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Assessment of the efficiency of sustainable economic housing

Basmaya city as a model

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Abstract

Globally, and in Iraq in particular, environmental and urban deterioration are among the most pressing issues of our times. The urban environment continues to negatively affect contemporary residential areas on several ways. Aside from that, it is inefficient, costly, and does not suit inhabitants' social, economic, or environmental demands. Mainstream dwelling units are neither socially, ecologically, economically or urbanely viable due to their inadequacy to per capita income. Not taking advantage of new advancements and not understanding how to apply notions of sustainability to housing projects in general and economic housing in particular are major difficulties connected to housing. Affordability is the ability to live in a community that meets the requirements of all residents while maintaining high environmental, social, and economic standards, and a sense of community. Therefore, that economic housing for all social classes would be efficient, affordable, sustainable, and suitable. Due to the conventional housing's waste of resources and pollutants, it ignores the wind and sun's orientation. Moreover, not using environmentally friendly and economically viable local building materials. The research combined different sustainability with affordable housing. To obtain efficient, sustainable, and acceptable economic housing for all social classes, combine them.

Key words: Sustainable housing, sustainable development, sustainable design

1. Introduction

Housing affordability is an issue for development in both developed and developing countries. Because cheap housing is vital for social stability and economic success, as well as individual and societal advancement (Serageldin, 2002; Al-Shama`a, 2017). There is a lack of expertise of the current studied example and understanding of the principles of sustainability in the design and execution of affordable housing projects, which leads to a lack of different sustainable solutions (DCLG, 2010; Battle, 2001). It is possible to achieve sustainable (facilitated) economic housing by integrating sustainability concepts and components with economic housing design aspects and analyzing their efficiency (Aqaba, 2002). Therefore, applying it to the features and advantages of affordable housing has a direct influence. Because of the study, various hypotheses were developed, including the potential of creating sustainable (facilitated) economic housing. This is done by linking sustainability concepts and components to design features impacting affordable home design and analyzing their suitability. It is a current trend that meets family demands and is suitable with their financial condition, all within approved housing norms and design restrictions and standards. To analyze standards, components, and long-term environmental, social, and economic solutions. The research aims to assess the effectiveness of sustainable environmental, social, and economic solutions by tying sustainability components and principles to design aspects and indicators that influence the design of affordable housing.

2. Levels of establishing residential sustainability

2.2. Sustainable housing: is defined as housing that meets current needs of residents while preserving the environment and responsibly managing resources so that future generations have the right to healthy, decent housing that meets their physical and technical needs (Torrent and Edwards, 2000). Levels of residential sustainability would be included as below (Pol-service, 1983).

2.3. planning:

2.3.1. Public transit and planning integration: The Technical Guide-Code for Sustainable Homes requires that city and residential development be consistent with the local environment. Moreover, planning is based on public transit and pedestrian walkways rather than private mobility. To minimize pollution, traffic, energy use, and private parking. By redeveloping existing lands and reusing and restoring existing structures to fit new purposes, we avoid expanded urban planning and sprawl (Richardson, 1995; DCLG, 2010).

2.3.2. Multi-use development: Modern housing trends demand for multi-use development that supports blending and overlapping of multiple applications and functions. This helps people by providing housing options near work and shopping, and by creating areas with continuous activity 24 hours a day, which gives residents a sense of security (Zubaidi, 2001). On the other hand, a sustainable community is one that is self-sufficient, relies less on private mobility, and is oriented towards public transit. Thus, minimizing fuel use and pollution helps accomplish the following aims and concepts (Kim & Rigdon, 1998; Alam et al., 2020).

a. High housing density and diverse and various usage of areas and sectors.

b. Using open spaces to foster communication and social engagement, while enhancing the ecology.

c. Research waste management and pollution reduction solutions.

d. Preparing the provision of requirements for individuals with special needs such as ramps and the absence of impediments to access and staircases. Figure (1) depicts open spaces and meeting spots for residents, where the design concept is based on the movement of pedestrians and pedestrians, which is depicted by the gradation of confinement zones. Figure (2) depicts the gradient in the seclusion between the street, the square, and the square, which is the center of assembly and the performance of public events, and Sherwood Energy Village in the United Kingdom is an example of mixed-use development in sustainable residential communities. The design concept shown in figure (3) depicts the separation of pedestrian and motor vehicle traffic (IanBrearley, 2014).

