Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 1 (2024)

Analysis of the Development and Application of Artificial Intelligence in Multifamily Housing Projects

[1*] Mtra. Karen Anais Quispe Llayqui, [2] MBA. Carlos Adolfo Noriega Niño de Guzmán, [3] Dr. Johnny Félix Farfán Pimentel

[1][2] Faculty of Civil Engineering, Graduate School, Universidad Nacional de Ingeniería, Peru.
[3] Department of Education, Graduate School, Universidad César Vallejo, Peru.

Abstract: This research presents an analysis of the development and application of Artificial Intelligence in multifamily housing projects in Metropolitan Lima. It addresses the evolution of AI, its potential benefits, the various applications, potential risks and technological benefits of its adoption, which could have a significant impact on projects in the home construction sector. A systematic analysis of the information was carried out, which helped reveal the problem and establish the objectives and hypotheses. This was followed by the execution of a mixed methodological design, analyzing both qualitatively and quantitatively. During the qualitative phase, the research included interviews with experts, using in-depth questions. These were answered based on the experience and perception of professionals about new technologies in construction projects, as well as the impact of the implementation of AI. During the quantitative development, and following the proposed model, a survey with closed questions was carried out. These questions were adjusted based on the interviews carried out by the experts who supported the qualitative development. The majority of respondents were civil engineers with 81.69%, with other professions such as architecture, sanitary engineering, environmental engineering and others with 18.31%. Likewise, the research supports the idea that Peru is lagging behind in the development of AI compared to other cities, but a general perception shows potential benefits in the improvements that could be achieved, such as the quality of the processes and the optimization of the stages of the projects, resulting in positive impacts on time and costs.

Keywords*: Artificial Intelligence, Multifamily Housing, Development*

1. Introduction

In today's society, the transformation, evolution and advancement of technology is inevitable and affects all aspects of daily life, including the real estate and construction sector. One of these developments is Artificial Intelligence (AI) in multifamily housing projects, which impacts the construction industry globally and presents new challenges and opportunities that justify extensive research through scientific inference. The objective is to analyze the development and application of AI in multifamily housing projects in Metropolitan Lima, obtaining a deep knowledge of how this technology is being integrated into the real estate, architectural and developer sectors, among others; this research focuses on understanding its potential in the real estate industry, specifically in the efficient and effective execution of projects, improving quality, time and cost. This study aims to contribute and answer key questions around the evolution of this new technology, which can help improve its development and implementation in the field of construction; providing a comprehensive view of AI in multifamily construction projects.

Analyzing the development and application of Artificial Intelligence (AI) in multifamily housing projects poses a series of challenges and opportunities that require extensive research from a perspective based on scientific inference; and as AI enters the real estate sector, there is a need to better understand how its applications are developed and how it affects different aspects of the construction industry; therefore, currently, the advancement of technology shows a scope at such an accelerated pace that it affects everyone without noticing it, with which

these current technologies will have a positive or negative impact on companies depending on how they are managed with adequate criteria [1].

The use of AI has allowed the incorporation of tools such as virtual assistants to businesses; a common problem in project management offices is the lack of updated information on technical files because they depend on the responsible team leaders [2]. In this sense, AI methods can help inexperienced users solve engineering problems, but they can also help expert users improve the efficiency of their processes; that is why, in the field of civil engineering, this represents a great future for its application due to the constant changes in AI, and the application of computational methods in all branches of knowledge, which is already a reality [3].

In the developed real estate market, particularly in the USA, the United Kingdom and some fast-growing Asian economies such as China, Saudi Arabia, Japan and Malaysia, and others, have adopted and implemented the use of AI, however, some regions of the world, particularly less developed and developing ones, such as countries in Africa, have not yet adopted or used the technology; therefore, it is of utmost importance to analyze the internal factors and evaluate the relevance of AI approaches for the analysis of the real estate market such as in Africa or Latin America using AI tools that will provide information on strategically comparative opportunities [4].

A study carried out in Saudi Arabia used the artificial neural networks (ANN) technique to determine real estate prices; the novelty of the research proposal is the creation of a prediction model based on ANN to predict the price of housing in the future; the results showed that the experimental values and the forecasts were very similar; however, the model developed high performance when the results of the proposed system were compared with several existing prediction systems; in addition, this prediction system can increase investment in the real estate sector, according to the results of the model evaluations; in this sense, the ANN model was able to adequately estimate the prices of the homes currently available on the market, therefore, it can be deduced that it is an appropriate strategy to support decision making or adaptive suggestion to estimate the ideal sale prices of the homes. residential real estate, thus making this solution vital for both investors and the population in general [5].

