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The influence of sustainable building of gated communities on the natural environment and the user: the case of Madinaty city

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Abstract

Nowadays, the world is facing a global issue as a result of the depletion of the environment's natural resources. This is a consequence of conventional building techniques that exploit these resources without considering the negative consequences on the environment and the future. This is the reason why there is an urge to preserve these resources for the sake of future generations. Sustainability's main aim is to preserve the environment's natural resources, like water and energy, to meet current needs without compromising the ability of future generations to meet their own needs. Based on this, the United Nations initiated a global trend to face this challenge through sustainable building. This paper investigates the positive impact of sustainable building on the environment and the users in order to provide a better quality of life. The case study investigates Madinaty city, which is a gated community situated to the east of Cairo city center. Initially, sustainability is analyzed based on global and local criteria, and its impact on the environment and user is evaluated. Based on the global assessment, the results show that Madinaty has succeeded in achieving sustainable design; however, some issues need to be improved such as housing affordability, availability of services, and preserving the cultural heritage. On the local level, all criteria are met except for the balance between supply and demand. When evaluating these results, it is concluded that Madinaty has succeeded in having a positive impact on the environment and the users, eventually providing a better quality of life.

Keywords: Sustainable development, Gated communities, Environment, Natural resources, User

Introduction

Adopting sustainable practices such as energy and water efficiency practices, waste management, and implementing sustainable infrastructure can have significant impacts on the environment and the users over the long run. This in turn preserves the natural resources of the environment, provides better air quality, and minimizes pollution. In addition to this, a sustainable environment provides better quality of life through the positive social and psychological impact it has on its users. The literature shows that

a sustainable environment contributes to an improved health and well-being for its users, provide comfort and satisfaction, reduce stress, and provide social benefits such as enhanced communication, triggering positive emotions and a sense of belonging to the place.

Sustainability has become a global concern as a result of exploiting natural resources over the past few decades. The United Nations has put a framework for achieving sustainable development worldwide; consequently, many nations have followed this plan including Egypt. The UN's framework is divided into several goals "Sustainability Development Goals" (SDGs). Egypt developed a strategy called "Sustainability Development Strategy" (SDS) that ensures sustainable development for future projects. The strategy has several pillars classified according to the three main aspects of sustainability; environmental, social, and economic. This paper focuses on studying the environmental aspect with its two pillars; environment and urban Development.

A common worldwide problem that can be seen in developing countries is related to the quality of urban life. Those in less-developed countries are often questions of life and death, such as problems of poverty, clean water availability, waste, pollution, and congestion [1]. Amid these circumstances, the phenomenon of gated communities (GC's) as urban residential developments started to highlight the scene in some countries as the case in Egypt [2]. This trend is an effort to provide safe and sustainable urban environments with better quality of life. Gated communities in Egypt were developed to attract people to live better lifestyles that provide services, leisure, and activities for its users. The case study of this paper is Madinaty city, which is said to be a sustainable urban environment. Based on one of the UN's SDG concerned with making cities and human settlements inclusive, safe, resilient, and sustainable and Egypt's SDS Environmental pillars, Madinaty city sustainable design was evaluated.

Results of the case study show that Madinaty is indeed a sustainable urban environment that has succeeded in preserving the environment and providing a better quality of life for its users. However, the biggest concern of this assessment is that Madinaty, just like many other similar gated communities in Egypt, is aimed at attracting the rich/upper class users and not for everyone; although one of the UN's SDG requirements is for the city to be sustainable, it needs to provide not just adequate and inclusive but also affordable housing. This concludes that Egypt needs more inclusive gated communities that are aimed for everyone, including low-income people, not just the privileged ones.

Methods

This research follows a qualitative approach. It begins with literature review about sustainability concept and its influence on the environment and the user and this is represented by a diagram that illustrates clearly the relation between sustainability, environment, and the user. Next, the research proceeds to data collection about the global trend of sustainable development that was initiated by the United Nations and lists its goals focusing on the requirements of one of these goals related to cities and communities. In addition, the local environmental sustainability requirements in Egypt were also studied. Each of the global and local sustainability requirements is represented by a table for later assessment of the sustainability design of Madinaty city. Results show that Madinaty has met most of the requirements on both the local and global sustainability

criteria and has succeeded in providing a good quality of life for its users. Figure 1 illustrates the methodology of the research.

Literature review

Sustainability

Sustainability is the capacity to endure [3] which is crucial to maintain the normal ecosystem. The ecosystem is a complex system with a hierarchy of relations that can be easily altered by man-made practices. For humans, sustainability is the potential for long-term maintenance of well-being, which in turn depends on the maintenance of the natural world and natural resources [4]. Sustainability also minimizes the negative environmental impact of buildings. This ensures that current actions and decisions do not affect the opportunities of future generations. Sustainable building allows buildings to be energy-efficient with less carbon footprint. They are applied to every phase of a building construction development including the structure, design, and types of materials used.