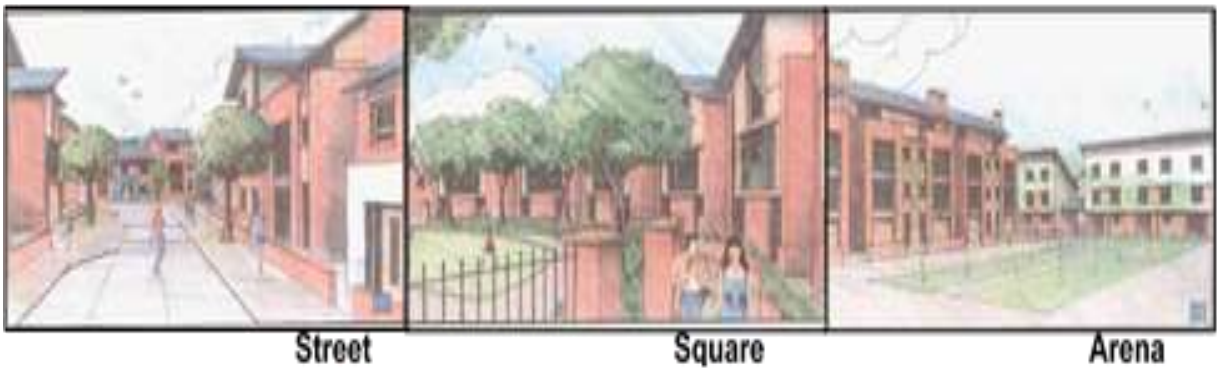

Figure (1) represents the open spaces and gathering areas for the population. The design idea is based on pedestrian and pedestrian movement, which is represented by the gradation of containment areas (Brearley, 2014).

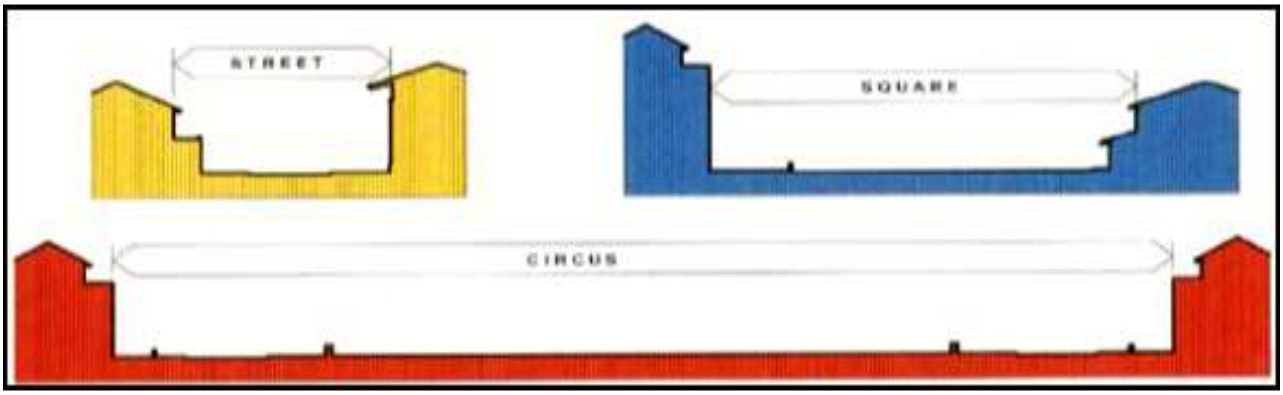

Figure (2) the gradient of privacy between street, yard and field in Sherwood Energy Village in the UK is an example of mixed-use development in sustainable residential communities (Brearley, 2014).