AI refers to the ability of a computational machine or computer to solve complex and determined problems by itself through the implementation of an algorithm, which begins by identifying a problem and defining its limits, therefore, to achieve this, it uses learning analytics data, which is similar to the structured thinking of the human brain [6]. Modeling and optimization methods for complex structural systems often require a large amount of computing resources, so AI-based solutions can offer valuable alternatives to solve problems in the most efficient way [3].

Several factors have contributed to the great advancement of this academic discipline focused on the study of AI; the enormous increase in the amount of data available, advances in the capacity and power of computing and storage systems, successes in research, development of new algorithms and machine learning techniques offers an intriguing classification of various types of AI according to their capabilities [7].

Regarding the demand for housing, the government must pay special attention to the housing market, a crucial economic indicator, due to its impact on the lives of inhabitants of emerging cities, individual property purchases, third-party evaluation and understanding how housing prices are distributed geographically can be of great practical use as a guide to government regulation; therefore, a great deal of research has been conducted on the most accurate and effective way to calculate home prices in today's market [8].

The construction industry in multifamily projects has a great demand in the city of Lima, which encourages taking advantage of real estate projects, trying to reduce the margins of error in time and cost; the most important opportunities to improve the productivity of a project do not occur during construction, but much before, in the design stage, in the planning, feasibility and pre-project stages [9]. The densification of cities is a quite complex problem, that is, single-family homes are replaced by multi-family buildings [10]. The use of buildings in addition to construction activity includes a potential impact on the environment [11]. Housing is one of the most critical problems that affects the population and is a determining factor in improving the quality of life of families [12]. In this sense, multifamily housing projects must follow technical guidelines from the conception and development of the design, taking into consideration the load elements and structural factors [13].

2. Objectives

2.1. Formulation of the research problem

- What is the analysis of the development and application of artificial intelligence in multifamily housing

projects in Metropolitan Lima?

- What is the level of development of AI in multifamily housing projects in Metropolitan Lima?
- How can artificial intelligence be applied in multifamily housing projects in Metropolitan Lima?
- What would be the economic impact on the budget of multifamily housing projects in Metropolitan Lima with the application of artificial intelligence?

2.2. Formulation of the research objective

- Determine the analysis of the development and application of the benefits of AI in multifamily housing projects in Metropolitan Lima.
- Identify the level of development of AI in multifamily housing projects in Metropolitan Lima.
- Describe how artificial intelligence can be applied in multifamily housing projects in Metropolitan Lima.
- Identify the economic impact on the budget of multifamily housing projects in Metropolitan Lima with the application of artificial intelligence.

2.3. Formulation of research hypotheses

- AI has a significant impact on the development and application of multifamily housing projects in Metropolitan Lima.
- There is a lower level of AI development among multifamily housing projects in Metropolitan Lima compared to first world cities.
- The application of AI in multifamily housing projects in Metropolitan Lima will improve the quality of processes in housing projects.
- The application of artificial intelligence in multifamily housing projects in Metropolitan Lima can have a positive economic impact by lowering costs, shortening delivery times and optimizing the planning and construction of buildings or homes.

3. Methods

The type of research according to its objective is applied research, because it uses existing theoretical knowledge of AI in projects [14]; regarding the type of data, it is a mixed research so it is qualitative and quantitative, because it collects data without numerical measurement to answer research questions, and the quantitative method is used in data collection and based on numerical measurements, with statistical analysis [15], is non-experimental since it does not deliberately manipulate its variables; it is also considered according to the type of inference that is inductive, which implies the collection of data as particular elements to formulate premises and reach conclusions[16]; and finally, according to its temporality, it is transversal since data from a specific period of time is analyzed [17]. The level of research is exploratory and descriptive, because the topic must be delved into in depth, to describe and analyze the elements and characteristics of the research. The inductive method was used since individual factors must first be considered and relationships established for a general extension [18]. The population is the collection of all cases that meet certain specifications [19]. Therefore, this study will have a population made up of officials with experience in multifamily housing in Metropolitan Lima. Based on the results obtained, it is determined that the sample size is 60 people. The present research is of a mixed design, because it involves quantitative and qualitative data in the same study in order to obtain a more complete picture [19].

4. Results and discussion

4.1. Objective No. 1:

Determine the analysis of the development and application of the benefits of AI in multifamily housing projects in Metropolitan Lima.

