

Use Of Generative Artificial Intelligence In Sustainable Affordable Housing Projects In Iraqi Cities

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Abstract: With regards to Iraqi city housing market problems, the research "The Use of Generative Artificial Intelligence in Sustainable Affordable Housing Projects in Iraqi Cities" aims to identify the role of generative artificial intelligence to improve sustainable affordable housing projects. The research addresses how the techniques of this artificial intelligence are utilized in designing and planning low-cost housing projects, which assist in reducing the costs of these projects as well as their inefficiency. The research scrutinizes a range of uses of generative AI in affordable housing projects, such as enhancing space planning, population demand forecasting, resource management, and energy usage, and the provision of creative solutions to environmental and resource savings issues to achieve sustainability.

The results indicate that applying generative AI techniques can be a qualitative jump in the implementation mechanism of low-cost housing projects, helping to meet the demands of Iraqi society and minimize the cost of low-cost housing projects.

Keywords: housing, affordable housing, sustainable, artificial intelligence, Low-income households

INTRODUCTION

Low-cost housing schemes are one of the most important elements to provide sustainable development to modern societies as they provide appropriate housing at reasonable prices according to the economic resources of poor families, and with the rising demand for housing units and the limitations on land supply, it is the need of the time to seek new and innovative solutions to overcome such limitations.

It is here that the value of generative AI arises as a practical solution that can help shape the method of executing such projects and how they are handled.

Generative AI is among the advanced and modern methods which can be used in order to create new models and data from existing data. Generative AI has the potential to increase design productivity as well as accelerate construction work, and therefore it is a proper tool that can handle all the different requirements, obstacles, and hurdles in affordable housing projects.

The research seeks to establish what benefits generative artificial intelligence can have for affordable housing developments, from flexible design to reducing costs and increasing construction standards.

The research also seeks to provide a vision of how generative artificial intelligence can be used to achieve affordable housing aims that are focused on maximizing energy saving and highlighting challenges and opportunities posed by the application of such technology in affordable housing projects, as awareness of these elements will enhance the ability of planners and decision-makers to adopt modern strategies that actualize sustainable development aims and respond to the needs of the community. Research methodology

Research methodology

1- Research Problem:

The affordable housing schemes face numerous challenges, which constitute the challenge of achieving the goal of providing affordable housing to low-income individuals and showing the need for exploring new alternatives to address the challenges faced in the provision of these schemes, including using generative artificial models and methods.

2-Research Objective

The study intends to establish how generative artificial intelligence is applied in increasing the effectiveness of low-cost housing projects and decreasing their costs and determine the advantages gained from applying these methods and disadvantages related to them.

3- Research Hypothesis:

The use of generative artificial intelligence techniques enhances the efficiency of affordable housing projects and reduces their costs.

4- Importance of the research: -

The importance of this research is manifested through the need to provide new solutions to address the affordable housing crisis in a number of countries, as the research seeks to provide a vision of how to use

generative artificial intelligence techniques in enhancing the efficiency of affordable housing programs. The research also refers to enhancing community awareness of the importance of modern technology and the necessity of using it in the housing sector while emphasizing the need for decision-makers and planners to take serious steps in innovation in this vital and important field.

CONCEPTUAL THEORY

1. Artificial intelligence:

It is the intelligence displayed by machines and programs in proportion to human mental abilities and their working methods, such as the ability to learn, deduce and react to situations for which the machine has not been programmed, and it is also the name of the academic right concerned with the manufacture of computers and programs capable of producing intelligent behavior (Ramah Al-Qalamouni, article published on the Internet).

1-1- Generative Artificial Intelligence:

It is one of the types of artificial intelligence techniques that can produce multiple different types of content such as images, text, and sound. (Alaa Taima, article published online 2023)

1-2- The difference between artificial intelligence and generative artificial intelligence.

- Artificial Intelligence

is the largest, most comprehensive and broadest field and includes all applications of artificial intelligence, including generative artificial intelligence.

- Generative AI

is a branch of artificial intelligence that uses machine learning and neural networks to automatically produce new and innovative content. (Hind Khalifa, 2023).

2- Affordable housing:

It is the type of housing whose cost does not exceed a total of 30% of the annual household income to buy or rent a dwelling and is based on taking into account the change in annual needs over time, providing the latest and best possible information to be part of the country's infrastructure (Turei, 2014, p43).

