind energy and water, or mixing between renewable and non-renewable energy by using advanced technology. With the increasing the amount of waste resulting from human activities, another term has emerged in late sixties, which is (*Zero waste urbanism*) [24]. This term referred to the management, recycling and using various wastes again in new products, in addition to energy generation or fertilizer from these wastes, to reduce their existence in cities, especially the harmful ones [25].

As a result of the importance and scarcity of water resources in the world, some cities used the term of (*green water urbanism*) during the seventies, to manage water and achieve high quality for it, through the use of rain, flood waters and wastewater treatment, in addition to relying on less water-consuming uses [26].

Since the late seventies, the interest of providing more open areas in cities has increased, which called (*green Landscape urbanism*) [23]. This term means formation of urban landscapes with environmental, social and economic returns, through creation recreational areas within or on the edges of cities or on the roofs of buildings to reduce heat and purify the air [5].

International statistics at the beginning of the eighties indicated that the transportation sector contributed to more than 20% of pollution rates in major cities, so another term (*green urban transport*) [12]. This term motivates the using of clean transportation means, reducing the use of cars, as well as adopting on the lowest possible walking distances through the integration of different uses which were applied in the idea of Transit-Oriented development [27]. In the late eighties, there was increasing in using environmentally incompatible construction materials with high cost, which led to new term (*green building*) [28]. This term concerned with the use of available construction materials from the environment such as wood and glass, which easy to design buildings and can be recycled without any pollution or Harmful emissions [29].

Urban land uses of large cities have spread at the expense of agricultural lands and natural resources since the nineties, which called for applying the principle of urban design integration, creating compact cities and increasing the density within cities to achieve urban sustainability (*green urban densification or green mixed use*) [5,29]. This comes through reusing urban structures, utilizing the untapped capabilities within the city and mixing land uses in the same development unit with the preserving historical and cultural values of those cities [30].

The technological development in the twenty-first century gave new term, which called the (*green intelligent urbanism*) [30]. This term referred to using emerged modern technologies in design, energy use, water management, building design and waste management to reach more sustainable cities [30]. During the past few decades, the resilient city concept appeared to face the natural and human risks and put suitable solution for them. So the term of (*resilient green urbanism*) associated with this concept to address the risks in the cities, especially the environment risks and transform the cities to more green cities [31].

In the last years, urban management has an important role in achieving good green urbanism, which called (*green urban governance*) [3].This term is applied through (political support to achieve sustainability goals- providing new methods for making ideal planning decisions with the participation of residents- the development of appropriate legislative and legal frameworks) [3]. Recently, several international reports have developed some definitions for green urbanism that combines previous dimensions and concepts, such as the United Nations Cities Prosperity Report in 2018, which defined it as a model of urban design without any carbon emissions or waste and with supporting energy-saving and integrated urban growth to create socially and environmentally sustainable urban areas [32].

In 2022, The Green Cities Program of EBRD putted comprehensive definition, in which green urbanism is a framework for planning and designing cities in a more sustainable way to create environmentally friendly cities with less pollution, emissions and waste, and with using all available materials in the environment, including construction materials and renewable energy, and under good environmental management during the stages of the city's life cycle [18,19]. This concept includes previous concepts and principles in the sectors of water, energy, transport, waste and land use...and this is what the research focuses on. The following figure 2 shows the development of different green urbanism' terms and dimensions [18].

3.2. International programs and green rating systems for buildings and cities

There are many governmental and non-governmental organizations, associations and institutions that adopted the idea of green urbanism and proposed a set of systems and indicators for application and evaluation the buildings and urban elements according to the green standards. These indicators differ from one system to another and from one country to another. The first system is BREEAM system (Building Research Establishment Environmental Assessment Methodology), which was issued in the United Kingdom in 1990 and was used in many Western and Arab countries as an environmental assessment system by focusing on some sectors such as (building- water- transport - waste - efficiency of land use - pollution) [33].

In 1996, the SBTOOL system (Sustainable building tool) began in Canada to measure the environmental sustainability of buildings [33].Then the assessment systems were developed in 1998 into the LEED (Leadership in Energy and Environmental Design) system, which formulated by the US Green Building Council. LEED is the most widely used internationally; it focuses on measuring the sustainability of some urban elements (site efficiency- Energy, water, materials and resources, the improvement of the indoor environment, building design and innovation) [34].There are some versions from LEED system to measure the environmental performance of different levels (buildings, neighborhoods or cities).

On the other side, a number of evaluation systems appeared in some countries, such as the CHP system (Combined Heat and power) by the United States of America in 1999, which aims to achieve energy efficiency and reduce pollution rates in buildings and cities [35]. In 2000, the Green Globes evaluation system was issued in Canada to assess the environmental performance of buildings from (site - energy - water - resources - waste - internal environment - project management) [17, 36]. And try to confront the environmental problems facing the different stages of the construction process [36]. While in Hong Kong, the BEAM (Building Environmental Assessment Method) system was introduced in 2002 to improve the quality of old and new buildings during the life cycle stages of buildings [17, 37].

The United States of America formulated GGHC (Green Guide for Healthcare) system in 2003, to ensure the achievement of sustainable and healthy buildings in the design, construction and implementation stages, especially in industrial areas [38]. As for the Green Star system was issued in Australia in 2003 and used in many countries such as New Zealand and South Africa [39]. This system combined the principles and sectors of both BREEAM and LEED such as (management – quality of internal environmental – energy- transportation- water - materials - site ecology – carbon emissions) [17]. In 2004, the CASBEE system created by the National Green Building Council of Japan to measure the quality of buildings and their relationships with the surrounding environment through assessing the sectors of (energy – resources - site efficiency - internal environment - quality of services - off-site environment) [40].

In the same year, France issued the HQE system to measure the environmental quality of buildings in cities [41].This system also provided guidance during the project stages, whether for the development of old buildings or the construction of new ones. In India, the GRIHA (Green Rating for Integrated Habitat Assessment) system was

introduced in 2005 to control energy and water consumption and reduce the waste and emissions to a minimum level [42].Also in 2005, two systems appeared, the first one was NABERS system in Australia, which measures the environmental effectiveness of buildings after their construction and operation [43]. And the second system is BCA green mark system in Singapore as a method of evaluation and motivation the developers and buildings owners to achieve environmental sustainability in their urban projects [44].

In 2006, China issued two systems, GBAS and TREE Star. GBAS (Green Building Assessment System) is concerned with the environmental assessment of different types and levels of buildings and urban areas [45]. While TREE Star specifies in detail the criteria of environmental assessment for buildings and urban areas in the sectors of (Land- energy - Water- Resources- environmental elements - operation) [17].

In 2009, Germany had another evaluation system which called GSBC (German Sustainable Building Council) in order to improve the quality of life and achieve the highest rates of sustainability through building process [46]. In the same year, the American LEED system in Japan was developed into LEED V3. It used old LEED standards and focused more on energy and carbon dioxide emissions to reduce them in cities by using modern technological systems [47].

Since 2009, a group of environmental assessment systems have appeared in a limited number of Arab countries where a Green Building Council is present. In the Gulf area, a version of the BREEAM system was formulated in 2009, with a name of BREEAM GULF to meet the climate challenges in the Gulf area [48]. In Lebanon, there is a system of thermal standards for buildings, which was formed in 2010 as an attempt to rationalize energy in buildings [17].

While in the United Arab Emirates, the Estidama (AUE) system was issued, which uses PRS (Pearl Rating System) for buildings and residential communities to help owners, designers and real estate companies in building more sustainable communities by taking into account a set of environmental, social, economic and cultural criteria such as (natural systems- Internal and external spaces- water-energy- resources management- creative practices-integrated development) [49]. In Qatar, the QSAS (Qatar Sustainability Assessment) system was developed in 2010 to achieve a sustainable urban environment. This system includes many environmental, economic, social and cultural criteria such as (energy- water- indoor environment - economic and cultural value- location- Construction materials- urban communication - management and operation) [50]. In 2010, the LEED system was also developed in the United States of America to include the ND - LEED to achieve green neighborhoods and communities [51].In Egypt, the Egyptian Council for Green Buildings was formed, which developed an assessment system for green buildings (the Green Pyramid rating System) in 2011. This system combines the two systems LEED and BREEAM for covering the elements of (sustainable sites- energy efficiency- water efficiency - materials and resources- indoor environmental quality - management innovation and added value) in evaluation process [52].

The EBRD Green Cities Program was established in 2012 to implement the standards of green cities in many world cities by granting the necessary funding. EBRD focused on a number of sectors, especially the infrastructure sector for transforming the cities to green ones [19]. In the same year, Eco2Cities, World Bank programs and BREEAM communities system were created in 2012 for getting more compatible cities. In the period from 2012 until now [17], new versions of the old systems were reformulated along with some new systems to measure the sustainability of green cities, including the CASBEE-city system to assess environmental performance for cities. This version depends on two main axes: the first is to improve the quality of life inside the city, and the second is to reduce the negative environmental impacts (environmental load) outside the city [17].

The OECD Green Cities Program in 2014 dealt with the green growth of cities to improve the environmental and economic quality of urban areas [17]. In 2018, a new version of LEED was released, which called LEED CC or LEED v4.1. This version assesses the social, economic and environmental conditions in the cities to achieve comprehensive sustainability [17].

The United Nations Human Settlements Program presented the city prosperity index in 2018 through the sectors of (productivity- infrastructure- integration-environmental sustainability- quality of life- governance) [53]. In 2019, ADB's Green Cities proposed an integrated framework to address environmental, economic and social challenges in cities, especially those related to climate change [17].The European Green Cities Network also provided a framework in 2020 to reach green buildings and cities. The old BEAM program was developed in 2021 into BEAM plus to ensure the sustainability of buildings in new urban communities. Finally, a recent publication was issued for the EBRD's Green Cities Program, which puts a comprehensive principles and indicators for implementing green urbanization in cities [17].

The following figure 3 shows the time evolution of International programs of Green building and urbanism in the world and the table 1 shows the degree of covering the green urbanism' principles in green cities programs. As the program is considered one of the most programs and systems that deal with the principles of green urbanism, it is also one of the modern programs that target many cities to use it to obtain appropriate funding for their development.

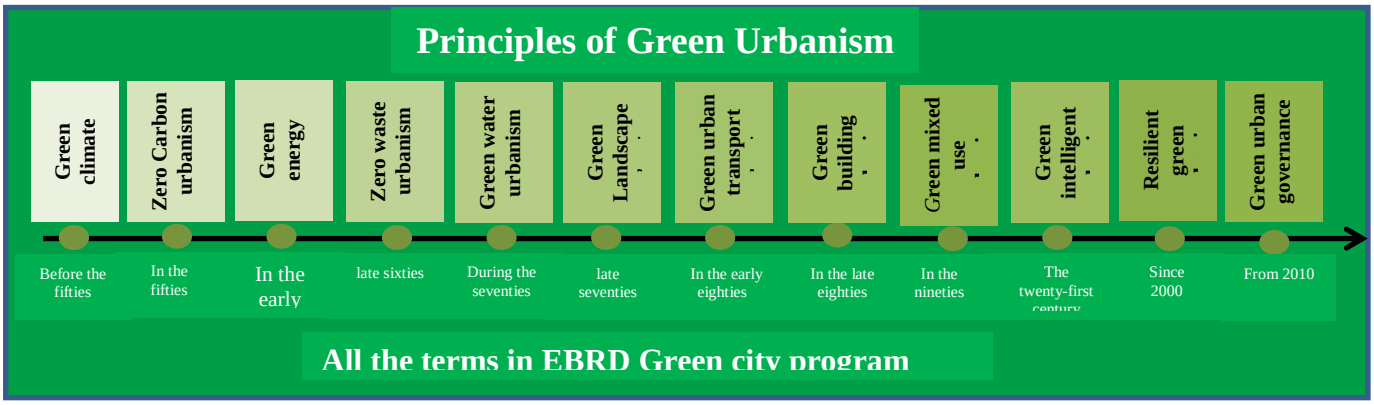

Fig. 2. Different green urbanism' terms and their dimensions (Author)