Sustainability, environment and user

There is a mutual relation between sustainability, environment, and the user. Sustainable building benefits the environment in various ways such as preserving the natural resources through water and energy efficiency, improving air quality, and minimizing waste, which has a negative impact on the environment. This in turn positively influences the users of the environment by improving the user's health and well-being,

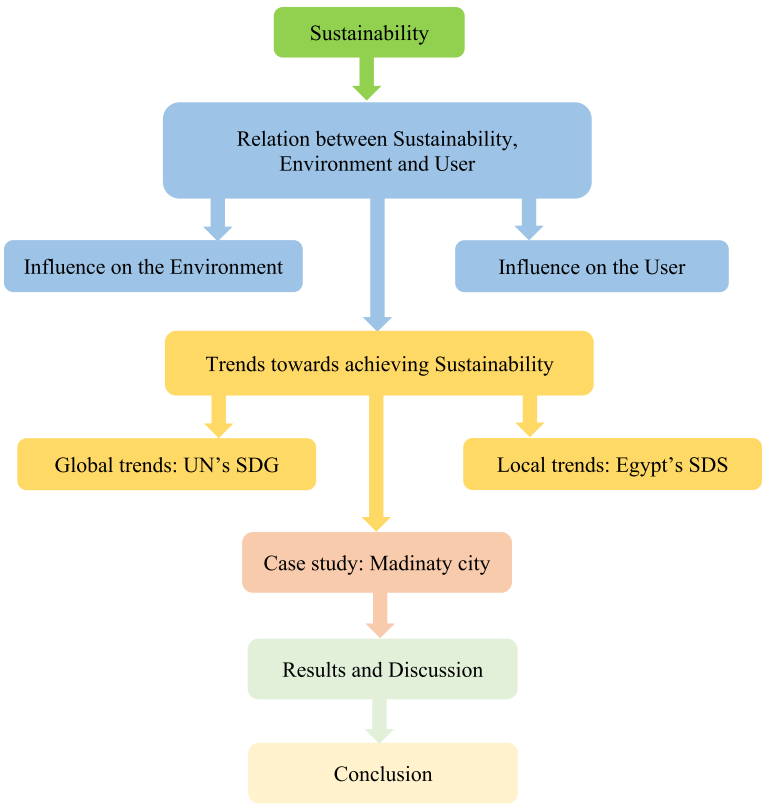

Fig. 1 Diagram illustrating the methodology of the research. Source: author

improving mental health, providing comfort and satisfaction, and reducing stress. In addition to these benefits, sustainable environments provide social benefits for its users through better communication, emotional functioning, and sense of belonging. Eventually, users of this environment will have a better quality of life. The relation between the three aspects; sustainability, environment, and user, is explained in the following section and summarized in Fig. 2.

Influence of sustainability on the environment

Sustainability has a positive impact on the natural environment [5] by reducing the dependence on natural resources, improving environmental quality, including temperature control, air quality, and daylighting. It is also possible to save water by depending on an alternative water source like rainwater to ensure that both the current and future generations have a good and permanent supply of clean water.

The primary aim of sustainable building is to reduce the energy dependency of buildings on non-renewable sources such as coal, which are not just expensive but also are a source of pollution to the natural environment. Green building helps achieve a clean natural environment. To achieve this, solar panels and other similar sustainable techniques are implemented, which utilize energy from solar radiation. Eventually, there will be a reduced need for any artificial sources.

In addition, sustainable building materials are often made from recycled or renewable resources, which means that less new material need to be produced [6]. It also requires less resources, minimizing the amount of waste produced. Studies suggest that "LEED projects are responsible for diverting more than 80 million tons of waste from landfills, and by 2030 that number is expected to grow to 540 million tons" [7].

Influence of sustainable environmental design on the user

Sustainable buildings create spaces that can account for better health and comfort of its users. When studying health benefits resulting from green building, it is crucial to focus on the environmental quality, specifically the air quality. Good air quality protects the user's health, reduces stress, and enhances the quality of their life. This is because the

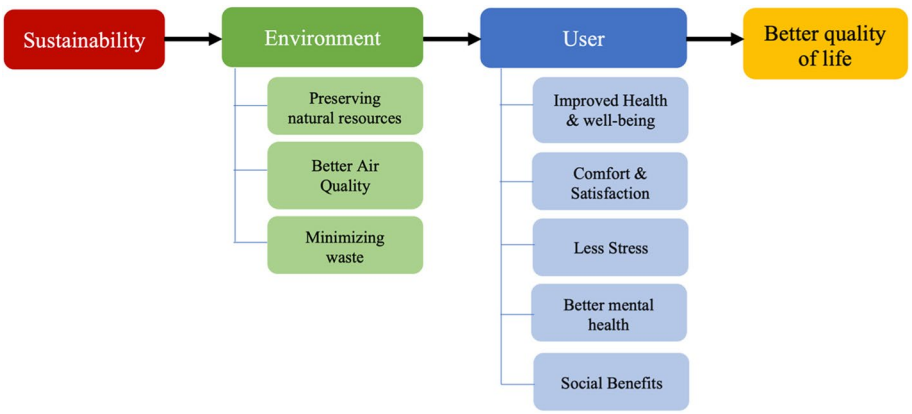

Fig. 2 Diagram showing the relation between sustainability, environment and user. Source: author

effects on health are a consequence of the different environmental stimuli which interact with the users physically.

Evidence shows that specific sustainable features, such as amount of daylight, access to views, and connection to outdoor, are likely to result in positive states of health and well-being. Research shows that occupants' satisfaction with lighting and air quality is higher than their thermal and acoustic satisfaction [8]. It is of great importance to improve occupant comfort and satisfaction because discomfort has negative influences on their quality of life.

Many of the green building benefits are concerned with the mental health and well-being of people who work or live in green buildings through what is called "psychological interpretation" of the environment. Depending on the environmental conditions and the surrounding context, this interpretation influences people and results in psychological responses which affect the user in various ways. A growing number of studies have shown that visiting green spaces and being exposed to natural environments can reduce psychological stress [9]. This is because the views have positive influences on users' well-being.

Another benefit of sustainable building is the "social value." Sustainable building has a significant positive social impact on users. Social experiences are enhanced through the presence of spaces for social interaction. Not only do these spaces tend to have positive psychological benefits, but also social benefits, which include improved emotional functioning, "increased communication, and sense of belonging to the place" [10].