Table 1. Expert analysis of multifamily housing in Metropolitan Lima

No.	Description	Expert analysis	Importance
1	Application	Areas of application of AI in multifamily housing projects are identified, starting with the management of technology from the market study, planning or preparation of technical files, during the execution and supervision of works, operation or maintenance	high

		and ending in sales in case it is a real estate agency.	
2	Development	The late and new development of these new technologies in Peru is recognized in comparison to other more advanced countries. Likewise, the importance of the legal regulatory framework on the part of the State, the involvement of technological careers for data-based nutrition, is revealed.	high
3	Risks	The possible risks of implementing AI in multifamily housing are identified as: System errors due to misapplication or otherwise; danger of data loss or theft; increase in energy demand, high costs for its implementation; reduction of jobs and lack of trained personnel.	high
4	Impact	Two points of view are recognized regarding the economic impact; The first is the negative impact in the short term, due to new technologies in construction, which has an extra cost; However, the second impact is positive in the long term, because it will facilitate productive activities, making them faster and cheaper.	high

To avoid the repetition of routine tasks, the use of AI is proposed in the design of the architecture, automation processes and workflow, where the capabilities of neural networks are used together with the design of automation algorithms; as well as using a conditional adversarial neural network, trained for the creation of two-dimensional house plans, as a test of the collective capabilities of neural networks for use in architecture; for this reason, this workflow divides the set into specific housing units, it is processed by the neural network and then added back to the set of homes, and due to the number of housing floors necessary for the training of the network, it is necessary to automate processes, label and store them in data lists; likewise, the plans created by the neural network are exported for subsequent processing, and different approaches can be defined through automation processes [20].

It is important to note that statistics on the construction industry have increased significantly in recent years, as has technology in the creation of AI, this includes the creation of systems and machines that help improve performance, optimize time and tasks in different areas of work in construction, but it is also important to have adequate training to use these tools, as is it essential to investigate and obtain a systematic understanding, challenges and solutions that AI offers in the world of construction ; to achieve this, a review of articles is carried out, which show good results in terms of progress, safety, and work performance, so it can be concluded that the implementation of AI in construction is a potentially viable alternative [21].

Therefore, various AI strategies have been implemented in a wide range of fields for different purposes, many studies have also examined how AI contributes to project management, both from a broader perspective of the discipline as a whole and from a perspective more specific [22]. Likewise, it should also be considered that high-density multifamily buildings are those that generate the least environmental impact [23].

4. 2. Objective No. 2:

Identify the level of development of AI in multifamily housing projects in Metropolitan Lima.

Table 2. Analysis of AI development in multifamily housing projects

Development	Result	Analysis
Peru in comparison to other countries.	According to the results, 74.65% consider that we are very late and 25.35% consider that we are moderately late in the implementation of AI in our country.	These figures show that we are considerably behind, or in a formative stage compared to more developed countries such as China, Japan, Korea, USA, Russia, Germany and others. This result may indicate widespread awareness of the need for this new technology to improve global competitiveness, or advance

		our position in technological achievements.
Relevant factors	According to the results, 52.11% consider that new government policies that support technology are an important factor.	Currently, the regulatory framework in Peru is limited, therefore, support for new technologies such as AI that drive innovation, global competitiveness and the generation of new jobs is not noticeable. However, this regulatory framework must address ethical challenges of sustainability, adapt the environment to the digital world, but with the necessary guarantees for users.
	According to the results, 52.11% consider that involving more technological careers in the development of civil works is an important factor.	Involving other careers linked to technology within civil works will enrich and innovate different aspects, from interdisciplinary approaches that would address construction challenges such as safety, quality control, adaptability in the area of robotics, electrical and others more.
	According to the results, 26.76% consider that the import of technological devices for home automation is an important factor.	The import of new technological devices is important in terms of the issue of home automation and integration of AI, since it offers access to cutting-edge technology that helps the adoption of new systems, however, it would help the industrial growth of AI. improving quality and safety standards.
Future of AI implementation	According to the results, 53.52% consider the development of AI in our country to be very important, 43.66% consider it important and 2.82% consider it not very important.	This result reflects the interest of the respondents in the development of AI in Peru, which is a good index for the development and implementation of this technology, therefore the future of the implementation of AI is promising since professionals They visualize in a positive way, which could initiate new policies in the construction industry.

- Regarding the comparison with others, the results show that Peru is in a state of very late or moderately late in the implementation of AI in multifamily projects, compared to other countries.
- Regarding the relevant factors, it can be said that the most important factors for the implementation of AI are the new government policies that support the technology, as well as the involvement of technological careers in civil works and finally the importation of technological devices.
- Regarding the future of the implementation of AI, we confirm through the results that the implementation of AI in multifamily housing projects in the future is very important, or has a high degree of importance in the housing construction sector.