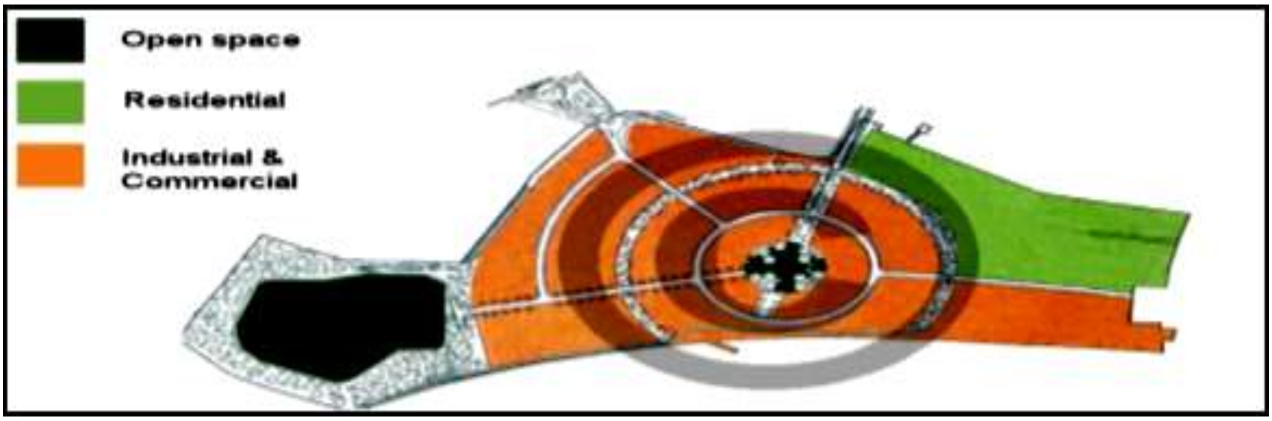

Figure (3) the design idea is based on the separation between traffic and cars and the emphasis on the privacy of the residential area (Brearley, 2014).

2.3.3. Pedestrian traffic design: When developing residential complexes, the goal is to meet human standards while also preserving the environment. As a result, the design concept must first and foremost rely on pedestrian mobility, as well as ecologically beneficial modes of transportation such as bicycles and vehicles that rely on renewable sources of energy and are utilized for need. As shown in figure (4) the combination of planning, public transit, and pedestrian mobility is the degree of attaining sustainability in housing, (Battle & Mc Carthy, 2001).

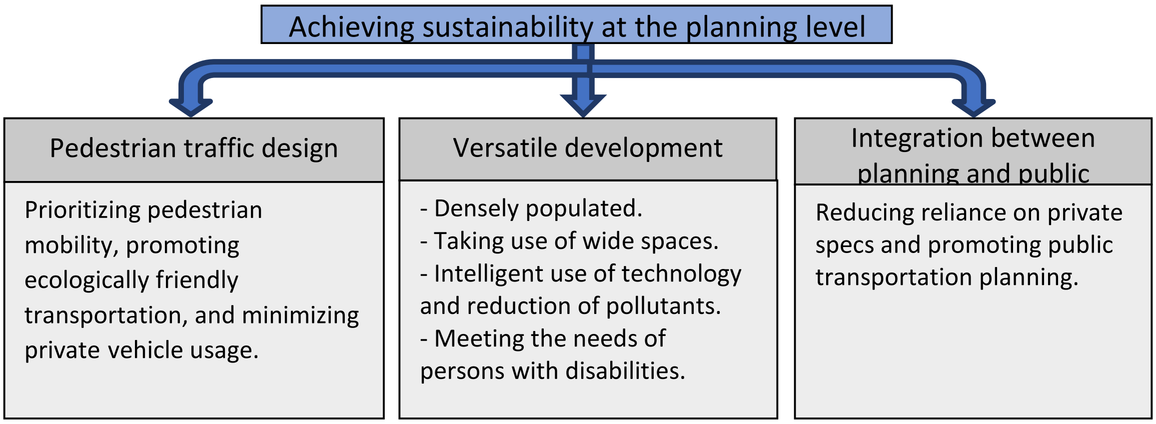

Figure (4) shows the levels of achieving sustainability in housing.

3. Economic housing (affordable housing)

A key component of sustainable housing is a home that is both cost-effective and high-quality, providing occupants with a place to live that is both safe and pleasant for the now and the future (Al-Tharwa, 2002).

3.1. The importance of affordable housing: The significance of low-cost economic housing may be addressed at two levels: state and family, by highlighting the core principle that is based on a balance between the demand process and the available resources as shown in figure (5), which are limited and scarce (Al-Issawi, 1996).