Global trends towards achieving sustainability

UN Sustainable Development Goals

In the year 2015, 195 nations agreed with the United Nations (UN) that they can make a difference in the world to improve the lives of their people. Figure 3 illustrates the 2030 Agenda. According to this vision, there are seventeen different sustainability development goals (SDG) which need to be achieved by the year 2030. This research focuses on one goal (number 11), which is about making cities and human settlements inclusive,

Fig. 3 The Sustainability Development Goals specified by the UN. Source: https://www.un.org/sustainabledevelopment/sustainable-development-goals/

safe, resilient, and sustainable [11, 12]. According to the UN, this goal is derived from the fact that cities "account for more than 70% of global greenhouse gas emissions If well-planned and managed, urban development can be sustainable and can generate inclusive prosperity" [11, 12]. The following points summarize the goal aims which need to be achieved by the year 2030:

The goals of SDG number 11 are listed below. These are summarized in Table 1 to be used for assessing sustainability of any project based on these criteria. This table will be used to assess the degree to which the case study succeeded in achieving sustainability on a global level.

SDG number 11 goals:

- Ensuring access to adequate, safe, affordable housing and basic services to everyone and eliminate slums.
- Provide access to safe, affordable, accessible, and sustainable transport systems for all.
- Enhance inclusive and sustainable urbanization.
- Strengthen efforts to protect the world's cultural and natural heritage.
- Giving special attention to air quality and other waste management.
- Providing universal access to safe, inclusive, and accessible green and public spaces.
- Adopting and implementing plans towards inclusion, resource efficiency, and adaption to climate change.
- Building sustainable cities using local materials.

Egypt's Sustainable Development Strategy (SDS)

Founded in November 2012, the Egypt Green Building Council (Egypt GBC) is a non-profit organization under the laws of the Arab Republic of Egypt [13] which is an emerging member of the World Green Building Council (WGBC). The WGBC is a global network which aims to establish green buildings around the world and facilitate change. It is comprised of a total of 70 Green Building Councils each with a different stage of development with their member companies.

Table 1 Sustainability criteria based on the UN's Sustainability Development Goal number 11. Source: author

Global Sustainability Criteria
Making cities and human settlements inclusive, safe, resilient, and sustainable
• Adequate, safe, affordable housing for everyone
• Basic services for everyone
• Inclusive and sustainable urbanization
• Protect cultural and natural heritage
• Improved air quality
• Sustainable waste management system
• Universal access to safe, inclusive, and accessible, green and public spaces
• Resource efficiency
• Adaption to climate change
• Building using local materials

According to Egypt Green Building Council (GBC), Egypt is among the countries that adopted an environmental development approach. Egypt has followed a number of effective steps which include "Following the UN Sustainable Development Goals (SDGs) [14], efficient use and investment of natural resources to protect the rights of future generations, applying special measures from the building design phase all the way through to construction and operation of projects to produce environmentally responsible structures" [15]. The following discusses the Sustainable Development Strategy (SDS) of Egypt's 2030 vision.

Egypt 2030 Vision is an inclusive long-term plan of political, economic, and social vision. It was developed following the Sustainable Development Goals (SDGs) of the United Nations. The SDS has utilized the principle of sustainable development as a general framework for enhancing the quality of life, while considering the rights of future generations to have a prosperous life. This vision deals with the three main sustainability dimensions; economic, social, and environmental (Fig. 4).

SDS pillars

According to Egypt 2030 vision, several pillars were developed following the UN Sustainable Development Goals (SDGs) as shown in Fig. 4. This section focuses on the environmental dimension pillars which are environment and urban development. The urban development pillar aims at creating "a balanced spatial development management of

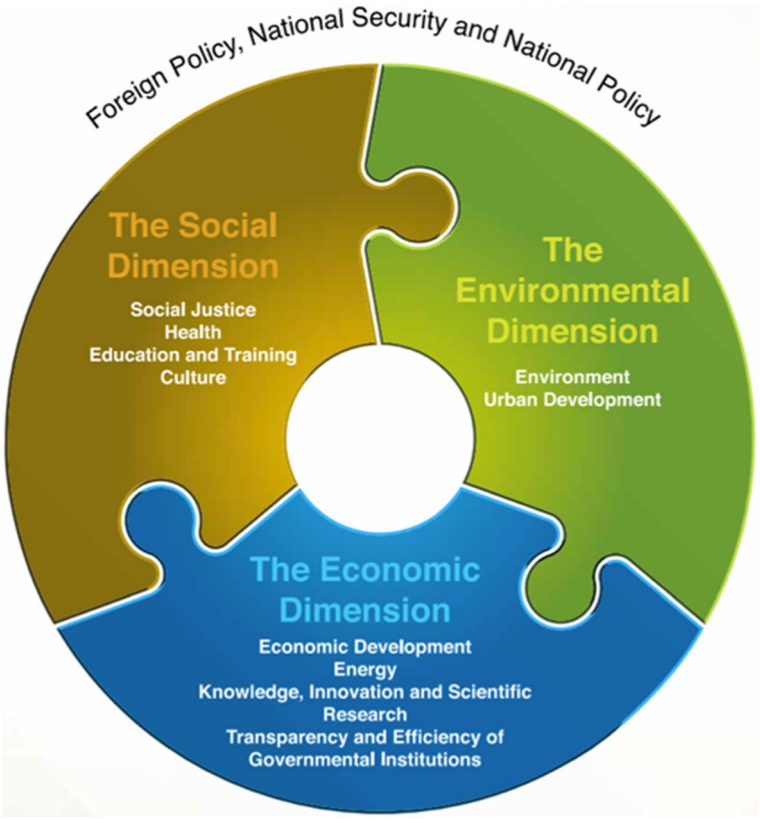

Fig. 4 The three main categories of the sustainable development strategy. Source: SDS document

land and resources to accommodate population and improve the quality of their lives" [16], while the environment pillar assumes that "Environment is integrated in all economic sectors to preserve natural resources and support their efficient use and investment, while ensuring the next generations' rights. A clean, safe and healthy environment leading to diversified production resources and economic activities, supporting competitiveness, providing new jobs, eliminating poverty and achieving social justice" [16]. Each pillar has several projects and plans,however, this paper focuses on the plans that relate to the nature of this study. The following points list the plans related to each pillar.