2-1- Sustainable Affordable Housing:

It is housing that meets the housing needs of the current generation without compromising the ability of future generations to meet their housing needs and requirements. (M. Rana Mazen Mahdi, Department of Architecture, University of Technology).

2-2- Low-income households:

They are families that suffer from deficiencies in providing social and economic needs and cannot achieve a reasonable standard of living, These families have a lack of resources or a fixed resource that contributes to the satisfaction of their needs and become in need of providing services to them by community institutions. (Hessa Abdulrahman & Badria Salman Alamro, Identifying the needs of poor families in social security).

3- Uses of Artificial Intelligence in Affordable Housing

Generative artificial intelligence can be used in multiple fields in affordable housing projects, including

I: Analyzing housing needs:

Generative AI is able to forecast where the housing demand will be highest in the future using data that covers demographic information, population patterns, geographic information, and economic information. This allows developers and policymakers to direct resources to areas where there is a likelihood of a scarcity of affordable development projects (Li&Zheng&Wang 2022).

2. Resource allocation:

Resource allocation is among the most important challenges that must be considered in affordable housing projects because the budget of affordable housing projects may require hard decisions between cost, quality, and sustainability and generative artificial intelligence is one of the most important solutions because it provides highly powerful tools to improve resource allocation and guarantee the utilization of materials, space, and energy at the maximum level of efficiency by avoiding waste and maximizing efficiency for affordable housing projects (Biri & Krogstie, 2020).

Such technologies can help in delivering reasonably good-quality low-cost housing at lower costs. Generative AI increases resource utilization efficiency by studying the use of materials. Traditional construction methods usually lead to significant waste of materials due to inefficiencies in design and procurement (buying more than required). AI-based algorithms can analyze the specific requirements of a project and determine the amount of materials needed for this project. For example, generative design algorithms can create several designs, and each

of these designs is optimized for different materials, which means there are multiple opportunities or options in front of architects and gives them more space or freedom to choose the option that minimizes waste and maintains the integrity of the structure. (www. Ijeijournal. Com, p259).

Artificial intelligence can also predict the performance of materials to be used in a project under different conditions, allowing designers to choose the most suitable materials for the environment in which the project is held, and AI tools used in the design of affordable housing projects not only reduce the waste of materials but also extend the life of the housing, which leads to reduced costs in the long run (www. Ijeijournal. Com, p25). (Gue&Yang&Yu&Buehler, 2021).

3. SPACE OPTIMIZATION:

This area is considered one of the areas in which artificial intelligence can significantly affect, as in affordable housing projects, maximizing the available space is very important in order to provide comfortable living conditions for the occupants of these dwellings while keeping costs low. (He&Gue&Zhang, 2022) Artificial intelligence tools can analyze spatial data to determine the most efficient designs for affordable housing projects. These tools can also create more livable spaces within a limited space by optimizing the arrangement of rooms, furniture, objects and other elements while taking into account issues of natural light, privacy and ventilation. Generative AI has the ability to simulate different usage scenarios for affordable housing projects, such as family sizes and changing needs over time, allowing designers to create flexible and adaptable spaces that accommodate the changing needs of the population over time (Sha. Et Al, 2020).

4. ENERGY UTILIZATION:

The subject of energy use in low-cost housing projects is a very relevant subject in such projects from both the cost and sustainability standpoints, and generative artificial intelligence can optimize energy use by learning from data associated with building performance, weather, and behavior of building or housing inhabitants. Energy management systems based on AI can predict heating and cooling needs based on weather forecasts, and building systems are adjusted appropriately, leading to reduced energy consumption and cost. Generative AI can analyze data on the energy usage pattern of the occupants to suggest improvements such as the installation of energy-saving appliances. Generative AI can render affordable housing projects more sustainable and also reduce the cost of such projects by optimizing energy usage. (Hafez et al., 2023).

Improving design accuracy is a very important issue in low-cost housing projects since minor design errors can affect the cost of the entire project.. (Adabre et al., 2020).

5. ENHANCING DESIGN ACCURACY:

AI-powered algorithms can improve the accuracy of project designs and lower the chances of errors to help decrease the project's overall cost. Architects and designers can create more accurate designs using the AI capabilities and this leads to better results in the construction and functionality of low-cost housing units (Chadee, Ray & Chadee, 2021).