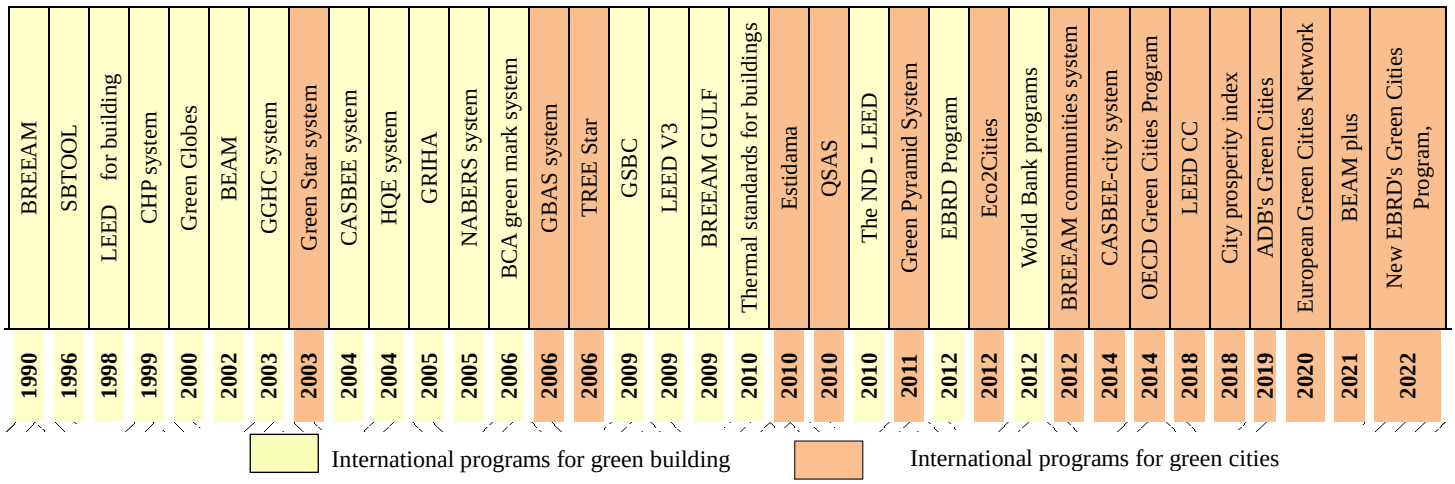

Fig. 3. The time evolution of International programs for Green building and cities in the world (Author)

Table 1. The degree of covering the green urbanism' principles in green cities programs

Programs for green cities / Principles of green urbanism	Green star 2003	TREE Star 2006	GBAS 2006	Estida-ma 2009	QSAS 2010	Green Pyram-id System 2011	Eco2 Cities 2012	BREE-AM system 2012	OECD Green Cities 2014	CASB EE-city 2014	LEED CC 2018	city prosp-erity 2018	ADB's Green Cities 2019	Europ ean Green Cities 2020	BEAM plus 2021	EBRD 2022
Sustainable site selection				■	■	■				■			■		■	
Climate and context			■	■			■	■	■	■	■	■	■	■	■	■
Transportation	■						■	■			■	■	■	■	■	■
Zero co2 emissions	■		■	■			■	■	■	■	■	■	■	■	■	■
Density and retrofitting and mixed land use											■	■				■
Green buildings and internal design			■	■	■	■	■		■	■	■	■	■	■	■	■
Water management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Landscape, garden and Biodiversity	■	■	■	■			■	■	■	■	■	■	■	■	■	■
Renewable Energy	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Local materials	■		■	■	■	■		■	■	■	■	■	■	■	■	■
Zero waste			■	■			■	■	■	■	■	■	■	■	■	■
Natural Resources		■		■		■	■		■	■	■	■	■	■	■	■
Governance									■							■
Operation and management	■	■		■	■	■		■				■				■
Environmental awareness												■				■
Preserving cultural values					■		■		■	■	■	■				■
Health and welfare							■	■	■	■	■	■	■	■	■	■
Community participation							■				■	■				■
Creativity and using technology				■	■	■	■		■	■	■	■	■	■	■	■
Special Strategies for Developing cities																■

Source: Author based on [17].

3.3 EBRD Green city program

3.3.1. Background about the program

The European Bank for Reconstruction and Development (EBRD) was established in 1991, and its environmental goals have been clear since 2012 by proposing a number of strategies to transform cities into sustainable green cities. These strategies included Green Economy Transition (GET), Municipal and Environmental Infrastructure Sector Strategy (MEI), Environmental and Social Policy (ESP), Economic Inclusion (EI), Gender Equality (GE), and Local climate initiatives (LCI) as shown in figure 4. [18, 19].

In 2018 and 2022, the EBRD Program developed a General Green City Action Plan (GCAP), in which most of the previous strategies were used as one of the central components of the program to cover the environmental, social and economic dimensions. Through this action plan, the environmental challenges of each city are systematically identified and evaluated according to a number of sectors (air - water sources - soil - natural hazards - land uses - climate - transport - buildings - energy - industry - waste..).Then, the cities determine their priorities and develop suitable action plan with suggestion some policies and procedures that are linked to sustainable infrastructure projects to meet their environmental challenges [18,19].

3.3.2. EBRD program Goals and Methodology

The EBRD program aims to transform 100 cities worldwide into green cities until 2024, and about 48 cities have joined the program until September 2022. Only 30 cities have developed an action plan to address their environmental challenges by offering some priority activities and projects.

The program covers the environmental, social and economic dimensions of green cities by focusing on investment in the infrastructure sector to achieve these dimensions. The following figure 5 illustrates the objectives and dimensions of EBRD green city program [18].

EBRD green city program follows general steps as shown in figure 6 to achieve the previous goals and dimensions. these steps focus on the approach of Pressure-State-Response (PSR), in which Status are the indicators for understanding the degree of environmental quality in the city, and Pressures are the factors that may negatively affect the environment. While Response are the actions that have been taken or that can be taken to address the pressures and improve the state of the environment, whether through the government, the private sector or civil society [18].

3,3.3. Principles and indicators of EBRD green city program

The following table 2 shows EBRD principles and indicators to implement, evaluate or transform the cities into green ones. The total numbers of indicators are 119 indicators, in which consist of 22 status indicators (nine of them are basic indicators), 63 pressure indicators (26 of them are basic) and 34 response indicators [18].

3.4. Main results of studying EBRD Green cities plans (International Case studies)

A number of EBRD member cities were selected as case studies, according to a set of criteria that serve the paper' objectives, including the selection of cities which (have already putted a framework for implementing the EBRD program – cover most of the environmental challenges- correspond to the existing environmental limitations in new Egyptian cities – have a diversity in the proposed projects and activities to address their challenges) [18].The following table 3 shows the results of those study cases, which are useful in knowing the projects types to address the environmental challenges and create more sustainable green cities.

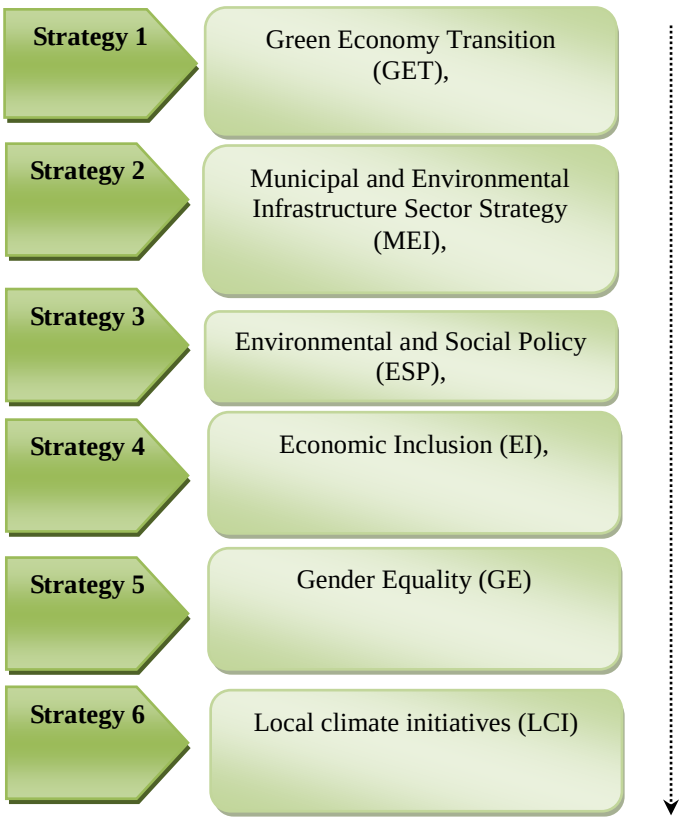

Fig. 4. Main strategies of EBRD Green city program (Author based on [18,19].

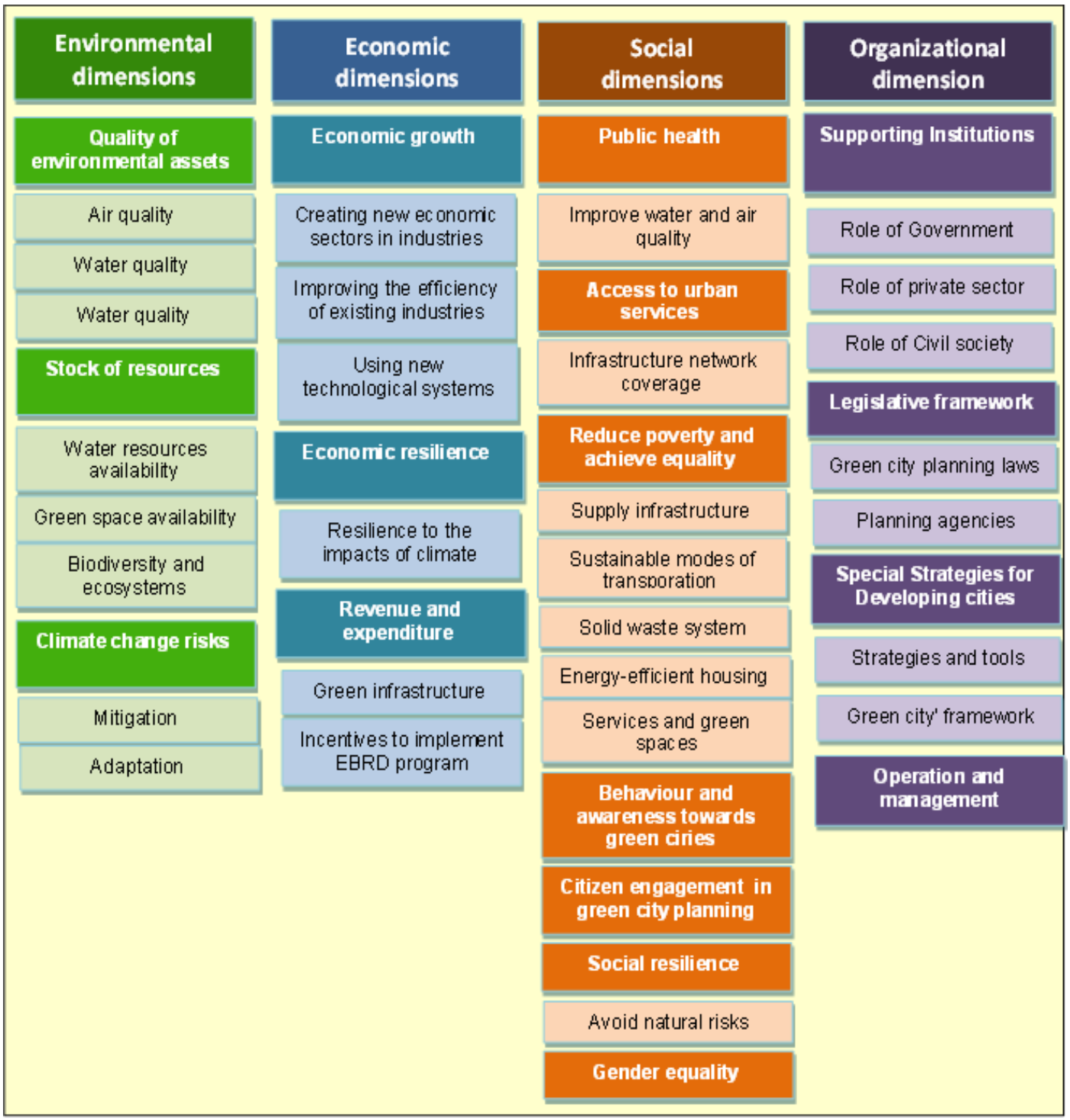

Fig. 5. Main dimensions and goals of EBRD program (Source: author based on [18]