Environment pillar

(1) Strengthening the institutional and legislative structure of water resource management system.
(2) Expanding infrastructure for supporting a sustainable water system.
(3) Adopting fiscal policy reforms to encourage sustainable consumption patterns of water and natural resources.
(4) Raising the awareness to reserve environment and natural resources, providing incentives for more advanced alternatives and technologies for water conservation and natural resource protection.
(5) Enhancing the efficiency of solid-waste management system and supporting its sustainability.
(6) Developing a system for disposal of hazardous wastes.
(7) Developing the infrastructure required to reduce air pollution and face climate changes.
(8) Enhancing the efficiency of public administration and infrastructure to protect biodiversity.
(9) Monitoring the implementation of international conventions on environment.
(10) Encouraging civil society and private sector participation in preserving and protecting biodiversity.
(11) Enhancing the efficiency of protecting coastal and marine areas.
(12) Establishing a higher council for sustainable development.
(13) Adopting policies to reduce air pollution adjust to climate change and protect the environment.

Urban development pillar plans

(1) Reforming the institutional and governance system of urban development planning and management.
(2) Linking the comprehensive investment plan and the national urban plan for the year 2052.
(3) Encouraging municipalities, role in execution and management of urban plans.
(4) Promoting the population settlement in the new development areas.
(5) Achieving a balance between supply and demand in the housing sector.
(6) Eliminate informal settlements and insecure areas.
(7) Substituting and renewing infrastructure and expanding the provision of utilities in new areas.

(8) Encouraging the use of green and sustainable building methods.
(9) Eliminating infringement in new urban communities.
(10) Increasing the capacity and improving the quality of public transportation in cities.
(11) Increasing the construction capacities in new urban communities.

Table 2 summarizes these plans in a simple way that allows for assessing environmental sustainability of any project based on these criteria. This table will be used to assess the degree to which the case study, succeeded in achieving sustainability on the local level.

Case study: Madinaty gated community

This section discusses the different sustainability design aspects of Madinaty city gated community, to accurately assess the degree to which the design achieved the previously discussed sustainable criteria on both the local and global level.

- *Location and accessibility*

Acting as an extension to New Cairo City [17, 18], Madinaty is a mega project situated to the east of the city center, at Cairo 33 km on the Cairo-Suez road as shown in Fig. 5. The city is approximately a 10-min drive from Heliopolis and 20 min from downtown Cairo. It is also located near the second ring road [19]. Initially some users complained about the project's location on the Suez Road which may seem a bit far from the vital places of Cairo,however, with the existence of a large network of roads and axes, surrounding Madinaty Compound, it will be easy to reach the vibrant areas of Cairo [20] as illustrated in (Figs. 5 and 6). Its location is considered in much drier and hotter climatic zone of Cairo Governorate, northern Egypt [21].

- *Masterplan*

Madinaty city is built on a total area of 8000 feddans which accommodates around 700,000 residents including all of their needs (refer to Fig. 7). The residential areas

Table 2 Sustainability criteria according to Egypt's SDS plan. Source: author

Local sustainability criteria	
Environment	**Urban development**
Sustainable water system	Population settlement in new development areas
Sustainable water consumption patterns	Balance between supply and demand in housing sector
Sustainable solid-waste management system	Eliminate informal settlements
Hazardous waste disposal system	Substitute and renew infrastructure
Preserve natural resources	Provision of utilities in new areas
Sustainable infrastructure	Sustainable building methods
Minimal environmental conventions and protect biodiversity	Eliminate infringement
Protect coastal and marine areas	Improve and increase the capacity of public transportation
Reduce air pollution	Increasing construction capacity

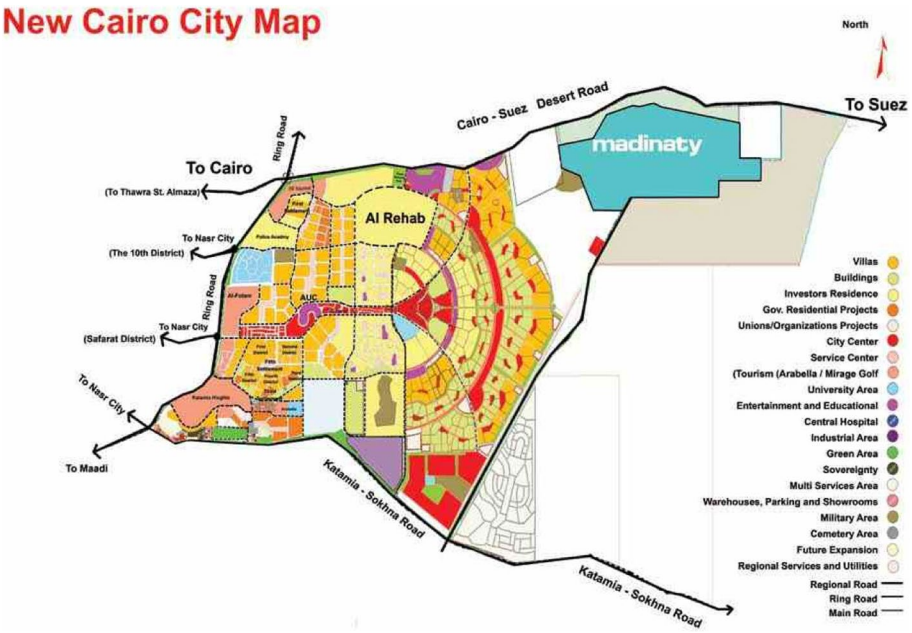

Fig. 5 Madinaty location on the map. Source: http://www.madinaty.com/en/project.aspx