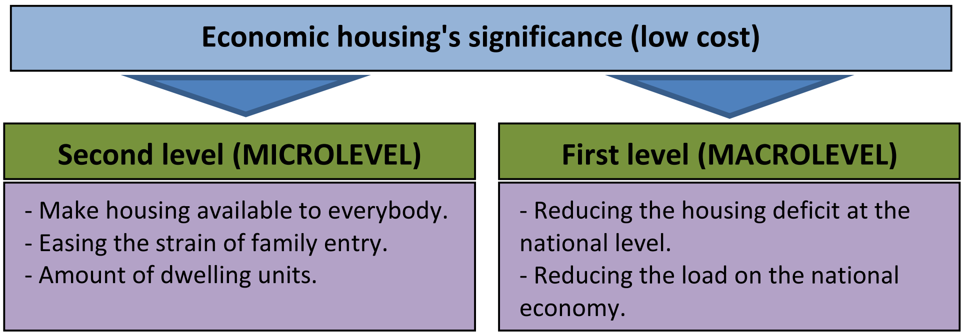

Figure (5) Levels of importance of low-cost economic housing (Al-Shammaa, 2017).

4. Factors affecting housing economics

4.1. Land divisions: The existing land divides overlook the notion that housing is at the heart of a community. If roadways for automobiles were to become the foundation. The housing is then signed without an analytical analysis of the site and the suitable direction, as well as how to deal with the site's environmental circumstances and research to identify acceptable solutions (Idris, 2004).

4.2. House and land size: It is shown by making efficient use of land and preserving its worth as well as the expenses of essential infrastructure, and then altering the cost. In most cities, the cost of land and the cost of constructing the site are among the most prominent elements in the growth in house costs. One of the most essential considerations in securing land and providing enough housing is reducing the land area and the size of home fit for the real demands of the family (Idris, 2004).

4.3. House design: By using natural variables in the building's operation and lowering reliance on mechanical and technological methods, the house's design plays an essential part in creating cost-effective housing. The cost of operation and maintenance rises as a result of these methods (Idris, 2004).

4.4. The construction process and materials: The concrete structural system is used in the building of the majority of contemporary dwellings. Despite the variety of building technologies that are suitable for small residences (2-3) floors. In addition to the reduced cost of worker payment and the cost of construction materials needed as compared to a concrete structure. As demonstrated in Figure (6). The designer or owner may choose exterior and interior finishes that are basic and appropriate for the local context, as well as at reasonable prices that accomplish quality and efficiency (Li & Wang, 2016; Al-Hadithi, 2014).

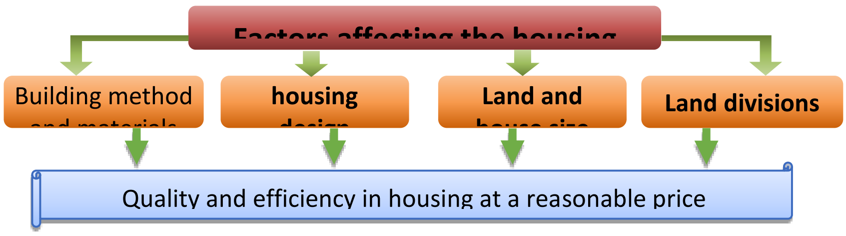

Figure (6) Factors affecting the housing economy.

4.5. Methods and strategies for affordable housing: Techniques controlled by governmental authorities and methods managed by planners, designers, and developers, as shown in Figure (7), are two of the most essential aspects and ways that contribute to produce affordable housing (Eastman et al, 2011).