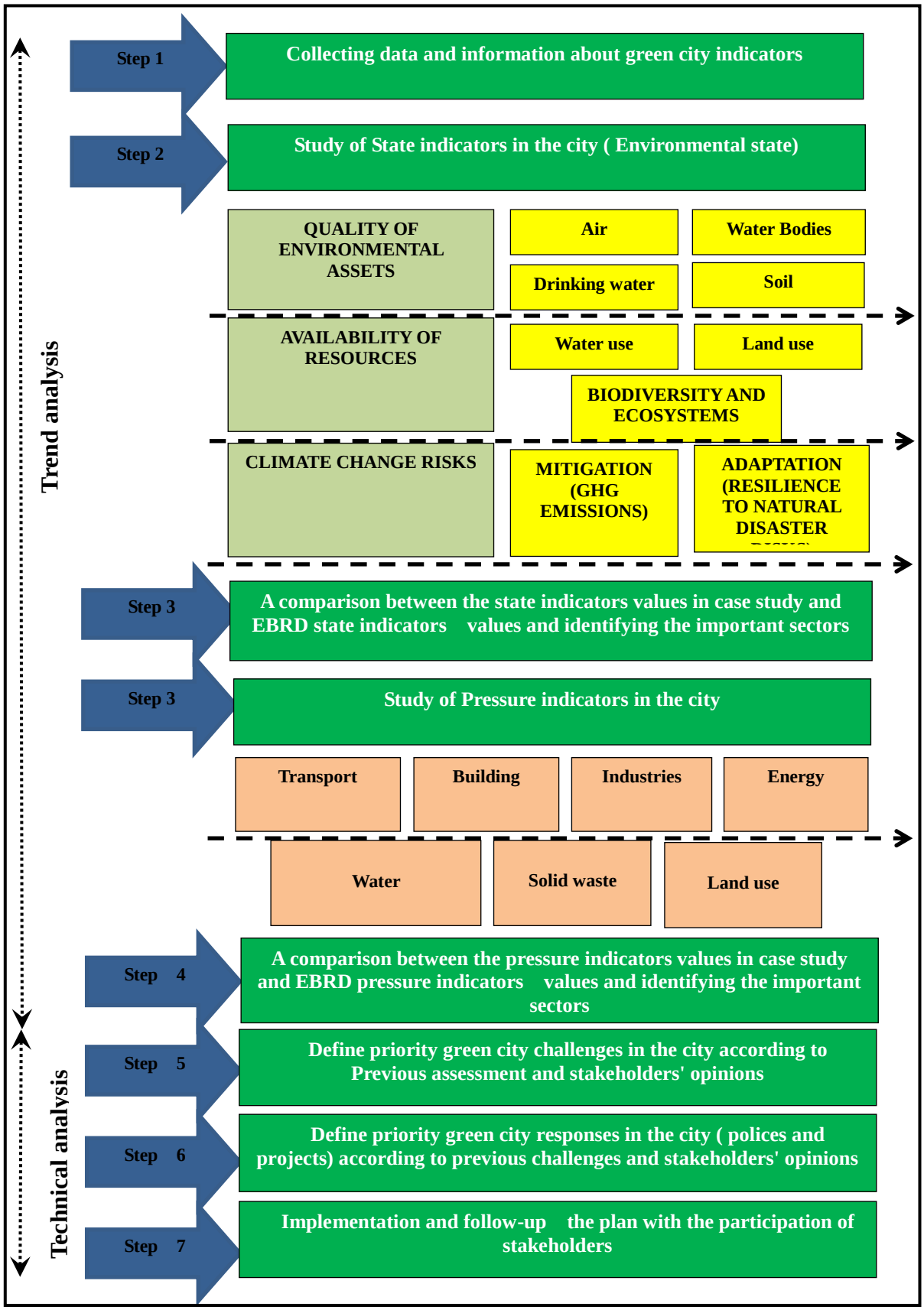

Fig. 6. EBRD green city program' methodology (Source: author based on [18]

Table 2. The principles and indicators of EBRD green city program

Sectors	Principles	Codes	Indicators	Its values		
				Accepted Score 3	MED Score 2	Not accepted Score 1
1/ Air		1/1	Percent of PM2.5 concentration per year (mg/m^3)	< 10	10–20	> 20
		1/2	Percent of PM_{10} \ concentration per year (mg/m^3)	< 20	20–50	> 50
		1/3	Average daily concentration of SO_2 (mg/m^3)	< 20	20–50	> 50
		1/4	Average annual concentration of NO_x (mg/m^3)	< 40	40–80	> 80
2/ Water (supply, sanitation , drainage)	2/1 Water bodies	2/1/1	Biochemical oxygen in rivers (mg/L)	< 2	2–4	> 4
		2/1/2	(NH4) concentration in waterways (mg/L)	< 150	150–200	> 200
	2/2 Water Drinking	2/2/1	The percentage of potable water (%)	> 97	90–97	< 90
		2/2/2	Plans of water drinking treatment	Existing	Having challenges	Not existing
	2/3 Water use	2/3/1	The ratio of Water using (%)	< 20	20–40	> 40
	2/4 Water consumption	2/4/1	Water consumption per capita (L / day / capita)	120-200	80–200 or 200-250	< 80; > 250
		2/4/2	Water consumption per GDP (L / day / USD)	< 0.022	0.022 – 0.055	> 0.055
		2/4/3	Unit of water consumed in power plants (l / MW / h)	< 0.5	0.5–1	> 1
		2/4/4	Percent of Industrial water consumption (%)	< 17%	17 – 50%	17 – 50%
		2/4/5	Plans for water billing management	Existing	Having challenges	Not existing
		2/4/6	Awareness campaigns for water saving			
	2/5 Efficiency of water supply networks	2/5/1	Non-revenue water (%)	0–30	30–45	> 45
		2/5/2	The annual average number of hours of water availability for each household	> 20 h/day	12–20 h/day	< 12 h/day
		2/5/3	Existence of plans for management the water supply networks	Existing	Having challenges	Not existing
	2/6 Waste water treatment	2/6/1	Percent of treated wastewater according to national standards (%)	< 12	40–60	< 40
		2/6/2	Percentage of non-industrial buildings that reuse treated wastewater (%)	> 80	60–80	60–80
		2/6/3	Percentage of treated wastewater from activities	> 60	40–60	< 40
		2/6/4	Existence of plans for connecting homes to sewage treatment systems	Existing	Having challenges	Not existing
		2/6/5	Existence of plans of wastewater treatment			
		2/6/6	Management of wastewater billing			
	2/7 Resilience to floods	2/7/1	Percentage of housing units affected by floods (%)	< 0.5	0.5–3	> 3
		2/7.2	Number of floods and annual rainfall flow	< 20	20–50	20–50
		2/7/3	Awareness of natural hazards (%)	Having awareness	Having awareness but not face	Not having awareness
		2/7/4	Existence of plans to drain rainwater	Existing	Having challenges	Not existing
		2/7/5	Awareness campaigns to face flood risks			
3/ Soil		3/1	Number of contaminated sites	<10	10-20	> 20
		3/2	Mercuy concentration in soil (mg/kg)	< 0.3	0.3 – 10	> 10
		3/3	Cadmim concentration in soil (mg/kg)	< 0.8	0.8 – 12	> 12
		3/4	Concentration of zinc in soil (mg/kg)	< 140	140 – 720	> 720
		3/5	Minerl oil concentration in soil (mg/kg)	< 50	50 – 5000	> 5000

4/ Land use	4/1 Green areas	4/1/1	Percentage of green areas per 100,000 inhabitants (hectares)	> 10	7–10	< 7
		4/1/2	Percentage of green areas within the city (%)	> 50	30–50	< 30
	4/2 Density / Integrated land-use	4/2/1	Population density on urban land (population / km2)	7000–20000	20000-25000	>25000
		4/2/2	Distance of commuting (km)	> 5	5–10	<10
		4/2/3	Time of commuting (min)	< 30	30–60	> 60
		4/2/4	The percentage of the population residing within 20 minutes of services (%)	> 75	50–75	< 50
		4/2/5	Controlling the density	Existing	Having challenges	Not existing
	4/3 Urban sprawl	4/3/1	Average annual urban growth rate	< 3	3–5	> 5
		4/3/2	The rate of development over the potential within the city	> 40	20-40	< 20
		4/3/3	Transit-Oriented Development	Existing	Having challenges	Not existing
	4/4 Use of existing built-up areas	4/4/1	The percentage of vacant offices	< 6%	6 – 10%	> 10%
		4/4/2	Percentage of multi-family housing units out of the total housing units	NA	NA	NA
		4/4/3	Existence of plans to support mixed land uses	Existing	Having challenges	Not existing
5/ Biodiversity & ecosystems		5/1	Percentage change in bird species	0%	0%-2%	> 2%
		5/2	Percentage of new birds species	0%	0%-2%	0%-2%
6/ Mitigation (GHG Emissions)		6/1	Annual emissions of carbon dioxide per capita (Tonne / annual/ capita)	< 5	5–10	>10
		6/2	Annual emissions of carbon dioxide per unit of GDP (Tone / USD of GDP)	< 0.35	0.35–0.8	> 0.8
7/Adaptation (Resilience to natural disaster risks)		7/1	The ratio of the damages resulting from the risks as a share of GDP (%)	< 0.5	0.5–1	> 1
		7/2	Percentage of public infrastructure at risk (%)	< 10%	10–20%	> 20%
		7/3	Percent of households that face risk (%)	< 10%	10–20%	> 20%
8/ Transport	8/1 Energy efficiency and type of used energy	8/1/1	Average age of cars (years)	< 6	6–12	> 12
		8/1/2	Percentage of diesel cars in total vehicle fleet (%)	< 20	20–30	> 30
		8/1/3	Vehicle fuel standards	EURO 6	EURO 5	EURO < 4
		8/1/4	Percentage of passenger cars which using clean energy (%)	> 3	1–3	< 1
		8/1/5	Existence of plans to reduce pollution from vehicles and support the use of clean energy	Existing	Having challenges	Not existing
	8/2 Choice of transport mode	8/2/1	Percent of private transport	< 30%	30–50%	> 50%
		8/2/2	Percent of private transport from total trips	< 30%	30–50%	> 50%
		8/2/3	Number of cars per capita	< 0.3	0.3-0.4	> 0.4
		8/2/4	Number of cars per household	< 0.5	0.5-1	> 1
		8/2/5	The designated roads lengths for public transportation per 100000 population	> 40	10–40	< 10
		8/2/6	The designated roads lengths for bicycles per 100000 population	> 25	15–25	< 15
		8/2/7	Percentage of the population served by public transportation by walking 15 minutes	> 80	60–80	< 80