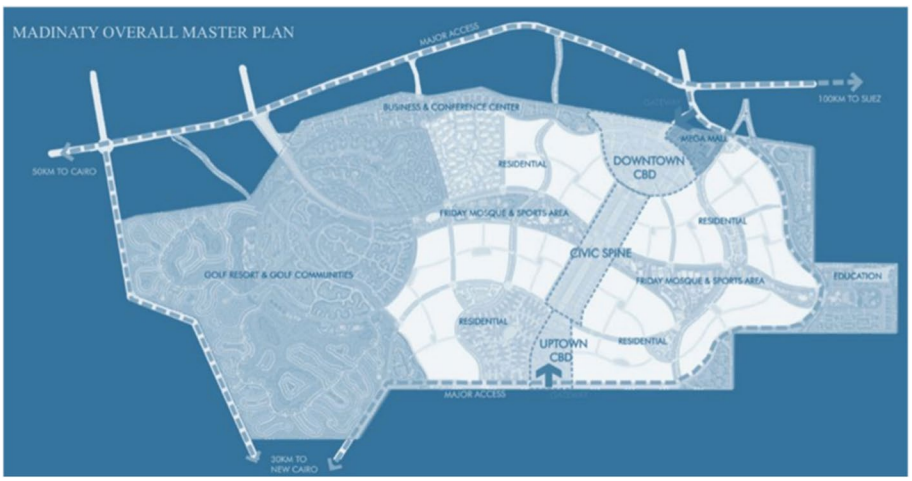

Fig. 6 Madinaty zoning and accessibility diagram. Source: TMG Strategy Presentation, June 2020

account for around 73% of the total area which is 5848 feddans, with fully integrated services. The residential areas have a variety of unit spaces starting from 42 to 324 sqm to serve different housing and user needs. There are 120,000 housing units over 18 zones vary from apartment to villa accommodations [22].

Madinaty Sustainability Analysis

This section analyzes sustainability according to the previously discussed global criteria:

- *Adequate, safe, affordable housing*

Fig. 7 Masterplan of Madinaty city. Source: http://www.madinaty.com/en/project.aspx

Madinaty is considered a luxurious city which is targeted for rich communities only. This is because the private sector builders see higher profit margins in luxury developments [23]. However, according to the world bank document released in February 2007, the investment company previously has agreed to provide 7% of the total cost to NUCA in the form of housing units for low-income beneficiaries after the project is completed [24]. Property prices vary depending on each property's size, layout, location, and delivery date. According to the city's most updated listings, prices range from 1,750,000 Egyptian pounds which is a two-bedroom apartment, with a total area of 70 m^2 to 46,125,000 Egyptian pounds which is a stand-alone villa with a total area of 615 m^2.

The environment is safe for users, everyone can move easily during anytime of the day between different destinations [2]. Some measures are integrated within the planning of the city to ensure safety and security of residents such as securing tree fences surrounding the city, securing main entrance and side gates, regular check and property patrol, monitoring internal traffic, firefighting and rescue service, cooperation with the Ministry of Interior of Egypt regarding any actions that deviate the law to maintain order, ensuring that the city's internal policies and procedures are followed, training personnel on evacuation and first aid plans [25], installing roads and reversing bumps to prevent speeding and road accidents, Security guards and surveillance cameras, and working 24 h a day to preserve the safety of all residents [20].

- *Services*

It is ensured the provision of a variety of services, facilities, and means of entertainment in Madinaty Compound, so that all residents can benefit from them. These services includes commercial areas, restaurants, sports courts, gyms, health clubs, medical centers, parking and underground garages, and mosques in addition to educational services. The general plan shows the stages of project implementation, in

each of them a part of the residential areas and their services, as well as a part of the huge services. Each stage is surrounded by arterial roads that connect them with the external roads surrounding the project. That achieves the integration of services and expands the freedom of choice for the residents, which is required as a design objective.

- *Air quality*

All apartments have more than one destination so that their residents can enjoy the greatest amount of sun and fresh air. Districts are designed into more green and walkable communities, as seen in Fig. 8, to minimize the dependence on vehicles and reduce air pollution. The inclusion of green areas like trees and parks all over the community acts as shades, decorative icons, pollution cleaners, and reduction of heat island effects. The installed underground trash bins also preserve air quality, to maintain a civilized look for the city and to avoid harming the beauty of the city [26, 27].

- *Energy efficiency*

For regular electric current service, high-efficiency electricity networks are incorporated in the design of Madinaty city. Other units are installed to generate electricity during emergency situations. In addition to this, solar power is integrated in several locations in the city including the garbage collection system.

Solar heaters are used to heat water in the villas area [28]. The British school in Madinaty and the main mosque both have solar cells integrated in the roofs design in order to warm the water required for Air Conditioning System and the toilet taps. Sun light is admitted during the day to illuminate the school and the mosque interiors, and LED lights are used only if needed [29]. In addition, Streets Solar Lightening Cells, seen in Fig. 9, are also used in several streets and it is planned to convert all streets into solar lighting systems.