One of the ways in which artificial intelligence improves the accuracy of design is through automatic design generation and verification. We often notice that traditional design processes have multiple iterations and revisions and this in turn leads to errors and inconsistencies that lead to a waste of financial resources and time. On the contrary, we find that algorithms that adopt artificial intelligence can automatically generate a set of design options based on specific criteria such as (site conditions, budget, etc.) and then these algorithms can evaluate each design according to the established criteria can automatically generate a set of design options based on specific criteria such as (site conditions, budget) and others, and then these algorithms can evaluate each design according to the established criteria and choose the optimal or best option among the set of generated designs This procedure leads to accelerating the design phase and ensures that the final design is optimized in terms of its efficiency and accuracy. (Adabre&Chan, 2020).

Global experiences of sustainable affordable housing projects in which generative AI has been used.

1- Green Urban Living Initiative:

It is a project that aims to improve the quality of urban life and minimize the negative effects of the environment to achieve sustainability. (Green Urban Living Initiative, Wikipedia)

This initiative started in a rapidly urbanizing area and the goal of this initiative is to provide sustainable and affordable housing at prices commensurate with the income of the target group, which is the low-income group, while taking advantage of modern technology methods and techniques that rely on generative artificial

intelligence to improve and develop construction and design processes (yaqoob, s. & Azmat, 2023).

This initiative made extensive use of Building Information Modeling (BIM) throughout the project life cycle, which allowed architects and engineers to create three-dimensional models of buildings with high details and heights, as well as significantly reduced errors in the design process and minimized the waste of resources, resulting in accurate planning and high coordination between stakeholders, and the construction process adhered to the principles of sustainability. (Olan rewaju & Others, 2022).

Generative AI algorithms were incorporated to analyze BIM, demographic and economic data in order to accurately predict the needs of residents. These models helped determine the optimal unit sizes and number of units and what planning method is needed in order to meet the demands of the community, and in order to optimize the distribution of materials, energy resources and labor, resource allocation tools based on generative artificial intelligence were used, which in total reduced construction time and thus reduced costs. (Zulkifli, Mohd_Raheem, Zainon, 2020).

One of the most important and prominent results of the Green Urban Living Initiative is the successful integration of sustainable design elements (energy-efficient systems, green building materials). Highly effective strategies to minimize the environmental impacts of residential units were selected through the use of generative artificial intelligence to simulate different design methods (Www. Ijeijournal. Com, p262).

Lessons learned:

We conclude from the above that the project (Green Urban Living Initiative) has contributed to reducing energy consumption and greenhouse gas emissions and thus achieved or contributed to achieving the city's sustainable development goals, and also the project provided affordable housing at prices commensurate with the ability of low-income families. (Olan rewaju & Others, 2021).

2- Smart Living Community Project:

A community that seeks to achieve sustainability and economic development in order to improve the quality of life for residents by managing natural resources through participatory methods and policies. This project aims to promote the provision of affordable housing projects through community participation in the selection of designs that suit the conditions of the residents or beneficiaries of these projects and fulfill their desires" (Villanueva-Rosales, 2016). (Villanueva-Rosales, 2016).

The Smart Living Community project was initiated in one of the cities that suffer from a major shortage of affordable housing projects, and the idea behind this project is the idea of addressing this housing shortage through the rapid construction of a number of affordable housing units by or through the use of modern technologies in construction. (Lornic, J, 2022).

The modern construction techniques used in this project are: -

A- 3D printing systems as well as generative artificial intelligence technologies that play an important role in accelerating the construction process while maintaining a high level of accuracy.

B- Automated systems that perform excavation and demolition operations and minimize human errors as well as enhance safety in environments that are not conducive to work. (Alodah Contracting Company, web article, 2024).

In the Smart Living Community project, design optimization tools based on generative artificial intelligence were used to enhance the efficiency of the design phase. These tools analyzed big data (occupant needs, local building codes, environmental factors) to provide design options that reduce overall project costs and maximize the use of space. The generative artificial intelligence algorithms provided opportunities for rapid iteration and optimization of housing planning by providing real-time feedback to the project's design team. Also, the Smart Living Community project used virtual reality and augmented reality technologies during both phases (design and planning). These technologies allowed stakeholders, including future residents, to visualize the housing units and provide feedback on their design. This method or participatory approach ensured that the final design of the housing units was functional and suited to the community's desires and needs. (Mishra&Singh, 2023).