		8/2/8	The number of buses passing through the station during the hour	> 30	30–6	< 6
		8/2/9	Existence of plans to improve the public and non-motorised transport	Existing	Having challenges	Not existing
		8/2/10	Awareness campaigns for public and non-motorised transport			
	8/3 Road congestion	8/3/1	Average speed on major roads during rush hour (Km/h)	> 30	15-30	< 15
		8/3/2	Daily average travel speed of bus service on on major roads (Km/h)	> 25	15-25	<15
		8/3/3	Existence of plans to manage traffic and reduce congestion	Existing	Having challenges	Not existing
	8/4 Resilience of transport systems	8/4/1	Operation of public transport networks in the presence of risks	running normally	Run with less efficiency	Stop working
		8/4/2	Efficiency of transport emergency	running normally	Run with less efficiency	Stop working
		8/4/3	Existence of emergency transport management plans	Existing	Having challenges	Not existing
9/ Building	9/1 Electricity consumption	9/1/1	Electricity consumption in buildings (kWh / m2)	< 47	47 – 75	> 75
		9/1/2	Consumption of Electricity in housing buildings (kWh / m2)	< 21	21 – 26	> 26
		9/1/3	Consumption of Electricity in non-housing buildings (kWh / m2)	< 122	122 – 213	122 – 213
		9/1/4	Using green building standards	Existing	Having challenges	Not existing
		9/1/5	Raising energy efficiency in buildings			
		9/1/6	Regulation for energy saving			
	9/2 Heat / fossil fuel consumption	9/2/1	Total consumption volume of buildings from fossil fuels (kWh / m2)	< 104	104 – 148	> 148
		9/2/2	consumption volume of residential buildings from fossil fuels for heating or cooling (kWh / m2)	> 148	96 – 126	> 126
		9/2/3	consumption volume of non-residential buildings from fossil fuels for heating or cooling (kWh / m2)	< 127	127 – 210	> 210
	9/3 Building standards	9/3/1	Percentage of institutions in the city that have green accreditation certificates (%)	NA	NA	NA
		9/3/2	Percentage of projects that have a green building certificate out of all projects in the city (%)	> 50	25-50	< 25
10/ Industries	10/1 Electricity consumption	10/1/1	Consumption of electricity in industries, per GDP (kWh / 2010 USD)	< 0.3	0.3 - 0.4	> 0.4
		10/1/2	Use of industrial machines that save electrical energy	Existing	Having challenges	Not existing
	10/2 Heat consumption	10/2/1	Consumption of heat in industries, per GDP (MJ / 2010 USD)	< 0.1	0.1 – 0.25	> 0.25
		10/2/2	Support the use of technology in the industrial sector to save energy	Existing	Having challenges	Not existing
	10/3 Consumption of fossil fuels in industrial processes	10/3/1	Emission density of Heavy metals in manufacturing industries (kg per million USD	< 0.02	0.02-0.04	> 0.04
		10/3/2	Fossil fuel in industries , per GDP	< 1.4	1.4 – 2.2	> 2.2
		10/3/3	Percentage of industrial consuming from renewable energy (%)	> 20	10–20	< 10
	10/4 Industrial waste treatment	10/4/1	Percentage of recycled industrial waste out of the total volume of waste (%)	> 95%	80 – 95%	< 80%
		10/4/2	The efficiency of industrial waste disposal systems and the existence of facilities for treatment, recycling and reusing	Existing	Having challenges	Not existing

	10/5 Industrial wastewater	10/5/1	Percentage of treated industrial wastewater according to national standards (%)	> 60	40–60	< 40
		10/5/2	Existence of plans for industrial wastewater treatment, recycle	Existing	Having challenges	Not existing
11/ Energy	11/1 Electricity provision	11/1/1	Percentage of the population benefiting from an official electricity network (%)	> 90	70–90	< 70
		11/1/2	The number of annual outages of the electricity network	< 10	10–13	> 13
		11/1/3	Investing in providing and improving the electricity network	Existing	Having challenges	Not existing
	11/2 Thermal comfort provision	11/2/1	Percentage of population with access to heating means (%)	> 90	70–90	< 70
	11/3 Renewable energy provision	11/3/1	Percentage of renewable energy use out of the city's total energy consumption	> 20	10–20	< 10
		11/3/2	Existence of financing for the use of renewable energy in private buildings	Existing	Having challenges	Not existing
		11/3/3	Investment in renewable energy			
		11/3/4	Existence of awareness campaigns about using renewable energy			
	11/4 Resilience of the electricity network	11/4/1	Percentage of population affected by power outages during the last 5 years (%)	< 10	10–25	> 25
		11/4/2	The resilience of electricity networks	Existing	Having challenges	Not existing
12/ Solid Waste	12/1 Solid waste generation	12/1/1	The annual production of solid waste per capita (Kg / year / capita)	< 300	300–500	> 500
		12/1/2	GDP per domestic material consumption (USD / kg)	< 1	1-2.5	> 2.5
		12/1/3	Existence of awareness campaigns to reduce the generation of solid waste	Existing	Having challenges	Not existing
	12/2 Collection of solid waste	12/2/1	Percentage of population who benefiting from municipal solid waste collection (%)	90–100	80–90	< 80
		12/2/2	Create plans for solid waste collection system	Existing	Having challenges	Not existing
		12/2/3	There are laws penalizing littering			
	12/3 Treatment of solid waste	12/3/1	Percentage of MSW that is recycled and reused (%)	> 25	15–25	< 15
		12/3/2	Percentage of MSW that is disposed away from landfills (%)	< 10	10–20	> 20
		12/3/3	Percentage of landfills for solid waste according European standards (%)	90–100	80–90	80–90
		12/3/4	Percentage of converted solid waste to compost (%)	> 20	5–20	< 5
		12/3/5	Existence of plans for recycling and transforming the waste to energy	Existing	Having challenges	Not existing
	12/4 Landfill efficiency / capacity	12/4/1	The validity period of landfills (years)	> 8	5–8	< 5
		12/4/2	Existence of plans for dealing with landfill	Existing	Having challenges	Not existing

State indicators | Pressure indicators | Response Indicators | Mandatory state indications | Mandatory pressure indications

Source: Author based on [18].

Table 3.Results of studying international EBRD Green cities (issues, responses and projects)

City	Membership year	Environmental issues	Suggested responses	Main projects
Aman (Gordan)	2018	-Solid waste generation. -Air pollution. -High Energy consumption.. -Climate change.	-Solid waste management. -Reducing air pollution. - Reducing Energy consumption. -Confronting climate risks.	-Sewage and solid waste treatment projects. -Projects to develop buses by using electricity. - Lake treatment projects.
Yevan (Aremia)	2018	-Using non-renewable energy. -Air pollution.	-Use of new energy alternatives. -Reduce pollution rates.	-Projects to introduce clean energy facilities.
Bana (Bosna)	2018	- Road congestion. -High Energy consumption. - High water consumption.	-Traffic control. - -Energy efficiency. -Water supply management.	-Road projects and traffic regulation on main roads. -Rationalizing water use. -Using renewable energy in buildings.
Batmi (Jeorgia)	2018	-Lack of an adequate. Transportation system. -Low open areas. -Using nonrenewable energy.	-Transportation demand. -Energy consumption management. -Connection between land uses.	-Public and private transport systems support projects. -Using renewable energy in buildings. -Providing open areas inside the cities.
Belgrad	2018	-Carbon emissions and air pollution. -Low Energy efficiency in building. -Traffic jam.	-Reducing air pollution. -Using green buildings codes. -Traffic control.	-Projects of green Public Buildings. -Using renewable energy in buildings. -Road toll projects to reduce bottlenecks.
Chinau (Modov)	2018	- Lack of solid waste system. - High Energy consumption.	-Energy efficiency in building. -Solid waste management.	-Solid waste collection, sorting, recycling and reuse project. -Application green building standards.
Gymri (Armnia)	2018	-Road congestion. -High Transportation demand.	-Reducing congestion rates. -Providing transportation system	- Creation of new road hubs. -Establishing new public transport stations.
Bati (North Modov)	2019	-Climate challenges. -Air pollution. - Old transportation system. -High energy consumption.	-Climate change control. -Reducing air pollution. -Create new transportation system.	-Renewable energy projects. -Renovation of old means of transport.
Bishkek (Kyrgyzstan)	2019	-Pollution and low air quality.- -Lack of clean transportation.	-Reducing air pollution. - New transportation system.	-Using renewable energy in transportation.
`Craiva (Roania)	2019	-High urban growth. -Low open areas.	-Urban growth management. -Increasing open spaces area.	-Exploitation projects for brownfield areas. -Urban Rehabilitation projects.
Dusanbe (Tajkstan)	2019	-Air pollution. -Old transportation system. -Climate challenges. -High Energy consumption.	-Reducing air pollution. -New transportation system. -Reducing of renewable energy.	-Using renewable energy in building and transportation.
Vana (BulJaria)	2019	-Climate change and depletion of natural resources. -Deterioration in infrastructure networks.	-Climate change control. - Preserving resources. -Create new infrastructure networks.	-Climate Resilience Project. -Providing infrastructure network.

Source: Author based on [19]

3.5. EBRD program for developing new Egyptian cities

3.5.1. The Egyptian member cities in the program

In 2019, the program was interested in financing infrastructure projects in Egyptian cities to transform them into green cities with lower carbon emissions, which is one of the most important environmental challenges facing major cities in Egypt [19]. The cities that have entered the membership of this program are represented in (Cairo, Alexandria and Six October) to solve their high rates of pollution and overcrowding. The program in Cairo focused on modernizing the second metro line, while in Alexandria, it focused on modernizing a metro line that connects the city center with the city of Abu Qir in the northeast of Alexandria [19, 54]. The city of Six October is considered the first member in the program from the new Egyptian cities, which is currently seeking to put a framework for implementing the program recommendations in it [20]. In 2021,the October City Authority has proposed a dry port project in the city to achieve the principles of EBRD green city [20], but is this what the city needs to be green city according to the program indicators?. The following points will answer to this question and define the appropriate framework for transforming the city to green cities.

3.5.2. Current legislative and regulatory framework for green cities in Egypt

The New Urban Communities Authority is responsible for urban development in Egypt, which determines the locations of new cities, applies development requirements in them, and sets their development strategies. There is a Sustainable Cities and Renewable Energy Unit that was formed by Ministerial Resolution No. 512 of 2014 and it is affiliated with the New Urban Communities Authority [20]. This unit focuses on rationalizing energy use and stimulating the use of renewable energy in residential and industrial projects in cities through its tasks (setting strategies and standards for renewable energy systems - preparing long- and short-term plans in the field of sustainability - preparing training programs for workers for implementing sustainability projects- providing technical support to investors and businessmen) [20]. For planning the new sustainable cities, the authority follows the set of requirements and laws such as (the Urban Communities Law No. 59 of 1979 - the Unified Building Law No. 119 of 2008, in addition to the special requirements of new city authorities. Therefore, there is no specific law or a separate unit that takes into accounts the standards of green urbanism and its special requirement [20, 55].

3.5.3. Case study (Six October city- Location and Characteristics)

The city of October is located 17 km from the pyramids area and about 32 km from Cairo center. Its boundaries are the Northern road in the end of the city's cordon, oasis road from the South, Egypt-Alexandria road from the East and the Southwest arc from the West as shown in the following figure 7 [56].The total area of Six October city is about 55 thousand acres, distributed over industrial uses (16%), residential uses (23%), tourist residential use 46%, and service uses (15%). And the current population size reaches 1.5 million people with an expectation to reach 3 million in 2030 [57].

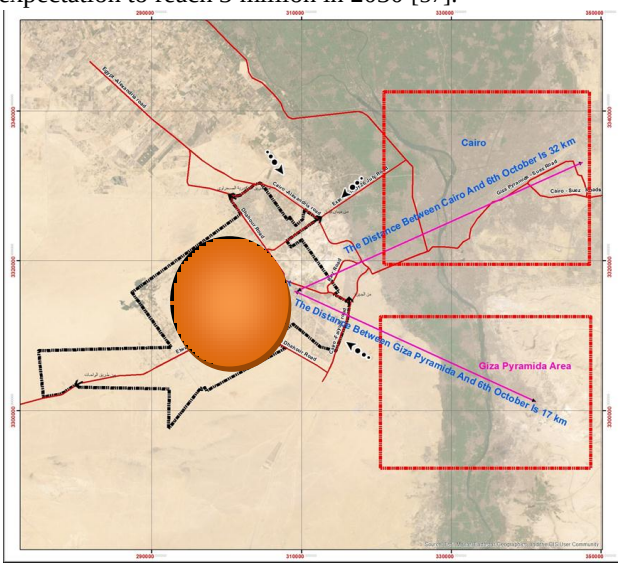

Fig. 7. Location of Six October city (Author)

4. Application framework (Results and discussion)

This part refers to the results of the comparison between EBRD indicators and the environmental characteristics of Six October city. The data and information were collected from the New Urban Communities Authority and Six October City Authority, in addition to the recent studies and researches that analysis the different environmental characteristics of Six October city. In this part, the statistical methods such as excel program were used to determine the influence degree of indicators in the city and to reach the priorities in challenges and development decisions. The analysis process was depended also on using Landsat8 satellite images for the city and the Arc Gis 10.2 program to analyze its different environmental characteristics.

4.1. Measuring EBRD indicators in Six October city

The previous table No. 2 showed a set of indicators related to the state, pressure and response, which will be measured in the city of 6 October to determine city status according to the principles of green urbanism and suggest the appropriate framework for its development. In this part, the research uses the recent reports of October City Authority and New Urban Communities

Authority, in addition to the statistics of the relevant ministries and recent studies and papers to measure the values of these indicators. Their values range from high, medium and low, the score of 3 indicates to high value of indicator and the score of 2 is a medium value. While score 1 means a low value of indicator and zero is an indicator no value.