- *Land efficiency*

Fig. 8 Green and Walkable district design. Source: https://ipgegypt.com/en/properties/1151-special-apartment-with-garden-90-m2-for-sale-at-madinaty

Fig. 9 Street solar panels. Source: [29]

The planning of the city also ensures land use efficiency, while considering building orientation and massing principles to ensure that occupants are exposed to optimum sun radiations. In addition to scaling the nearby parking lots and spaces to accommodate one car for each apartment within the building or parking spaces for schools and in front of the mosque to accommodate the users [29].

- *Efficient water consumption*

In Madinaty, there is a high-tech network for distributing pure water to the various units, in addition to the availability of an irrigation network necessary for afforestation

and irrigation of green areas, maintenance, and development operations with the latest scientific methods that ensure optimal use of water [28]. The amount of water consumed in the villa is consumed through the balance charging system. This system is applied to all residential units in Madinaty. It is an accurate system depending on the user (using the credit card), then entering it into the water meter, and the balance appears on the screen. The water is used up as well as the remaining balance [28].

- *Waste water treatment*

Gray water treatment is used for the Golf area irrigation. The temporarily constructed water treatment is designed for 15,000 persons. However, there is a plan to build a new big one serving 1.2 million people. Cars collect the water and take it for irrigation lands that do not have an automatic irrigation system or sprinkles. Drinking water/tab water is coming for a water line from El Sherouk [28].

The provision of sewage treatment plants was taken into account when designing the sewage network that it should be sufficient for the perpetuation of the sewage process, with planning for the stream of rain and torrential streams and a complete rain drainage network, in addition to the efficiency of gray water treatment and reuse for spraying fountains and latrines and in irrigating the vast green spaces in Madinaty [28].

- *Solid waste treatment*

Underground trash bin system by an Italian company named Ecologia is shown in Fig. 10. Big trash bins are located underground properly covered by a land surface and a small entry trash bin is placed on the street ground, this is where the citizens will throw their trash into that will fall into the bigger one underneath. Trash bins are categorized as organics, plastics, and metals according to color.

- *Hazardous waste*

From the beginning of the construction process, it is assumed that there are not and will not be any structural or latent defects within the properties. We have assumed that

Fig. 10 Underground trash bin system. Source: [29]

no known deleterious or hazardous materials have been or are being utilized in the construction of any of the properties [30].

- *Building materials*

Madinaty administration has introduced the use of local and manufactured materials at sites such as natural stones in pedestrian paths to reduce transportation and maintenance costs, recycling building materials and construction elements, and using and preserving natural resources represented in garbage collection bins (environmentally friendly) and using recycled materials in infrastructure such as paving streets and pedestrian paths [28]. This is illustrated in Fig. 11.

- *Infrastructure*

The city's infrastructure includes the previously discussed water, irrigation, and sewage networks; in addition to storm water network, a road network is a 100-km-long network of road widths ranging from 9 to 22.8 m, along with parking facilities stretching over a total area of 510,000 m^2. Other services include low and medium voltage networks, telephone network, and Street Lighting [17, 18].

Streets depend on two types of streets: the first is the main streets represented by the ring road around the boundaries of the project and some internal main roads, which are 15 m wide and the second curved secondary streets with closed ends, which are 12 m wide where transportation is available in Madinaty.

Boundaries of the project and some internal main roads are 15 m wide and the second curved secondary streets with closed ends are 12 m wide where transportation is available in Madinaty. Regular service of private buses inside and outside the city to connect them to areas in Cairo.

- *Environmental protection*

Preservation of work focuses on environment protection, public places, and public passageways. In addition, cleaning of all residential buildings, including entrances

Fig. 11 Stone used in pedestrian paths in Madinaty. Source: [28]

and spaces in front of the apartments, is done on a regular basis. Also pest control is achieved using substances approved and authorized by health authorities with latest scientific techniques which comply to public health and environmental standards [25]. Madinaty is the first city to recycle waste in Egypt which aims to recycle both food waste and solid waste, such as plastic and various metals. That system aims mainly for keeping humans and the environment in a healthy state [31].

- *Capacity and quality of public transportation*

What distinguish Madinaty from other new cities is its strong internal and external transportation system due to having external transportation lines; Madinaty—Saray Al Qouba, Madinaty—Nasr City, Madinaty—Al Rehab. Regarding public transportation inside the city, there are 22 bus lines functioning regularly every half hour for the transfer of Madinaty residents to and from the city. Also there are a 9 internal bus lines to facilitate the residents' movement within the city.

- *Green and open spaces*

The largest percentage of the area of Madinaty Compound is allocated to green spaces and landscapes. The city features green spaces suitable for picnics and all kinds of events as seen in Fig. 11. Families and friends can gather in the Oasis area, inspired by the Bedouin style, in Madinaty New Cairo Compound [20]. The city has one of the largest gathering areas in the region "Madinaty Central park" which has an area over 35 feddans. It also includes one of the largest open air shopping centers called "Open Air mall" (Fig. 12). This mall spans over 96 feddans and has many entertainment and shopping anchors as well as a cinema complex. In addition, it is planned that the city will accommodate an important spine "Madinaty spine" of 624 feddans with different services arranged along its length, such as shopping, hotels, educational institutions, business park, and mixed use buildings which have restaurants, cafes, gym, and gathering areas.

Results and discussion

To validate the proposed sustainability criteria that are previously discussed in this paper, this section assesses Madinaty sustainability design based on the local and global criteria. This assessment aims at evaluating the degree to which the case study achieved sustainability on both levels. Eventually, the influence of the city's design on the environment and the user will be also evaluated based on this assessment.

Fig. 12 Madinaty open air mall. Source: https://twitter.com/OpenAirMall

Initially, this section begins by assessing the sustainability of Madinaty based on the criteria of the UN's Sustainability Development Goal number 11 which is "Making cities and human settlements" as shown in Table 3. There are 3 different indicators used to assess each point; strong, intermediate, or weak). It is obvious that most of the goal points are achieved successfully except for some points that will be discussed.