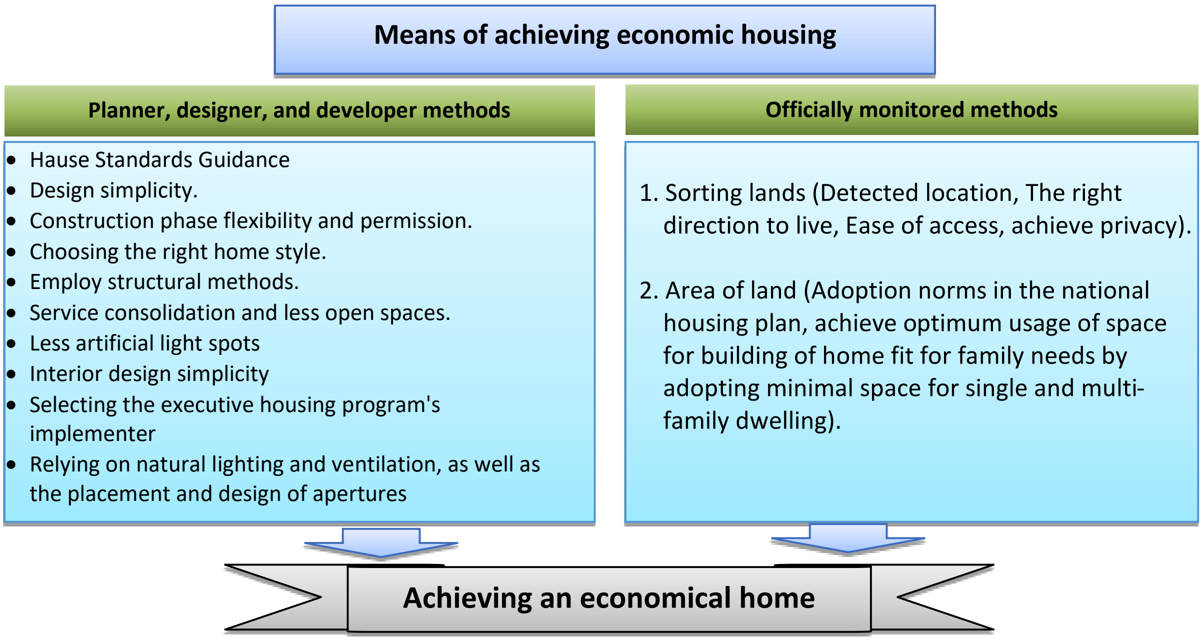

Figure (7) methods and means to achieve economic housing.

A procedural definition of affordable housing may be established based on the above. It is characterized as low-cost, high-quality housing that is adaptable to current and future family requirements and is economical to construct, run, and maintain (Bahamam, 2003)

4.6. Indicators of economic housing

4.6.1.Approval required: which gives the highest functional degree of vacancy with the prospect of dwelling for the family's development and expansion, and financing may be provided according to the family's economic capabilities.

4.6.2. Improving quality: It includes indicators for achieving social requirements that are proportional to various housing desires, that improve overall quality of life, and that interact with the urban identity in a way that is compatible with environmental and climatic factors while minimizing environmental impact.

4.6.3. Cost Reduction: Contributing to cost reduction is one of the indicators of offering the greatest value for the paid cost. Additionally, it adds to the reduction of maintenance and operating expenses and has a quick implementation duration. Maximizing use of existing construction technology, materials and ensuring the long-term viability of housing. The reduction contributes to the rationalization of electricity and water usage (Bahamam, 2003).

5. Case study example:

The Basmaya residential project was chosen as a study subject (Al-Janabi and Ashour, 2019; https://www.bismayah.org).

5.1. Project location: The project lies 10 kilometers southeast of Baghdad, on the route that connects Baghdad and Kut city. The project was started in 2013 and completed in 2019 with the delivery of 30,000 dwelling units.

5.2. Project description: The project includes 100,000 dwelling units, with a population density of 6 individuals per housing unit. The population is estimated to be about 600,000 per capita. The project would take up 183,000 m^2 of land. The project consists of 834 structures with a maximum height of ten stories, with a seven-year execution span. The project has a total cost of $7.75 billion USD. This project included the creation of a new city with mixed-use land and all of the necessary infrastructure. Water and electricity networks, as well as recycling and water treatment facilities, are examples of social and technological institutions providing educational, recreational, religious, and commercial functions. Precast concrete was used to construct the project, as seen in figure (8) which depicts the project's aerial viewpoint and dwelling unit designs.

5.3. Selecting the project: The project was chosen because it is a multi-family building with a high density, which is a sign of accomplishing features of economic sustainability. It has the features of sustainable and affordable housing, as well as flexibility, scalability, and future expansion, and it reflects Iraq's new residential complex construction trend.

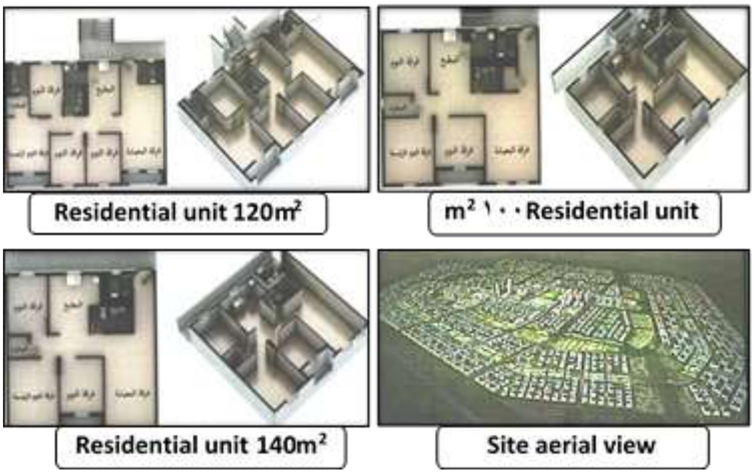

Figure (8) unit shapes and sizes in the Basmaya housing complex.