4.1.1. State indicators in Six October city

EBRD program refers to three basic sectors for monitoring the environmental situation in the city and identifying its most important challenges. These principles are (Quality of Environmental assets- Availability of resources- Climate change risks) as shown in the following points [18].

A. Quality of Environmental assets

According to the proposed methodology and indicators of the EBRD program, determination the quality of μg environmental assets in Six October city depends on measuring the values of four basic elements, which are (air, water bodies, water drinking and soil) as shown in the following table 4.

Table 4. Quality of Environmental assets in Six October city

Sector		Code of indicators	Its value and score	
Air		1/1	50 mg /m3	3
		1/2	70 mg/m3	3
		1/3	20 mg /m3	2
		1/4	85 mg /m3	3
Water	2/1Water bodies	2/1/1	5.1 mg/L	3
		2/1/2	200 mg/L	2
	2/2 Water Drinking	2/2/1	92 %	2
Soil		3/1	12 mg/kg	2
		3/2	4 mg/kg	2
		3/3	5 mg/kg	2
		3/4	320 mg/kg	2
		3/5	2000 mg/kg	2

(Source: author based on [57, 58].

B. Availability of resources

The measurement of resource availability is carried out through three main sectors (water use - land use – biodiversity and ecosystems) as shown in table 5

Table 5. Availability of resources in Six October city

Sector	Code of indicators	Its value and score	
2/3 Water use	2/3/1	52 %	3
Land use	4/1/1	6	3
4/1 (Green areas)	4/1/2	32 %	2
5/ Biodiversity and Ecosystems	5/1	0.9 %	2
	5/2	Slight decline	2

(Source: author based on [57, 59]

C. Climate change risks

Climate change risks is measured in Six October city through two main elements, which are mitigation (GHG emissions) and adaptation **(**resilience to natural disaster risks) as shown in table 6

Table 6. Climate change risks in Six October city

Sector	Code of indicators	Its value and score	
Mitigation (CHC emissions)	6/1	6.2 Tone / year / capita	2
	6/2	0.6 Tone / USD	2
Adaptation (Resilience to natural disaster risks)	7/1	0.4 %	1
	7/2	19%	3
	7/3	12%	2

(Source: author based on [56, 57, 60].

4.1.2. Priority environmental challenges

The evaluation of status indicators in Six October city showed some environmental challenges according to their value and relative weight. The main environmental challenges are (Air - Water bodies- Water use- Land use and green spaces) as shown in table 7.

Table 7. Environmental challenges in Six October city

Sector		Relative weight	Sector	Relative weight
Air		2.75	Land use (Green areas)	2.5
Water	2/1Water bodies	2.5	Biodiversity and Ecosystems	2
Water	2/2 Water Drinking	2	Mitigation (CHC emissions)	2
Soil		2	Adaptation (Resilience to natural disaster risks)	2
Water use		3		

Major environmental challenges (> 2)
Sub-environmental challenges (< 2)
(Source: author)

4.1.3. Pressure indicators in Six October city

Some sectors have caused the previous environmental challenges in the city of October 6, and EBRD program has developed a number of pressure indicators that will be measured in October city to identify the priority sectors as shown in the following points and figures. These sectors must deal with them to face the environmental challenges and put suitable solutions and responses to make the city as green city.

A. Transport sector

The transport sector in October city is measures by four basic principles related to (the used energy types in transport system - transportation means - traffic congestion on the roads - Resilience of transport system) as shown in table 8 and figures 8, 9, 10

Table 8. Characteristics of transport sector in Six October city

Sector		Code of indicators	Its value and score	
8/ Transport	8/1 Energy efficiency and type of energy used	8/1/1	8 year	2
		8/1/2	56%	3
		8/1/3	EURO 5	2
		8/1/4	3	1
	8/2 Choice of transport mode	8/2/1	45%	2
		8/2/2	45%	2
		8/2/3	0.37 vehicles	2
		8/2/4	0.6 vehicles	2
		8/2/5	14 km	2
		8/2/6	17 km	2
		8/2/7	67 %	3
		8/2/8	5 bus	3
	8/3 Road congestion	8/3/1	25 Km/h	2
		8/3/2	24 Km/h	2
	8/4 Resilience of transport systems	8/4/1	able to run with reduced efficiency	2
		8/4/2	able to run with reduced efficiency	2

(Source: authors based on [56, 57, 61]

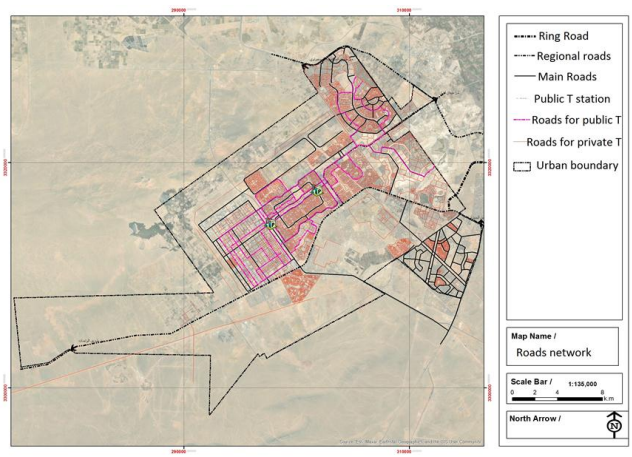

Fig. 8. Roads network and transportation means by using GIS (author based on [56,57, 61]

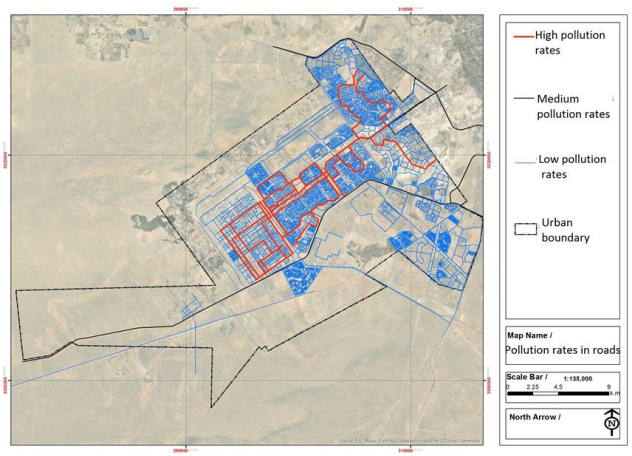

Fig. 9. Fuel pollution rates in Six October' roads by using GIS (author based on [56,57, 61]

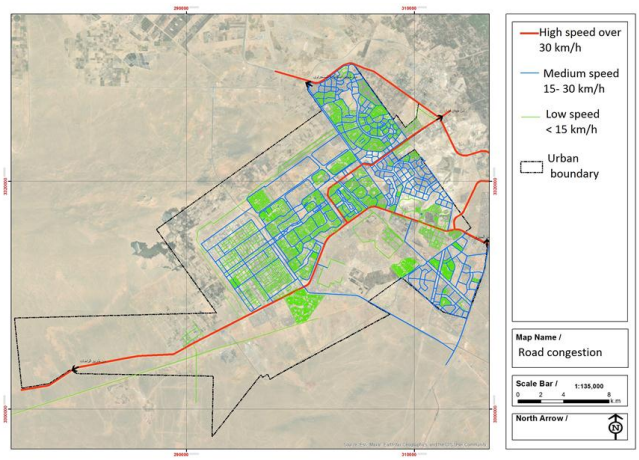

Fig. 10. Road congestion in Six October city by using GIS (author based on [56,57, 61]

B. Building sector

Achieving green buildings in the program depends on measuring three principles, namely (the percentage of electrical energy consumption in buildings - the percentage of fuel consumption in buildings- the followed building standards) as shown in table 9 and figure 11.

Table 9. Characteristics of building sector in Six October city

Sector		Code of indicators	Its value and score	
9/ Building	9/1 Electricity consumption	9/1/1	80 kWh / m2	3
		9/1/2	25 kWh / m2	2
		9/1/3	140 kWh / m2	2

9/2 Heat / fossil fuel consumption	9/2/1	130 kWh / m2	2
	9/2/2	110 kWh / m2	2
	9/2/3	170 kWh / m2	2
9/3 Building standards	9/3/1	NA	0
	9/3/2	22 %	3

(Source: author based on [56, 57, 63]

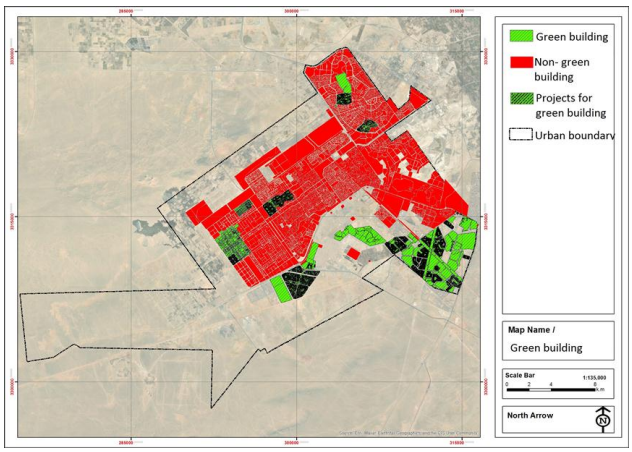

Fig. 11. Green buildings in Six October city by using GIS (author based on [56,57]

C. Industries sector

The industries sector in Six October city is measures by five principles which are (Electricity consumption - Heat consumption - Consumption of fossil fuels in industrial processes- Industrial waste treatment - Industrial wastewater) as shown in table 10 and figure 12.

Table 10. Characteristics of Industries sector in Six October city

Sector		Code of indicators	Its value and score	
10/ Industries	10/1 Electricity consumption	10/1/1	2 kWh / 2010 USD	3
	10/2 Heat consumption	10/2/1	1.5 MJ / 2010 USD	3
	10/3Consumption of fossil fuels in industrial processes	10/3/1	0.3 kg heavy metals equivalent released per million USD GVA	3
		10/3/2	19 MJ / USD	2
		10/3/3	12%	2
	10/4 Industrial waste treatment	10/4/1	60%	3
	10/5 Industrial wastewater	10/5/1	32%	3

(Source: author based on [56, 57, 58]

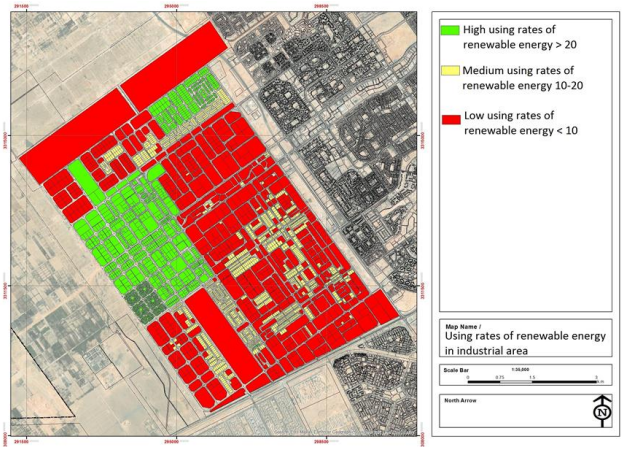

Fig. 12. Renewable energy using rates in the industrial zone by using GIS (author based on [56,57, 60]

D. Energy sector

There are four basic principles for measuring the energy situation in Six October city, which are (Electricity provision- Thermal comfort provision- Renewable energy provision- Resilience of the electricity network to climatic extremes) as shown in table 11 and figure 13.