The strategies that were used in the Smart Living Community project are summarized as follows: -

A- Community Participation: - This is a strategy that allows citizens to participate in making decisions related to housing design and planning to know what they want and aspire to.

B - Minimizing environmental impact: - By minimizing the waste of resources, as the environmental impact affects the health of the population and reduces the quality of life. (Mohammed Saifuddin, Smart Cities and Social Justice, 2025).

The project (Smart Living Community) faced a number of challenges related to the use of generative artificial intelligence techniques, as the team based on the completion of this project faced difficulties in the work

represented by incomplete and old data, which led to delays in the design process and required revisions of the models created through generative artificial intelligence tools and programs.

However, the project achieved its intended goals of providing affordable housing for low-income people while highlighting the importance of using generative AI tools in the construction industry (Sajida Ashraim, Challenges Facing Smart Cities from Technology to Reality, 2024).

Analysis.

The (Smart Living Community) and (Green Urban Living Initiative) project presented us with the benefits of using generative artificial intelligence techniques in the design of affordable housing, as they both succeeded in taking advantage of these techniques in reducing the total costs of the two projects as well as improving and enhancing the accuracy of the design and improving sustainability, as these two projects faced challenges and obstacles that can be utilized as lessons for future projects. The two projects were not the same in terms of the use of generative artificial intelligence techniques, but there were differences between them, we find that (Green Urban Living Initiative) focused on the first degree on the use of artificial intelligence, which led to achieving sustainability as well as improving the efficiency of materials. While we find that the Smart Living Community Project focused on integrating design optimization based on generative AI techniques with virtual and augmented reality techniques and participatory design process, this approach resulted in the Smart Living Community Project achieving more accurate and more community-centered results. Perhaps the most important lessons learned that should be applied in future projects that were drawn from these two projects are:

1- The necessity of involving stakeholders in the design process of affordable housing projects in order to know the desires of the community and implement them accordingly to ensure the success of these projects.

2- The necessity of relying on accurate data, as the use of generative AI techniques leads to results that depend on the data provided by the project management, so if we want to obtain correct and accurate results, it requires accuracy in the data provided.

Therefore, if we want to obtain correct and accurate results, it requires accuracy in the data provided.

3- The two projects faced challenges, and this applies to most projects, if not all, and in order for the management staff of any project to be able to overcome the challenges facing the work, there should be flexibility and the ability to adapt to the changes that develop during the progress of work in any project in order to modify plans as needed to ensure the success of the project.

Smart Living Community Project

1- Focus on design optimization.

2- Using virtual and augmented reality technologies during both phases (design and planning).

3- Focusing on community participation to know the desires and needs of residents.

Green Urban Living Initiative

1- Focusing on the use of Building Information Modeling.

2- Using resource allocation tools.

3- Using generative artificial intelligence algorithms to accurately predict the needs of the population.

From the above, and based on what has been extracted from the two projects (Smart Living Community Project) and (Green Urban Living Initiative Project), the researcher believes that the Smart Living Community Project is concerned with the topic or issue of community participation, that is, the participation of stakeholders from the beginning of the planning process through the design of housing and then the allocation of materials and resources for it, and then the process of building affordable housing in order to know what they want and aspire to from the design of the housing they will live in. On the contrary, we see that the (Green Urban Living Initiative) project adopts the use of generative artificial intelligence algorithms to predict the needs of the population and these algorithms produce their results based on the data that was given to them, that is, any error in the data will lead to an error in the output of the predictive process, so the researcher believes that the (Smart Living Community) project is the best if we want to apply the policy of one of these two projects in Iraqi cities.

Lessons learned from experiences

The use of generative artificial intelligence techniques and tools in affordable housing projects represents a major advancement in addressing the growing demand for these projects as well as reducing the total costs of the projects and saving the effort and time needed to complete these projects and the two case study models (Green Urban Living Initiative) and (Smart Living Community Project). The idea that the use of generative AI techniques in affordable housing projects can revolutionize the provision, design and construction of such

housing, as these projects have succeeded in enhancing design accuracy and improving overall outcomes through the use of building information modeling, AI-based predictive analytics, and participatory design processes. Utilizing and relying on generative AI techniques provides a number of benefits:

- 1- The ability to predict the needs of the population more accurately.
- 2- Creating more efficient and sustainable designs.
- 3- Improved resource allocation.
- 4- Provides an opportunity for engineers and planners to work more accurately and creatively.
- 5- Minimize environmental impact.
- 6- Providing housing solutions that meet the needs of low-income families.