Madinaty city provides adequate and safe housing for its residents; however, these housing units are targeted for high-income families, which makes them not affordable. Even though some of them, only 7%, were dedicated for low-income families, but still this is a very low percentage compared to the total amount of housing units available. According to the UN's Sustainability Development Goal number 11, for a city to be sustainable, it needs to provide affordable housing as well not just safe and adequate housing.

Another goal that was not achieved is the protection of the cultural heritage. The reason for this is that the city was intended to have a European design style in an effort to show the uniqueness of the city. Some zones architectural styles are inspired by Andalusian architecture, and each zone design style is different from the other. This does not preserve the country's heritage which is crucial based on the UN's SDG number 11 goals. Lastly, the city provides plenty of services for its users; however, these services are not equally distributed on the different residential zones. Some zones have more services than the others, while other zones have more green/open spaces. Other than these points, the city has succeeded in meeting the other requirements of this SDG.

Next, the sustainability design of Madinaty is evaluated based on the local sustainability criteria previously discussed. Table 4 shows this assessment with the same indicators of Table 2. In some cases, N/A is used to indicate that it is not applicable. For the environment pillar, all of the requirements are met. However, for the urban development pillar requirement, the balance between supply and demand is not achieved due to the high prices of the available housing units in Madinaty. This results in the supply being significantly more than the demand, meaning that many housing units are available for sale which outweighs the demands of the potential buyers of these properties.

The sustainability techniques applied in the case study guarantees positive impact on the environment and the users. Efficient water and energy techniques preserve the natural resources of the environment, while waste management and sustainable transportation result in reduced pollution and improved air quality. Consequently, users will also benefit from this. The improved air quality results in improved health, comfort, and satisfaction. The provision of vast areas of green and open spaces have a significant impact on users as well. These spaces evoke positive emotions which improves the mental health and well-being. These spaces also encourage users to gather and communicate, enhancing social interaction. The gated community also guarantees safety for its users as a result of the gates surrounding the city, increased security, and elimination of infringement. Eventually, users of Madinaty city will have a better quality of life.

Conclusion

Conventional building techniques that exploit natural resources have resulted in a worldwide problem of depleting natural resources. Therefore, many nations have adopted sustainable development in an effort to solve this issue and preserve the

Table 3 Sustainability assessment based on the UN's SDG number 11. Source: author

Global Sustainability Criteria	
SDG no. 11: Making cities and human settlements inclusive, safe, resilient and sustainable	
Adequate, safe, affordable housing for everyone	○
basic services for everyone	◒
Inclusive and sustainable urbanization	●
Protect cultural and natural heritage	○
Improved Air quality	●
Sustainable waste management system	●
Universal access to safe, inclusive and accessible, green and public spaces.	●
Resource efficiency	●
Building using local materials	●

Key:
●: strong; ◒: intermediate; ○: weak

Table 4 Sustainability assessment based on the local criteria of Egypt's SDS. Source: author

Local Sustainability Criteria			
Environment		Urban Development	
Sustainable water system	●	Population settlement in new development areas	●
Sustainable water consumption patterns	●	Balance between supply and demand in housing sector	○
Sustainable solid-waste management system	●	Eliminate informal settlements	N/A
Hazardous wastes disposal system	N/A	Substitute & Renew infrastructure	N/A
Preserve natural resources	●	Provision of utilities in new areas	●
Sustainable Infrastructure	●	Sustainable building methods	●
Environmental Protection	●	Eliminate infringement	●
Protect coastal and marine areas	N/A	Improve and increase the capacity of public transportation	●
Reduce air pollution	●	Increasing construction capacity	-

Key:
●: strong; ◒: intermediate; ○: weak

natural resources for the benefit of future generations. To achieve this, it is crucial to follow the global and local sustainability development criteria. The UN's SDG number 11 which is "Making cities and human settlements inclusive, safe, resilient and sustainable" and Egypt's SDS two Environmental pillars; environment and urban development, are the base for evaluating sustainability in this paper.

The UN SDG includes several key points that, if followed, guarantee a sustainable urban community. It is also very important to ensure that the local sustainability criteria specified by Egypt in the Sustainability development Strategy are followed. Madinaty sustainable gated community is chosen as the case study for this paper and sustainability is evaluated based on both criteria. For the global criteria assessment, results show that Madinaty meets all of the global requirements except providing affordable housing, and this is because Madinaty city was aimed at providing a luxurious lifestyle for the wealthy only, even though the UN SDG goal states that a sustainable community has to ensure access to adequate, safe, and affordable housing to everyone. Results also revealed that the city does not equally provide services for everyone because some residential zones have more services than the other ones. In addition to this, the design did not succeed in protecting the cultural heritage of the city. Each residential zone is designed on a different architectural style that does not preserve Egypt's heritage. However, based on the local assessment, all of the criteria is achieved except the balance between supply and demand. This is a result of the very high prices of the different properties that the demand is only limited to certain social class of people that can afford such prices.

On the other hand, the sustainability design of Madinaty has effectively and positively influenced the environment and users. The sustainability techniques used, such as resource efficiency, sustainable infrastructure and transportation, waste management, green spaces, and security measures, all enhance the environmental air quality, reduce pollution, and preserve natural resources. This in turn improves the health and well-being of its users, reduces stress, encourages communication and social interaction, enhances safety and security, and eventually, provides a better quality of life. Therefore, sustainable urban communities preserve the environment and provide a safe environment and a better quality of life for its user.