Table 11. Characteristics of Energy sector in Six October city

Sector		Code of indicators	Its value and score	
11/ Energy	11/1 Electricity provision	11/1/1	93 %	1
		11/1/2	24 # / year / customer	2
	11/2 Thermal comfort provision	11/2/1	79 %	2
	11/3 Renewable energy provision	11/3/1	20 %	2
	11/4 Resilience of the electricity network to climatic extremes	11/4/1	22%	2

(Source: author based on [56, 57, 58, 60]

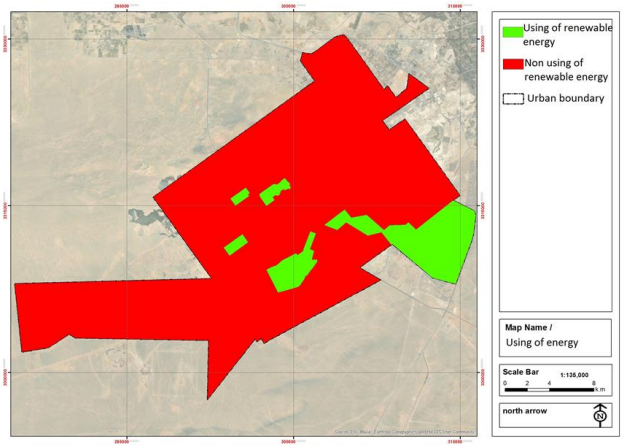

Fig. 13. Renewable and non-renewable energy networks by using GIS (author based on [20, 56, 57]

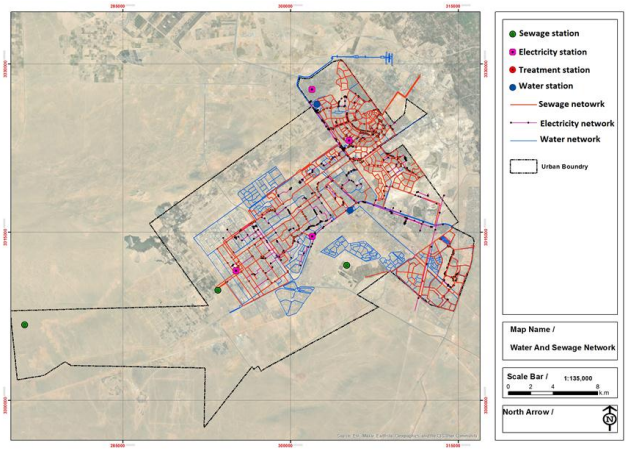

Fig. 14. Characteristics of water network in Six October city by using GIS (author based on [56,57]

E. Water sector

The program put forward five basic principles to achieve the best green performance of the water sector. These principles are (Water consumption - Efficiency of water supply networks- Wastewater treatment - Resilience to floods) as shown in table 12 and figure 14.

Table 12. Characteristics of water sector in Six October city

	Sector	Code of indicators	Its value and score	
2/Water	2/4 Water consumption	2/4/1	312 L / day / capita	3
		2/4/2	0.1 L / day / USD	3
		2/4/3	not available	
		2/4/4	28%	2
	2/5 Efficiency of water supply networks	2/5/1	32 %	2
		2/5/2	16 %	2
	2/6 Waste water treatment	2/6/1	35%	3
		2/6/2	34%	3
		2/6/3	22 %	3
	2/7 Resilience to floods	2/7/1	2 %	2
		2/7/2	< 20	1
		2/7/3	Citizens are aware of natural disaster	2

(Source: author [56, 57, 59, 60]

F. Solid waste

To measure the efficiency of solid waste system in October City, it is determined four principles which are (Solid waste generation - Collection of solid waste - Treatment of solid waste - Landfill efficiency / capacity) as shown in table 13 and figure 15 and 16.

Table 13. Characteristics of Solid waste sector in October city

	Sector	Code of indicators	Its value and score	
12/ Solid waste	12/1 Solid waste generation	12/1/1	400 Kg / year / capita	2
		12/1/2	not available	
	12/2 Collection of solid waste	12/2/1	85 %	2
	12/3 Treatment of solid waste	12/3/1	26%	1
		12/3/2	15 %	2
		12/3/3	80%	2
		12/3/4	16%	2
	12/4 Landfill efficiency / capacity	12/4/1	5	2

(Source: author [56, 57, 58, 64]

G. Land use

There are three main principles for achieving green land uses in Six October city, which are (Density / Integrated land-use- Urban sprawl - Use of existing built-up areas) as shown in table 14 and figure 17, 18, 19.

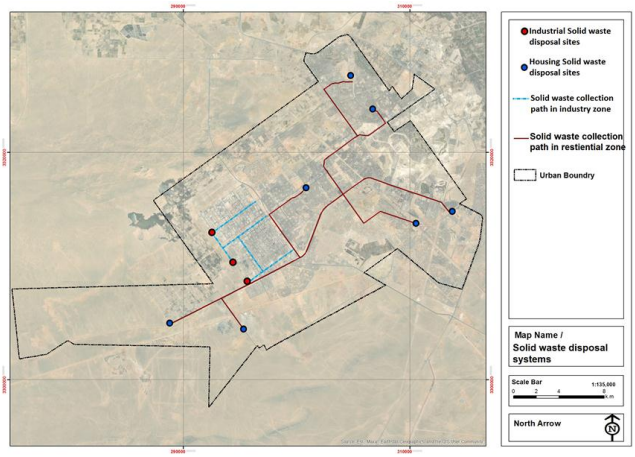

Fig. 15. Solid Waste Disposal system in Six October city by using GIS (author based on [56,57]

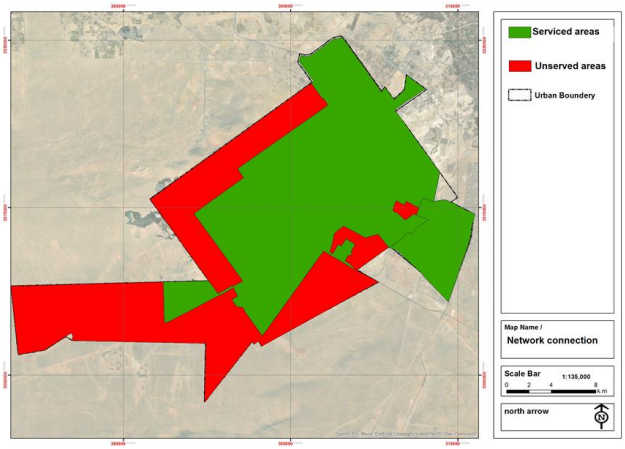

Fig. 16. Networks connection rates in Six October city by using GIS(Author based on [56, 57]

Table 14. Characteristics of land use sector in Six October city

Sector		Code of indicators	Its value and score	
4/ Land use	4/2 Density / Integrated land-use	4/2/1	6800 Residents / km2	2
		4/2/2	4.5	3
		4/2/3	32 min	2
		4/2/4	44%	3
	4/3 Urban sprawl	4/3/1	3.2	2
		4/3/2	12%	3
	4/4 Use of existing built-up areas	4/4/1	17%	3
		4/4/2	Not available	

(Source: author [56,57, 65]

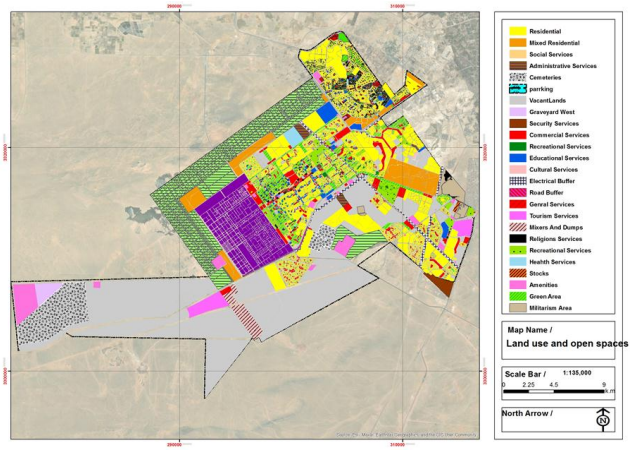

Fig. 17. Land use and open spaces in Six October city by using GIS(author based on [56, 57, 65]

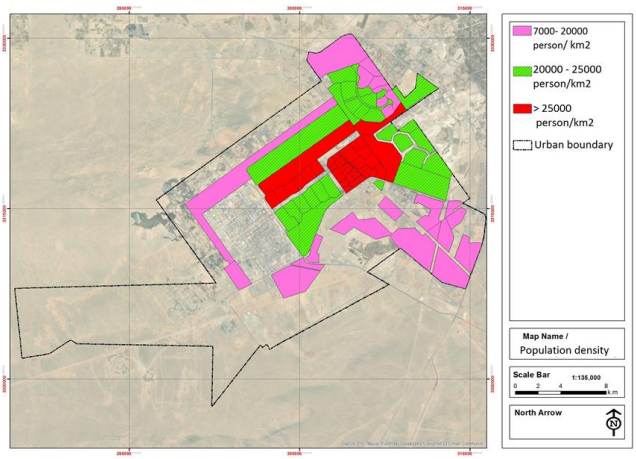

Fig. 18. Population densities in Six October City by using GIS (author based on [56, 57, 65]

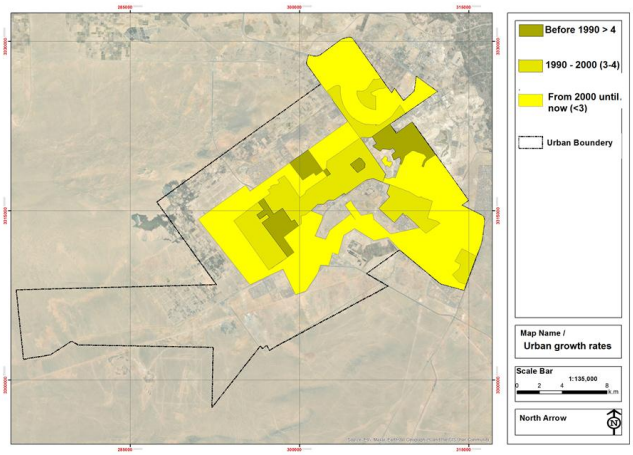

Fig. 19. Urban growth rates in Six October city by using GIS (Author based on [56, 57, 65]

4.1.4. Priority Pressure sectors

The evaluation of pressure indicators in Six October city showed some pressure sectors according to their value and relative weight. These sectors are represented in (Air - Water bodies- Water use- Land use and green spaces) as shown in table 15.

Table 15. Priority pressure sectors in Six October city

Sector		Relative weight	Sector		Relative weight
transport	Energy efficiency	2	Energy	Electricity provision	1.5
	Transport mode	2.25		Thermal comfort provision	2
	Road congestion	2		Renewable energy	2
	Resilience transport systems	2		Resilience to climatic extremes	2
Building	Electricity consumption	2.33	Water	Water consumption	2.67
				Efficiency of water supply networks	2
	fuel consumption	2		Waste water treatment	3
				Resilience to flood	1.67
	Building standards	3	Solid waste	waste generation	2
				Collection waste	2
				Treatment waste	1.75
				Landfill efficiency	2
Industries	Electricity consumption	3	Land use	Density	2.5
				Urban sprawl	2.5
	Heat consumption	3		Use of existing built-up areas	2.5
	Consumption of fossil fuels	2.33	Major pressure sectors (> 2)		
	waste treatment	3	Sub- pressure sectors (=2)		
	Industrial wastewater	3	Low impact pressure sectors (< 2)		

(Source: author)

4.1.5. Addressing environmental challenges (responses)

The analysis of State and pressure indicators in Six October city clarifies the most important environmental challenges facing the city, as well as the most important sectors causing these challenges, which need to put suitable dealing with them to ensure achieving a green city, as shown in the following figures 20 and 21.

This figure indicates that the main environmental challenges in Six October city associated with (air - Water bodies- Water use - Land use) which have a red color. These challenges are caused by a number of sectors such as (Transport modes - Electricity consumption in building – followed Building standards - Electricity consumption in industries - Heat consumption in industries - Consumption of fossil fuels in industries - waste and water treatment in industries - Waste water treatment- Water consumption - Use of existing built-up areas - Urban sprawl – Density). Therefore the Reponses deal with these sectors to solve their problems. The EBRD green city program putted some guiding solutions to the problems in each sector that can be used for developing Six October in a green way. On the other side, the comparison between those solutions and what is proposed in the projects of recent strategic plan for the city help to identify the most important failures to update the future plan and avoid these problems as shown in the following table 19.