As we noticed in our study of the two projects, we find that data quality and stakeholder engagement are among the crucial and important issues that affect the results of such projects, as ensuring data accuracy is essential and important in the operation of generative artificial intelligence algorithms to obtain accurate results, as well as involving stakeholders in the design process early on ensures that the wishes of the community are known. Generative artificial intelligence algorithms to obtain accurate results, as well as involving stakeholders in the design process early on ensures knowledge of community desires, and we should not overlook the importance of flexibility and adaptability, as these three elements are key strategies to achieve project goals and overcome any obstacles to its implementation.

The use of generative AI techniques in affordable housing projects provides efficient and sustainable housing solutions to address the growing demand for these projects by low-income families.

Practical side: Exploratory study

A questionnaire was conducted on a sample of the study population, which numbered 300 respondents, who answered 12 questions, and after unpacking the results of the questionnaire, the researcher will analyze the answers to the questions in detail as follows:

1. Developing the design of existing informal housing and incorporating it into affordable housing projects:

-We can see from Figure (1) that 90.9% of the respondents believe that the design of the current informal housing can be developed and introduced into affordable housing projects.

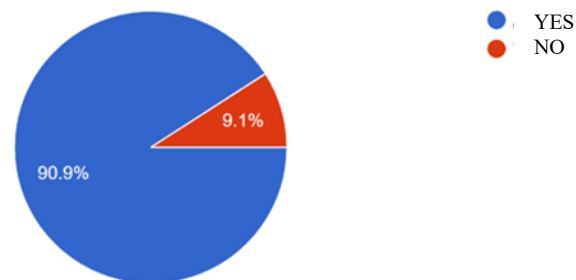


Figure 1: Developing the design of existing informal settlements and incorporating them into affordable housing projects

2. Community participation in the planning and design stages:

-From Figure (2), we can see that 72.7% of the respondents support community participation in the planning and design stages of affordable housing projects because the process of community participation is very important to reach proper and sustainable planning.

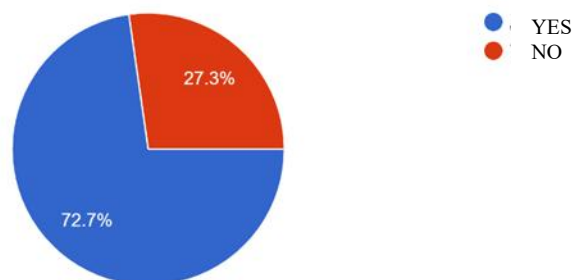


Figure (2) Community participation in the planning and design stages

3. The smallest size suitable for affordable housing:

- Opinions varied on the smallest suitable area for affordable housing, with some suggesting areas ranging from 100 to 150 square meters. This gives us an indication to utilize in developing housing plans and determining the size of housing units.

4. Can affordable housing projects contribute to sustainability?

- 100% of respondents believe that affordable housing projects can contribute to sustainability.

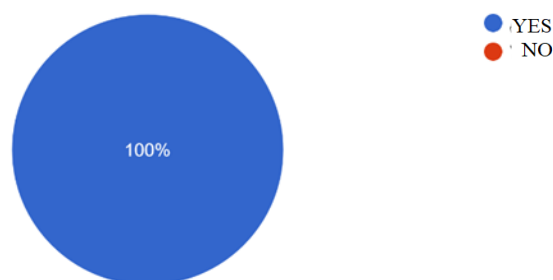


Figure 3: Contribution of affordable housing projects to sustainability

- Three main types of sustainability that contribute to housing projects have been identified: Environmental, Economic, and Social. The majority of respondents (41%) believed that sustainability contributes economically to affordable housing projects, 36% chose social sustainability, and 23% chose environmental sustainability.