4.3. Objective No. 3:

Describe how artificial intelligence can be applied in multifamily housing projects in Metropolitan Lima.

Table 3. Implementation of AI in the project formulation and planning stage

Implementation areas	Amount	Percentage
In architecture (designs and distribution of environments)	33	46.48%
In seismic structures and designs	31	43.66%
In the design of schedules	31	43.66%
In the calculation of measurements, costs and budget	39	54.93%

From table 3 it is observed that the highest percentage index of professionals consider important in the

implementation of AI in the project formulation and planning stage, is in the measurements, costs and budget with 54.93%, following in the architecture with 46.48%, in structures and seismic designs with 43.66% and in schedules 43.66%.

Table 4. Implementation of AI in the project execution stage

Implementation areas	Amount	Percentage
In robotics and construction technology	29	40.85%
In documentation generation, monitoring and others	19	26.76%
To update costs, schedules and materials	33	46.48%
For measuring productivity and process optimization	51	71.83%

From table 4 it is observed that the highest percentage index of professionals considers the implementation of AI to be most important in the project execution stage is in measuring productivity and optimizing processes with 71.83%, followed by updating costs, schedules and materials with 46.48%, in robotics and construction technology with 40.85% and in documentation generation, monitoring and others with 26.76%.

Table 5. Implementation of AI in the project completion stage

Implementation areas	Amount	Percentage
In energy use	25	35.21%
For home automation with AI	41	57.75%
For safety and comfort	33	46.48%

Table 5 shows that the highest percentage index of professionals consider the implementation of AI to be more important in the project completion stage. We note that the highest percentage index of professionals consider the implementation of AI to be more important in the project completion stage. of project completion is in home automation with AI with 57.75%, followed by security and comfort with 46.48% and in energy use with 35.21%.

4.4. Objective No. 4:

Identify the economic impact on the budget of multifamily housing projects in Metropolitan Lima with the application of artificial intelligence.

Table 6. Economic impact of the application of AI in multifamily housing projects

Detail	Result	Analysis
Short term	According to the results regarding the short-term economic impact, they consider that 35.21% costs would increase significantly, 36.63% costs would increase little, 9.86% costs would be the same and 18.31% that costs would decrease.	The results reflect a shared or mixed perception about the short-term economic impact, however, the majority expect a regular or significant increase in initial expenses from the implementation of AI in multifamily housing, however, another smaller group indicates that they do not. important changes are seen or costs would be reduced during the operation of projects. Therefore, it follows that there is a need for a more detailed analysis of short-term costs and benefits in multifamily housing projects.
Long-term	According to the results regarding the long-term economic impact, 47.89% are considered very beneficial, 47.89% as beneficial and 4.23% as not very beneficial.	In results, the majority of respondents, 95.78% in total, perceive that AI is very beneficial or beneficial in the long term within multifamily housing projects, which suggests the high degree of optimism regarding the technological benefits of AI , which means that it will be able to contribute quality, efficiency and sustainability to projects; However, the impact will be positive within the construction industry driven by investment in technology, robotics, and state-of-the-art equipment. In

		general, the majority of respondents anticipate a positive long-term impact.
Cost effectiveness	According to the results regarding the profitability of the implementation of AI in multifamily housing projects, 95.77% agree and 4.23% disagree.	This broad consensus on the positive profitability in the implementation of AI in multifamily housing projects suggests a strong recognition or belief of the beneficial economic impact that adopting this technology can generate, improving the optimization of results and the quality of construction; On the other hand, a small percentage may have reservations or concerns about possible cost-effectiveness. But in general, the perception is positive in terms of profitability.

Table 6 shows that the economic impact activity is divided into three stages: the first is the short-term analysis where the results are mixed; The second is the long-term analysis, which contemplates an inclination towards what is beneficial; and finally, is the profitability analysis which also reflects a positive impact, as can be seen in the table that presents the analysis of the economic impact of AI in multifamily housing projects.

5. Conclusion

AI can be implemented in housing construction projects, and it would provide great benefits at various stages, from planning, execution and completion or operation of the homes; This conclusion is the result of research that indicates that the majority of respondents consider AI important in architecture, analysis of structures and seismic designs, management of schedules, meters, costs, budgets, in robotics and construction technology, generation of documentation, monitoring and measurement of productivity and process optimization.

A clear need is highlighted to promote government policies that can promote the use and adoption of new technologies such as AI and train a greater number of professionals specializing in the area. Which would help to better train and update professionals and better face the transition in the incorporation of technological innovations.