6. A test of the theoretical framework's sustainability indicators.

6.1. Social sustainability indicators: multi-pattern household index This metric represents the average served family size of six persons. This design facilitates social interaction between families and respects their traditions are shown below.

a. The household index with many patterns. With an average of 6 individuals per family, this indicator corresponds to the average size of the serviced family. This style allows families to communicate socially and is in keeping with their norms and traditions.

b. Housing units aggregated. The design is U-shaped, with dwelling units distributed along the residential building's one storey, figure (9).

c. Style and geographical diversity in dwellings. The diversity is not only at the level of the building, but also at the level of one floor, allowing residents to choose the suitable type in proportion to their family's income.

Figure (9) housing unit aggregation pattern in Basmaya residential project.

d. The density index is a measurement of how dense something is. The project's population density is 54.64 percent, which is within the boundaries of high densities, and there is a match between the population (600,000) thousand people and the high densities that have been put in it, which is compatible with the size of the family (6 persons/ family). Despite the attainment of social interaction, however, large densities may have an impact on the family's social privacy.

e. The indicator of urban and open spaces. It should be emphasized that the building blocks are linked, resulting in the construction of urban areas. In addition to central spaces and play areas, these places provide for social interaction, and the distance between public spaces and residential regions surpasses 10 minutes on foot. The prevalence of pedestrian mobility characterizes the project, although it lacks adequate protection, as well as a lack of dependence on ecologically friendly public transportation, Figure (10).

Figure (10) depicts the connectivity of residential buildings and green open areas.

f. Indicators of social development as illustrated in Table (1). This sort of indicator identifies social, educational, commercial, and recreational structures that can be accessed on foot in less than 10 minutes.

Table (1) Indicators of social sustainability in the Basmaya residential project.

Indicator	Element	Vocabulary	Verification extent		
			efficiently verified	verified	unverified
Social	Residential type (single, multi-family)	Compatibility of the housing style with the size of the family		●	
		The extent to which the housing style conforms to customs and traditions		●	
		The extent to which the housing style is compatible with the achievement of social communication		●	
	The agglomeration style of the housing units	The compatibility of the grouping pattern with the size of the family		●	
		The compatibility of the collecting style with customs and traditions			●
		The compatibility of the aggregation style with the achievement of social communication		●	
	Densities	Compatibility of density with population size	●		
		The degree to which the density corresponds to the size of the family		●	
		The extent to which density corresponds to social privacy			●
	Urban spaces	Adequacy of urban space (qualitatively(			●
		Adequacy of urban space (quantitatively(		●	
		Access distances between urban spaces and residential units		●	
	Public social buildings	Access distances from the residential units		●	
		The extent of integration with urban spaces			●
		The adequacy of social services cadastral		●	

5. Environmental sustainability indicators:

The following are examples of these indicators (Building Research Establishment, 2005).

a. Compatibility with the surrounding environment. Although there is a flaw in the orientation of the dwelling units, the designer attempted to address this by adding masks to decrease the influence of direct sunlight. In urban environments, there is a visible connection between architectural design, environmental planning, and gradation.

b. An indicator of the most efficient use of energy. The project aims to create renewable energy on site, however there is a flaw in the site's solar energy use.

c. Indicator of rotation style. The project recycles rainwater and sewage, however there is a flaw in the project's waste recycling.

d. Indicator of plant and water source protection and adequate treatment. There is an obvious utilization of green areas in the project, as well as energy and water saving by recycling and reusing water.

e. Indicator of local materials use. Precast concrete was used to complete the job. However, the project lacks a local flavor in terms of construction, as well as a lack of local manufacture for the project and poor recycling of local resources.

f. Index of climate efficiency. The orientation of buildings in all directions is flawed, but the designer handled this issue by putting masks in front of the building facades. In addition, numerous trees were planted to soften the environment and function as windbreaks. There are certain portions of the project that are devoid of trees and plants, as well as water bodies that might help to temper the climate, as seen in table (2).