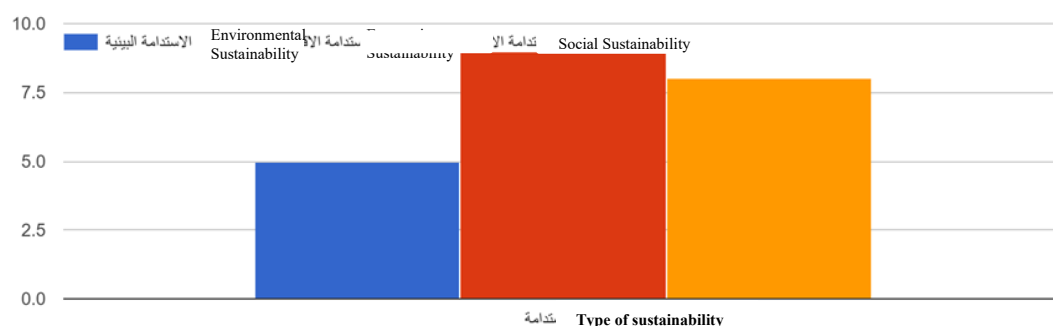


Figure (4) Types of sustainability that contribute to housing projects

5. Use of sustainable and renewable energy in housing projects: - 100% of respondents support the use of sustainable and renewable energy in housing projects. This indicates the awareness of the study community sample of the importance and necessity of using renewable energy to minimize negative impacts and reach sustainability.

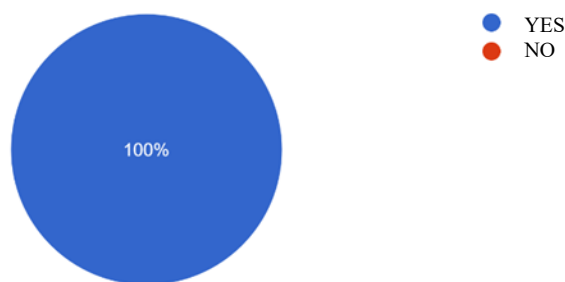


Figure (5) Use of sustainable and renewable energy in housing projects

As for the type of renewable energy in the previous question, several types of renewable energy were asked, and the majority of respondents were of the opinion that solar energy is the best.

6. Use of artificial intelligence in affordable housing projects:

- 63.6% of respondents believe that artificial intelligence can be used in affordable housing projects. As shown in Figure (6)

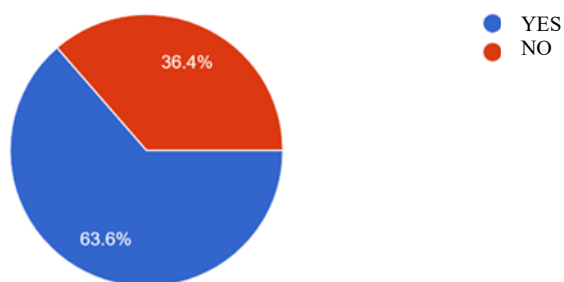


Figure (6) The use of artificial intelligence in affordable housing projects

Those who believe that AI cannot be used in affordable housing projects had different reasons, as their responses were ranked on a scale of 1-5 in terms of impact and importance, with 5 being the most important and 1 being the least important.

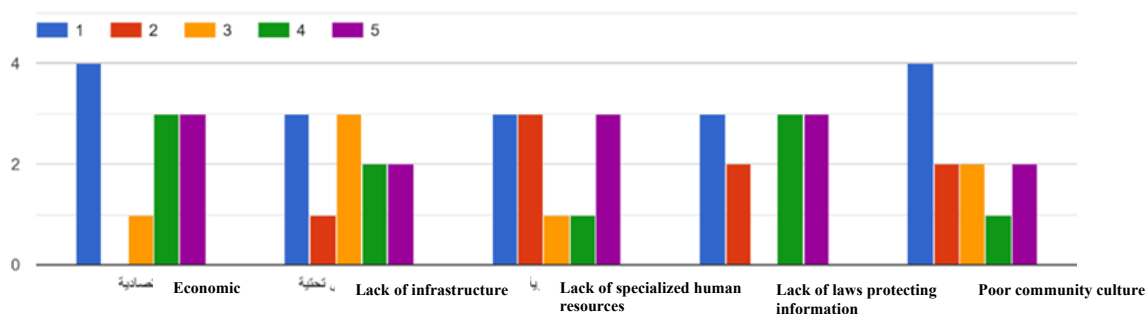


Figure (7)

7. Axes of using artificial intelligence in affordable housing projects:

The respondents had different opinions regarding the axes of using AI, as shown in Figure (8) below