Abbreviations

GBC	Green Building Council
LEED	Leadership in Energy and Environmental Design
NGO	Non-profit organizations
SDG	Sustainability Development Goals
SDS	Sustainable Development Strategy
UN	United Nations
WGBC	World Green Building Council

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Declarations

Competing interests
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References

1. Haque M (2000) Environmental discourse and sustainable development linkages and limitations. Ethics and the Environment 5(1):3–21. https://doi.org/10.1016/s1085-6633(99)00034-0
2. Azab N, Farahat B (2018) Gated communities; images of sustainability; Al-Rehab & Madinaty case studies. BAU J Health Wellbeing 1(3):47. https://doi.org/10.54729/2789-8288.1099
3. Environment and Ecology (n.d.) Sustainability. Retrieved February 15 2023, from http://environment-ecology.com/what-is-sustainability/247-sustainability.html
4. Bromley DW (2008) Sustainability. In: The new Palgrave dictionary of economics, 2nd edn
5. Egypt Green Building Council (n.d.) Why green building?. Retrieved May 23 2023, from https://www.egyptgbc.org/en/why-green-building
6. Ezimako N (2023) The advantages of using sustainable building materials. Retrieved February 19 2023, from https://www.linkedin.com/pulse/advantages-using-sustainable-building-materials-nnamdi-ezimako
7. U.S. Green Building Council (n.d.) Benefits of green building. Retrieved February 20 2023, from https://www.usgbc.org/press/benefits-of-green-building
8. Leaman A, Bordass B (2010) Productivity in buildings: the 'killer' variables. Build Res Inf 4(19). https://doi.org/10.1080/096132199369615
9. Ewert A, Chang Y (2018) Levels of nature and stress response. Behav Sci (Basel) 8(5):49. https://doi.org/10.3390/bs8050049
10. U.S. Department of Energy (n.d.) The business case for sustainable design in federal facilities: energy efficiency and renewable energy. https://www1.eere.energy.gov/femp/pdfs/buscase_frontmat.pdf
11. United Nations (n.d.) Take action for the sustainable development goals. Retrieved May 25 2023 from https://www.un.org/sustainabledevelopment/sustainable-development-goals/
12. United Nations (n.d.) Goal 11: make cities inclusive, safe, resilient and sustainable. Retrieved May 25 2023 from https://www.un.org/sustainabledevelopment/cities/
13. Egypt Green Building Council (n.d.) Who we are. Retrieved May 23 2023, from https://www.egyptgbc.org/en/world-gbc
14. Egypt Green Building Council (n.d.) Egypt and sustainability. Retrieved May 23 2023, from https://www.egyptgbc.org/en/egypt-and-sustainability
15. Egyptian Government (n.d.) Egypt Vision 2030. https://arabdevelopmentportal.com/sites/default/files/publication/sds_egypt_vision_2030.pdf
16. Abdel Latif A, Magdy D, El Sharkawy K, William M, Magid M (2018) Egypt SDS 2030: between expectations and challenges to implement. https://documents.aucegypt.edu/Docs/GAPP/Public%20Policy%20Hub%20Webpage/7-Sustainable%20Development%20Strategy%20(SDS)%20Egypt%202030%20Policy%20Paper.pdf
17. ECG (n.d.) Madinaty. Retrieved May 26 2023, from https://www.ecgsa.com/project/madinaty/
18. ECG (n.d.) Madinaty infrastructure. Retrieved May 26 2023, from https://apastyle.apa.org/style-grammar-guidelines/references/examples/webpage-website-references
19. Heidelberg Materials (n.d.) New Cairo City: Al Rehab and Madinaty settlements. Retrieved May 26 2023 from https://www.heidelbergmaterials.com/en/new-cairo-city-al-rehab-and-madinaty-settlements
20. Flat & Villa (2023) Compound Madinaty New Cairo. Retrieved May 24 2023, from https://flatandvilla.com/en/new-cairo/madinaty-compound/
21. Latlong (n.d.) Madinaty, Cairo Governorate, Egypt. Retrieved May 24 2023 from https://www.latlong.net/place/madinaty-cairo-governorate-egypt-13617.html
22. AAIMF (2023) Madinaty New Cairo. Retrieved May 24 2023, from https://aaimf.com.eg/page_detail.aspx?id=2145
23. Hafez T (2019) Affordable housing: opening doors. Retrieved May 24 2023 from https://www.amcham.org.eg/publications/business-monthly/issues/284/August-2019/3882
24. World Bank (2007) Arab Republic of Egypt: analysis of housing supply mechanisms, final note. Washington, DC. http://hdl.handle.net/10986/7554
25. TMG (n.d.) Madinaty: a city of International Standards in Egypt. Retrieved May 25 2023, from https://citypay.talaatmoustafa.com/project/M
26. Madinaty (n.d.) Facilities. Retrieved May 25 2023, from http://www.madinaty.com/En/utilities.aspx
27. Madinaty (n.d.) Masterplan. Retrieved May 25 2023, from http://www.madinaty.com/en/project.aspx
28. Eladham MG, Abdel Hafeez MM, Ahmed MM (2021) An initiative to achieve sustainability criteria in new gated communities in Egypt. 26(1):1–9. https://doi.org/10.21608/pserj.2021.74249.1108
29. Khattab M (2015) Guidelines for sustainable urban zero pollution community (S.U.Z.C) [Master's Thesis, the American University in Cairo]. AUC Knowledge Fountain. https://fount.aucegypt.edu/etds/223
30. Arab African International Bank (2007). Offering circular. TMG Holding. https://www.talaatmoustafa.com/Upload/Offering%20Circular.pdf
31. Aqarmap (2020) Your guide to Madinaty. Retrieved May 26 2023, from https://advice.aqarmap.com.eg/en/your-guide-to-madinaty/

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