Table 16. The main suggested responses and its executive status in recent strategic plan

Res	Description	In plan
1	Public and non-motorized transport is promoted	X
2	investment in energy efficiency	X
3	Green building is promoted	X
4	Using Energy efficient industrial machinery	√
5	Private investment in Energy efficient industrial	√
6	Using non-renewable energy efficient industrial	X
7	waste recycling projects- Industrial wastewater treatment / reuse / recycle	√
8	Put regulations and fiscal incentives for water waste treatment	X
	Improving treatment systems	√
9	Water saving / reuse through awareness campaigns	X
10	Mixed-use development in housing projects	X
11	Transit-Oriented Development is promoted	X
12	Density is regulated	X

(Source: author based on [57]

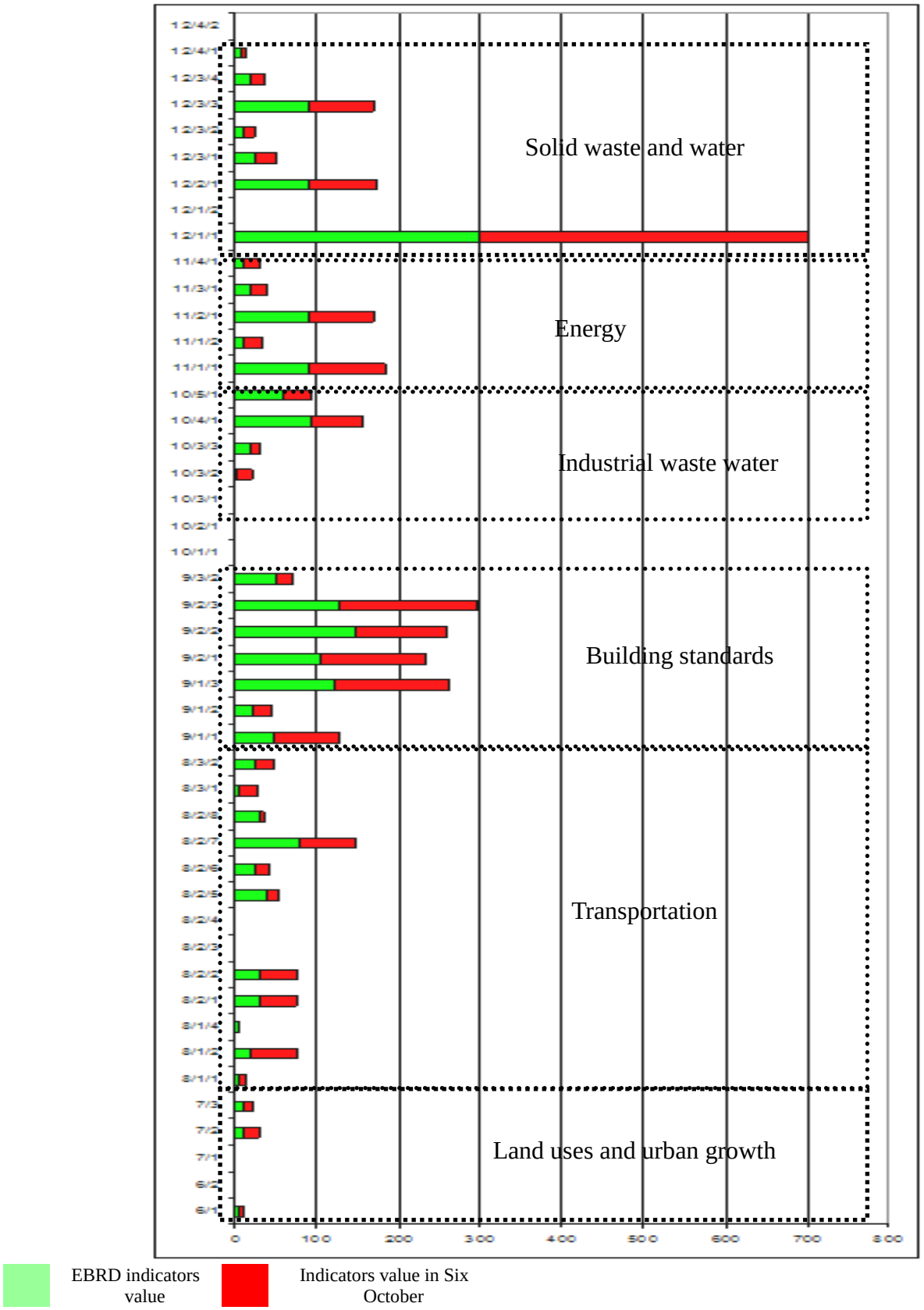

Fig. 20. The most important sectors causing environmental challenges in Six October city (Author)

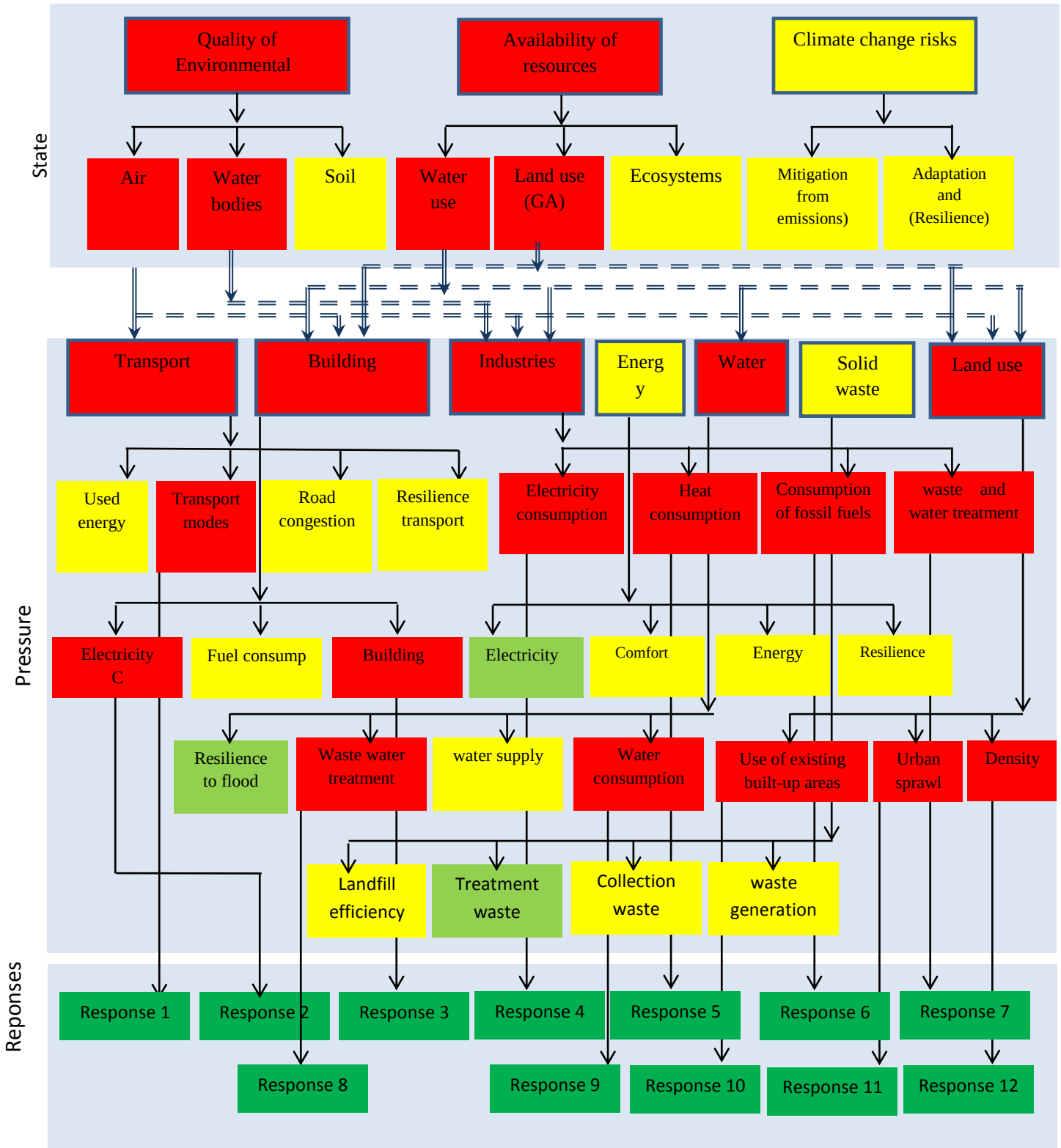

Fig. 21. Pressure-State-Response analysis (PSR) for Six October city (Author)

4.2. Framework of using EBRD green city program in developing Six October city

According to the previous results of Pressure-State-Response analysis (PSR) for Six October city, the framework for city development becomes clear. This framework was checked also through the results of the experts' opinions (in the field such as university professors and engineers in October City Authority (Questionnaire form in the appendix). The following figure 22 and points shows the main steps of this Framework that can be used in the development of the rest of the cities by using EBRD program to be green cities.

4.2.1. Pre-planning stage

A. The legislative framework for green city

The implementation of green urbanism' principles, especially what were indicated by the EBRD green cities program requires the development of some current laws in Egypt. These laws are represented in (environmental laws No. 4 of 1994- water law No. 147 of 2021- Uniform Building law No. 119 of 2008- waste management law No. 202 of 2020- Law for the Protection of the Nile and Waterways from Pollution No. 48 of 1982- industry law No 56 of 1996…) to preserve the characteristics of water, soil, air, energy, land use and activities for covering the current and future generations' needs and achieving the goals of Egypt Vision 2030. It also requires linking these laws and formulation a unified law for green cities to avoid any conflicts between the pervious laws.

B. The institutional framework for green city

The New Urban Communities Authority is responsible for planning new cities in Egypt and implementing green cities standards through its affiliated unit (Sustainable Cities and Energy). But there is a need for a separate unit to put the new requirements and standards of green cities and to review and implement their schemes which are different from other plans. This unit also must include some departments that cooperate with each other to cover all dimensions of green urbanism as shown in the following figure 23.

C. Providing a database about green city indicators

Most of cities authorities lack many data and information which needed to implement EBRD green city program. Therefore, it is necessary to provide a database about ((air - water - energy - soil - uses - transport - risks – waste) to measure the environmental status of city and solve their problems.

D. Training of employees in institutions

The application of green urbanism standards in cities requires training of engineers, planners and workers in different relevant institutions on dealing with green city indicators. As well as training them around how to measure these indicators and analysis them to formulate suitable policies and put executable urban plans to convert cities to green ones.

4.2.2. The stage of formulating Green city action plan (GCAP)

A. Identification the relevant parties

The relevant parties are represented in governmental institutions and stakeholders from investors, factory owners and businessmen, in addition to civil society. These parties must include in the development process of the city to achieve the green city objectives.

B. Data collection

This stage prepare the necessary data for the green development in the city through a group of different sources, whether from government agencies, statistics, stakeholders or specialized experts to identify the environmental situation of the city.

C. Identify the priority environmental challenges

According to the pervious collected data around the environmental status in the sectors of (air - water characteristics - drinking water - soil - water use - emissions -natural risks), the most important environmental challenges are determined , which were represented in (air – water bodies – water use – land use).

D. Finding the Pressure indicators

The previous environmental challenges are affected by some sectors which called pressure sectors, including (transportation - buildings - industry - water - land uses). These sectors need an appropriate method to deal with them to reduce these environmental challenges.

E. Formulate suitable responses

The responses are an attempt to develop solutions for pressure sectors' problems to avoid the city's environmental challenges. The most important responses in the city are (Develop public transportation- using renewable energy – application of Green building standards- Energy efficiency in industry - Water use management - Waste management - Application of mixed land uses in housing projects - Green areas preservation - Density regulation).

F. Putting strategies and actions for city development

To apply the previous responses, a set of strategies and objectives are developed that appear in the table 17.

4.2.3. The implementation stage

A. Participation of the different parties

The implementation of development strategies and actions need to the participation with different parties

such as Government agencies - Real estate developers – Investors - Real estate owners - land owners – residents- financing bodies).

B. Setting a timetable for implementation

According to the recommendations of EBRD program and the results of international experiences, the proposed priority projects must be developed during five years. This time period is appropriate to avoid the exacerbation of environmental negatives and the change of used indicators' values in formulating the development plan for the city towards green urbanism.

C. Raising environmental awareness

The implementation of some projects, such as (waste management- energy and water rationalization- management of transport system…) needs to increase the environmental awareness of the population about the requirements and returns of green urbanism on the city and its residents.

D. Evaluate process and achievements

At this stage, the implementation of the projects is evaluated to determine their most important challenges and the extent of their contribution on achieving green cities' goals.