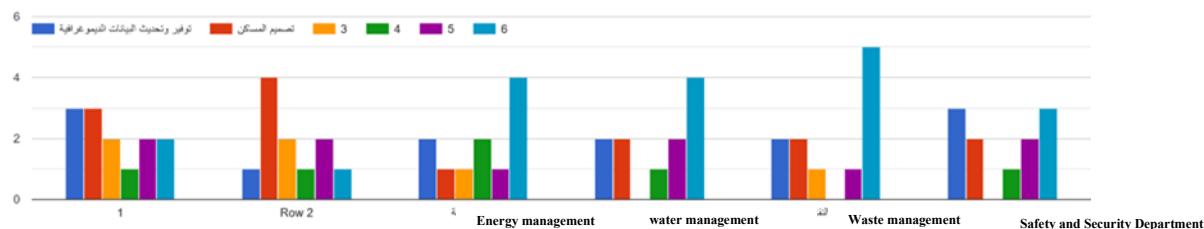


Figure (8) Axes of using artificial intelligence in affordable housing projects

8. Potential use of AI in housing design:

- 100% of respondents believe that AI can be used to design housing in affordable housing projects, as shown in Figure (9)

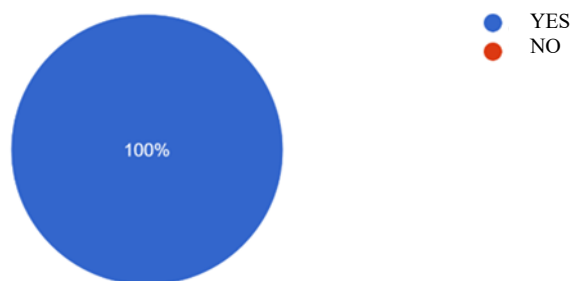


Figure (9) Axes of using artificial intelligence in affordable housing projects

9. Possibilities available for the use of AI for the respondents in the previous question who answered yes:

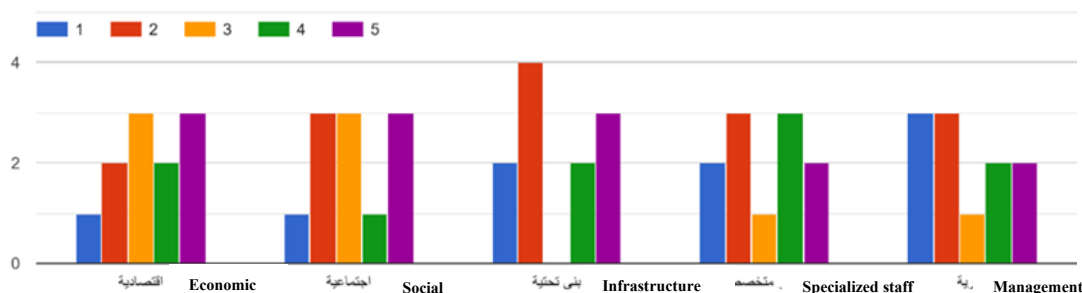


Figure (10) Potential for the use of artificial intelligence

It is clear from Figure (10) that there are potentials available in our cities that enable us to use AI technology in affordable housing projects, including infrastructure and specialized technical cadres, as well as the social and economic situation of the country that enables us to apply AI technology in affordable housing projects

The general conclusion from this survey is that there is great support for the idea of developing affordable housing projects using modern technologies such as AI and renewable energy, with the importance of community participation in the planning and design stages. There is also a consensus that these projects can contribute to environmental, economic and social sustainability.

CONCLUSIONS

- 1- There is absolute support for the idea of using modern technologies such as artificial intelligence and renewable energy in the development of affordable housing projects.
- 2- The importance of community participation (participation of the target community) in the planning and design phases of affordable housing projects in order to reach proper sustainable planning.
- 3- Affordable housing projects can contribute to achieving sustainable development goals (economic, social and environmental).
- 4- Orientation towards the use of renewable energy in affordable housing projects.

Recommendations

- 1- Obliging future research to focus on the use of artificial intelligence and renewable energy technologies in the development of affordable housing projects.
- 2- The necessity of involving the target community in the planning and design stages of affordable housing projects to be established in the future to ensure the success of these projects.
- 3- Emphasize the need to achieve sustainable development goals in future projects.
- 4- The necessity of using renewable energy in affordable housing projects to minimize negative impacts and reach sustainability

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