Table (2) environmental Sustainability Indicators for the Basmayaresidential project.

Indicator	Element	Vocabulary	Verification extent		
			efficiently verified	verified	unverified
Environmental	Harmony with the local environment	The extent of the interaction of architectural design and environmental planning		●	
		How efficient is the orientation of housing units and buildings?		●	
		The efficiency of urban spaces and their urban gradation		●	
	Optimum use of energy	Exploiting solar energy for heating			●
		Exploiting wind energy			●
		Exploiting renewable energies		●	
	Rotate style	The extent to which waste water can be recycled			●
		How much waste can be recycled?		●	
		How can rain water be recycled?		●	
	Good handling of plants and water	Efficient use of green roofs		●	
		Efficiency of using recycled water for irrigation	●		
		Efficiency of water use in the residential project			●
	Local Material use	The extent to which units and buildings can be implemented using local materials			●
		The extent to which local materials can be recycled		●	
	Climate Efficiency	Efficient routing processing for residential units		●	
		Efficient routing processing for public buildings		●	
		The extent of providing windbreaks and water sprinklers to mitigate the climate		●	
		Possibility to use sunscreens		●	

6.3. Architecture sustainability indicators

6.3.1.Structural density indicators: The area of the ground floor for all residential buildings is 1100,880m^2. The area of service, educational and commercial activities is 124.8 million square meters out of 18300,000 m^2, which is equivalent to 68% of the total area of the project. When the number of floors in the two sites' towers are added together, the proportion hits 80%, indicating that the buildings are densely packed. The project's open spaces account for 0.18 % of the total site area, which is acceptable since it ensures both quantitative and qualitative sufficiency.

6.3.2.Mixed-use indications: With the existence of complex administration buildings and the rest of the project services in close vicinity, mixed use in the project is relatively possible, since residential and service use such as hospitals, commercial centers, schools, mosques, public buildings, and stores are accessible. As illustrated in figure (11), the walking distance between the different events does not exceed 10 minutes.

Figure (11) land usage in the Basmaya residential complex.

6.3.3.Sustainably transported index: The idea encourages pedestrian circulation by shortening the distance between residential units and public activities. The absence of proper environmental protection for pedestrian roadways, as well as the lack of human-scale pathways, all undermine this aspect. The absence of ecologically friendly public transportation served as a poor indication, and the greater dependence on private transportation emerged.
6.3.4.Architectural design index: In terms of character, the project is a little out of town. The building facades do not blend in with Baghdad's local design, which is modern and contemporary. The project included modern technologies to some degree.
6.3.5.Threads index: The movement pathways in the project are characterized by gradation, and the gaps between the building and residential blocks, as well as the surrounding urban areas and numerous other activities, are well defined. As indicated in Figure (12), the walking distance between the different events and the residential units surpasses 10 minutes.

Figure (12) illustrates the project's center and its distance from the dwelling units, as well as the project's connectivity and gradation of areas and roadways.

6.3.6.The urban design index: It is a measure of how well a city is designed. Commercial and recreational activities, as well as public open spaces, are concentrated in the project's heart, which is marked by a higher level of planning objectivity. Indicators of urban sustainability are also included in Table (3).

Tab. (3) indicators of architecture sustainability Basmaya residential project.

Indicator	**Element**	**Vocabulary**	**Verification extent**		
			efficiently verified	**verified**	**unverified**
Architecture	**Structural density**	**The extent to which high building densities are available**		●	
		The extent to which open spaces are available in proportion to the structural density		●	
		The extent to which mixed use is available in the project		●	
	Mixed use	**Efficient ease of access between different uses**			●
		The extent to which walking and cycling can be encouraged		●	
		The extent to which walking and cycling can be encouraged			●
	sustainable transport	**Walkways are efficient, protected and environmentally friendly**			●
		The efficiency of the walkways and their suitability to the human scale			●
		Availability of public transport and public transport stations		●	
	Architectural Design	**The extent to which modern technology can be used in the project**			●
		Efficiency of scaling and sequencing in motion paths		●	
		Efficient ease of access between residential units and various events		●	
	Interconne-ction Urban design	**The extent of clarity of the project center**	●		
		Efficiency of the center distance from the residential units		●	
		Efficient ease of access between housing units and services		●	
		The extent to which streets can be connected and sequential		●	