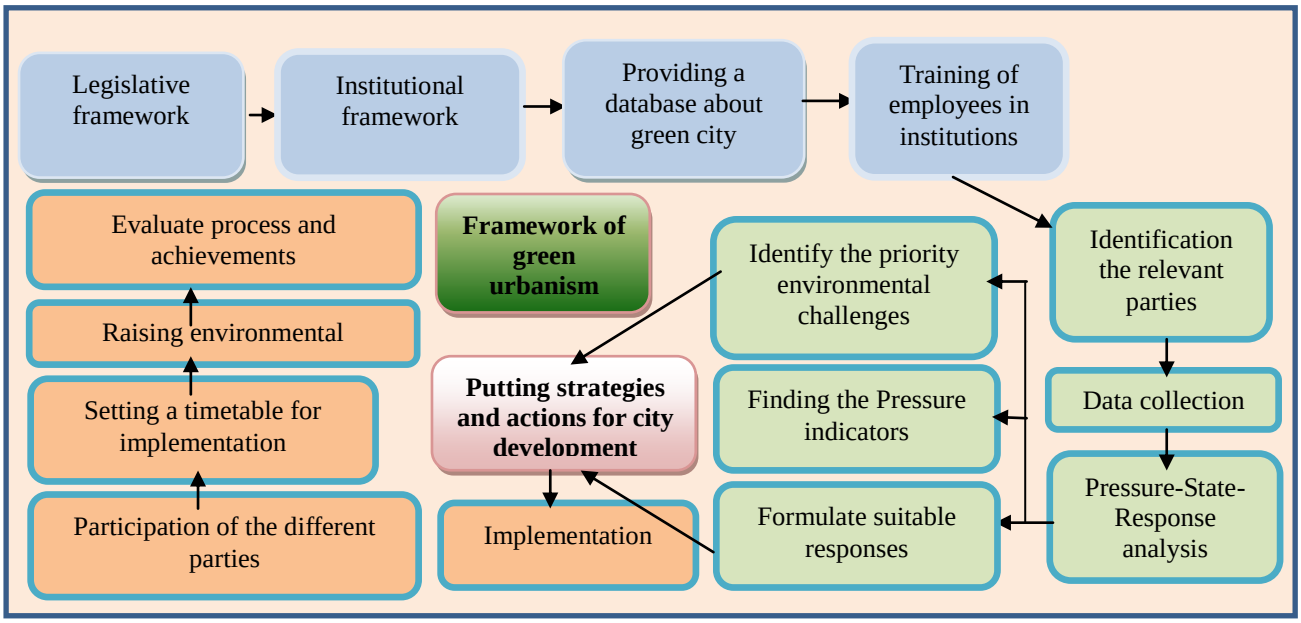

Fig. 22. Suggested framework for using EBED program in developing new Egyptian cities (Author)

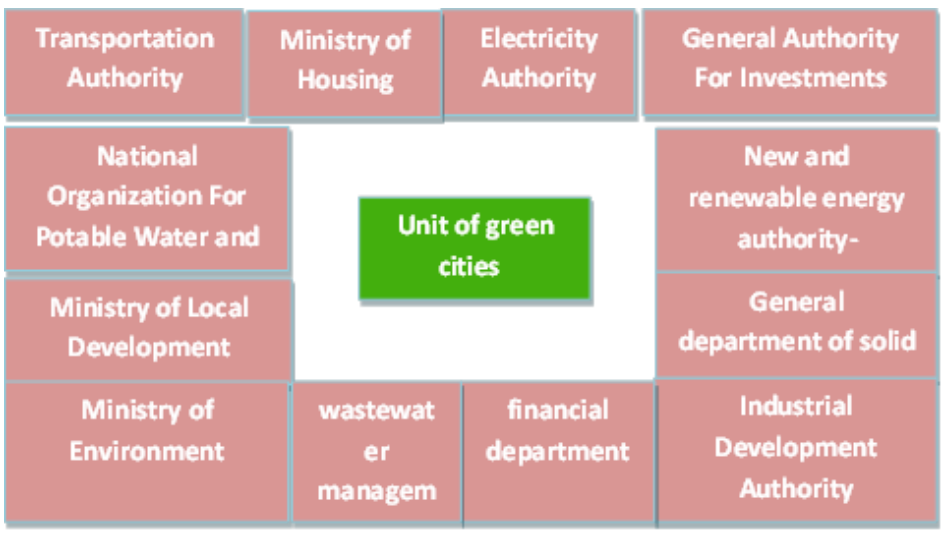

Fig. 23. Suggested departments for application EBRD program in developing new Egyptian cities (Author)

Table 17. The main strategies and actions for developing Six October into green city

The strategy	Action
Create a regulatory and legal framework for green cities	Creating institutional framework for green city
	Legal framework
Sustainable and green mobility and transport	Renewing old buses
	Use of renewable energy sources in transportation
	Road congestion management
Green building	Implementing energy management
	Renewable Energy Projects
	Energy efficiency program
	Applying building standards
Green industries	` Use of renewable energy
	Reuse of industrial waste and wastewater
	Production systems development
Water management	Rationalize the use of water
	Providing water stations
Waste management	Improvement of disposal site
	Modernization of waste collection systems
	Treatment of solid waste
Mixed land use	Balanced densities application
	Exploiting vacant buildings
	Maintaining green belts
	Create open areas within the city

(Source: author)

5. Conclusions

This paper discussed the interest of many countries in applying green urbanism' principles in different cities to reduce climate, energy and water challenges through using several international programs. The most important program is the (EBRD Green Cities Program), which is one of the comprehensive programs that covered environmental, social, economic and urban dimensions of green city. This program has developed a set of principles and indicators to implement the concept of green urbanism in many cities around the world. It aims to transform 100 cities into green cities until 2024 through application number of development strategies such as Green Economy Transition (GET), Municipal and Environmental Infrastructure (MEI), Economic Integration (EI), Environmental and Social Policy (ESP), Economic Inclusion Gender Equality (GE) and Local Climate Initiatives (LCI.) .

On the other hand, EBRD program has suggested a new method for evaluation and transforming cities into green ones, which called Pressure-State-Response Analysis (PSR). This method depends on assessing the state of environmental conditions in cities (State) to determine their environmental challenges and analyzing the sectors that causing these challenges (Pressure) for putting appropriate solutions (Response) to achieve the principles of green urbanism in cities. While the framework of using the program is determined according to cities characteristics in each country and the types of its environmental challenges.

By reviewing previous international experiences, it is clear that the program was implemented in about 48 cities around the world, such as Amman - Yerevan –Chisinau, in which number of solutions were proposed to meet their environmental challenges in the sectors of (transportation - buildings - energy - water - industry - land uses - waste). These solutions were represented in (managing transportation system- using clean transportation means – supporting renewable energy in transportation, buildings and industries- rationalizing the use of water - managing and recycling solid waste).

At the local level, October 6 city joined EBRD green city program in 2021 to transform it into a clean green city. Accordingly, the New Urban Communities Authority and the 6 October City Authority sought to formulate a framework for implementing the principles and indicators of this program in the city and using it as a guiding framework that can be used in developing the rest of new Egyptian cities. This paper suggested this framework by revision the previous experiments and studies and what the EBRD program presented for implementing green urbanism in cities. In addition to analysis the condition of new Egyptian cities and their requirements for implementing the program in them by choosing Six October city as a case study and surveying the opinions of experts and specialists in the field.

This framework included a set of elements divided into three main stages, which are (the pre-planning stage- the planning stage- the implementation and follow-up stage.).

In the pre-planning stage, there are the necessity of having a special legal framework for planning green cities and an organizational framework managed by specific green city unit with a number of departments that cover the dimensions of green urbanism such as (Transport Authority - Ministry of Transportation - Electricity Authority - Investment Authority - Renewable Energy Authority - Solid Waste Authority - Industrial Development Authority - Waste Management Authority - Finance Authority - Water Authority - Ministry of Environment - Ministry of Local Development). In addition to providing an updated database about EBRD program indicators to facilitate the evaluation process and development decision-making. Also, there should be training for employees and engineers at the pre-planning stage to deal with green urbanism indicators, put appropriate plans for green cities and formulate development policies which compatible with green cities goals.

While the proposed framework indicates the need to provide some elements in the planning stage represented in (identifying the relevant development parties to explore their opinions and needs in line with the goals of green cities - collecting information and statistical data to implement EBRD program - using geographic information systems in analysis and evaluation processes - applying the PSR approach- determining the priority environmental challenges in the city – identifying the priority sectors that cause those challenges – determining the necessary and urgent responses to overcome the city's challenges and transforming it into a green city – formulating strategies and objectives for the city's future planning).

In the implementation stage, the framework includes (the participation of the different parties - raising the environmental awareness of the population to implement green cities plans - setting a timetable for implementation that is less than 5 years - taking into account the compatibility between funding values and implementation costs). On the other side, the research recommends, using previously proposed framework to transform the new Egyptian cities into green cities in order to apply EBRD program without any obstacles.
Also the research recommends some projects beside the dry port project in Six October city to transform it to green urbanism. These projects are (clean transport projects by using renewable energy - renewable power plants - green building - ecological industrial projects - Liquid and solid waste recycling for housing and industry - mixed land use projects - green and open areas - maintaining green belts..) These projects help in addressing the environmental challenges of October city and updating the city's current strategic plan to be a green city.

Appendix:

The questionnaire is addressed to experts in the field of urban planning, whether at the New Urban Communities Authority or the engineers in Six of October City Authority, or the professors at the Faculty of Urban Planning, Cairo University.
This questionnaire aims to determine what the new Egyptian cities need in general and Six October city in particular to implement EBRD green city program in them, from the pre-planning stages to the implementation and follow-up stage. In addition to testing the proposed responses and strategies for city development which formulated according to the program indicators and identifying their relation with the recent city plan as shown in the following questions

Personal information

Name:..... Job:.....
.....

Pre-planning stage

Is there a legal framework for planning green cities in Egypt?
Yes ☐ NO ☐

Is there an independent unit for planning green cities in Egypt?
Yes ☐ NO ☐

Is it possible to plan new green cities in Egypt through the New Urban Communities Authority only?
Yes ☐ NO ☐

If the answer is no, what are the relevant authorities for green city planning?
.....
.....
.....

Is there a database for green cities' indicators in the city authority?
Yes ☐ NO ☐

If the answer is no, what are the main sectors' database for planning green cities?
.....
.....

Are there training centers for engineers in institutions to transform and plan cities into green?
Yes ☐ NO ☐

Is there any department in the city authority to deal with green cities?
Yes ☐ NO ☐

Has the city authority previously dealt with green city projects?
Yes ☐ NO ☐

The stage of formulating Green city action plan (GCAP)

What are the sectors of environmental challenges in the city
Air ☐ Water drinking ☐ Water use ☐
Soil ☐ Emissions ☐ Natural risks ☐
Land use ☐ Ecosystem ☐ Water bodies ☐

What are the sectors that cause environmental challenges in the city?
Transport ☐ Building ☐ industries ☐
Energy ☐ Water ☐ Solid waste ☐
Land use ☐

Does the recent strategic plan of Six October City take into account the pribciples of green urbanism?
Yes ☐ NO ☐

What are the your suggestions for transforming Six October city into a green city?
.....
.....

What are your opinion about the results of Pressure-State-Response analysis to transform the city into a green city?

Public and non-motorized transport ☐
investment in energy ☐
Green building ☐
Energy efficient industrial machinery ☐
non-renewable energy efficient industrial ☐
waste recycling projects ☐
Industrial wastewater treatment ☐
Water saving ☐
Mixed-use development ☐
Transit-Oriented Development ☐
Regulated density ☐

Implementation and follow-up stage

Who are the stakeholders in October City to discuss these suggestions with them?
Residents ☐ Factories owners ☐ Investors ☐
Real estate developers ☐ all of the above ☐

Are courses offered to residents to raise their environmental awareness?
Yes ☐ NO ☐

Will the dry port project contribute to transforming the city into a green city
Yes ☐ NO ☐

If the answer is no, what are the reasons?
.....
.....

What is the role of government agencies in implementing the transformation plan for a green city
.....

What is the role of factories owners in implementing the transformation plan for a green city?
.....

What is the role of real-estate developers and investors in implementing the transformation plan for a green city?
.....

What is the role of residents in implementing the transformation plan for a green city?
.....

What is the expected time to transform the city into a green city?
< 5 years ☐ 5-10 years ☐ > 10 years ☐

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