6.4. Economic Sustainability Indicators.

The project's economic analysis, as well as the following metrics, are included in this list below:

a. The project's development expenses are 7.75 billion dollars, and it entails the creation of a new city with mixed-use land over a five-year period.

b. Indicators of the materials that were employed to construct the structure. Because the project depended on the Precast concrete technology, which is rather local in character and relies on the importer for construction,

c. Areas of construction indicators. There are a number of dwelling unit types with areas of 100, 120, and 140 square meters, allowing for a simple variation in family sizes and income levels.

d. Space utilization indicators. The project's housing units are divided into three categories: A, B, and C, allowing for a range of sizes and spaces for families of varied cultural and economic backgrounds, as well as overlap between them.

e. There are five indications of the locality's economic health. In terms of establishing self-sufficiency and a low reliance on the economic basis, the project is regarded as mediocre.

f. Indicators of social and technological infrastructure. The social infrastructure covers 133 hectares of public space, or 7.3 % of the project's overall size. The educational buildings will cover 113 hectares, or 6.2 % of the overall project area, while the commercial buildings will cover 90 hectares, or 4.9 % of the total project area, for a total of 18.4 % of the total area.

g. The economic sustainability index assesses how long an economy can last. This shows the project's failure to attract expertise and money, as well as provide employment opportunities for residents. Table (4) shows the project's economic sustainability measures.

Tab. (4) indicators of economic sustainability in Bismaya residential project.

Indicator	Element	Vocabulary	Verification extent		
			efficiently verified	verified	unverified
Economic	construction cost	Residential unit costs		●	
		Rates of wages for building materials and labour			●
		Extent of using local building materials			●
	The building materials used	The extent of the use of imported building materials	●		
		Ratio of natural to manufactured building materials		●	
		The area of the housing unit relative to the size of the family		●	
	building spaces	Percentage of space per person in the project		●	
		The extent to which the functional spaces are proportional to the number of family members		●	
		The extent to which the employment function corresponds to the cultural level of the inhabitants	●		
	The use of space	Availability of public service buildings	●		
		Extent to which networks provide technical infrastructure services			●
		The extent of self-sufficiency			●
	Infrastructure	The extent of reliance on an economic base			●
		The ability to attract capital			●
	The economic performance of the locality	The possibility of attracting experienced		●	
	economic sustainability	Extent of providing job opportunities		●	

We further draw conclusions based on the sustainability metrics reached in the Basmaya housing project, which are shown in Table (5), on the most significant applied variables impacting the economic housing indicators achieved in the project.

Tab. (5) The inferred applied aspects affecting the economic housing indicators achieved in the Basmaya project.

Main indicators	**Secondary indicators**	**Verification extent**		
		efficiently verified	**verified**	**unverified**
Approval of requirement	**Maximizing the space**	●		
	Dwelling grows with family size	●		
	Affordable with the family ability	●		
Improve quality	**It fulfills social requirements**	●		
	Fits different housing needs		●	
	Raises standard of living		●	
	Interacts with urban identity			●
	Fits climatic factors		●	
	Environment friendly		●	
Minimization of costs	**Offered the best value for the cost paid**		●	
	Contributes to reducing construction costs			●
	Contributes to reducing maintenance and operating costs			●
	Characterized by a short implementation period		●	
	Optimizes the usage of construction materials and procedures.			●
	Offers housing with a long life	●		
	Contributes to saving electrical energy		●	
	Contributes to rationalizing water consumption		●	

7. Conclusions

Sustainable housing is housing that meets the real needs of residents through optimal and efficient use of available resources, in order to achieve a safe, comfortable and environmentally friendly neighborhood unit. The sustainable residential environment is achieved through the planning level through the integration of public transportation, planning and multi-use development, in addition to the design of pedestrian traffic. Economic housing is one of the necessary directions to confront the housing crisis in all countries of the world in general and in Iraq in particular. The importance of economic housing is on two levels: the state level and the family level. Land divisions, their areas, housing size and design, construction method and building materials used are among the most important factors that make housing economical and affordable.

8. Recommendations

To adopt sustainable and economical methods, means, and techniques when planning residential complexes at the planning level to obtain sustainable economic housing. Ensuring the minimum facilitation opportunities for sustainable housing for low-income families through the adoption of various means that achieve cost reduction. Orientation towards high-density housing with a multifamily style because it achieves economic, sustainable and self-sufficient housing complexes, and thus be able to provide job opportunities for its residents.

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