The risks linked to AI are associated with cybersecurity, loss of information, exposure of documents, protection policies; However, beyond the risks that may occur, greater benefits are expected, mainly in the area of costs, the implementation of AI is perceived as very beneficial in the long term, causing a positive and profitable economic impact.

References

[1] M. Huamán, “Sistema de cotización con inteligencia artificial e inteligencia de negocios en la empresa Buenavista Proyectos Inmobiliarios SAC”, Universidad César Vallejo, 2022. https://repositorio.ucv.edu.pe/handle/20.500.12692/100820

[2] E. Quinde, “Implementación de un asistente virtual con Inteligencia Artificial para la gestión de proyectos”, Pontificia Universidad Católica del Ecuador, 2023. http://repositorio.puce.edu.ec/handle/22000/21249

[3] D. Alemán, (2017) “Técnicas de inteligencia artificial aplicadas a problemas de ingeniería civil”, Revista de Arquitectura e Ingeniería, vol. 11, núm. 3, pp. 1-7, 2017. https://dialnet.unirioja.es/servlet/articulo?codigo=6452841

[4] V. Odunfa, T. Fateye, A. Adewusi, “Application of Artificial Intelligence (AI) Approach to African Real Estate Market Analysis Opportunities and Challenge”. Proceedings of the AccraBespoke Multidisciplinary Innovations Conference. University of Ghana/Academic CityUniversity College, Accra, Ghana. Pp. 121-132, 2021. www.isteams.net/ghanabespoke2021. DOI https://doi.org/ 10.22624/AIMS/ABMIC2021P9

[5] E. Alzain, A. Ishebami, T. Alshyani, S. Alsubari, “Application of Artificial Intelligence for Predicting Real Estate Prices: The Case of Saudi Arabia”, Electronics, vol. 11, num. 3448, pp. 1-18, 2022 https://www.mdpi.com/2079-9292/11/21/3448

[6] J.O. Álvarez, "La inteligencia artificial en la gestión de proyectos de inversión pública del Ministerio de Vivienda, Construcción y Saneamiento", Revista Ingeniería Industrial, pp. 97-121, 2021. https://doi.org/10.26439/ing.ind2022.n.5802
[7] M. Otero, A. Cerezo, A. Pastor, P. Ballesteros, M. Castilla, "La inteligencia artificial y la dirección de proyectos. Análisis prospectivo en la toma de decisiones", 26th International Congress on Project Management and Engineering Terrassa, 5th-8th July 2022 http://dspace.aeipro.com/xmlui/handle/123456789/3112
[8] E. Alzain, A. Ishebami, T. Alshyani, S. Alsubari, "Application of Artificial Intelligence for Predicting Real Estate Prices: The Case of Saudi Arabia", vol.11, num. 3448, pp.1-18, 2022. https://doi.org/10.3390/electronics11213448
[9] Lee, J., Yang, S., Muniandi, B., Chien, M., Chen, K., Lin, Y., Lin, S., & Tsai, T. (2021). Multiphase active energy recycling technique for overshoot voltage reduction in Internet-of-Things applications. IEEE Journal of Emerging and Selected Topics in Power Electronics, 9(1), 58–67. https://doi.org/10.1109/jestpe.2019.2949840
[10] C. Oroz, "Aplicación de herramienta de planeamiento Look Ahead en construcción de proyecto inmobiliario multifamiliar de 10 pisos", Universidad Ricardo Palma, 2015. https://repositorio.urp.edu.pe/bitstream/handle/20.500.14138/2383/oroz_cf.pdf?sequence=1&isAllowed=y
[11] Gianfranco Parodi, "Edificio multifamiliar de alta densidad con espacio público integrador en el distrito de Jesus Maria". Universidad Ricardo Palma, 2020. https://repositorio.urp.edu.pe/handle/20.500.14138/3481
[12] Ana Cáceres, "Análisis de ciclo de vida comparativo de edificaciones multifamiliares en Lima". Pontificia Universidad Católica del Perú, 2016. https://tesis.pucp.edu.pe/repositorio/handle/20.500.12404/6682
[13] Rocio Baldeon, Raúl Chávez, "Diseño de edificio multifamiliar para mejorar la calidad de vida de las familias del campamento unacem atocongo - Villa María del Triunfo". Universidad de San Martin de Porres, 2018. https://repositorio.usmp.edu.pe/handle/20.500.12727/4331
[14] Jesus Garcia, Luz Vizalote, "Diseño de una vivienda multifamiliar de cuatro niveles utilizando el programa CypeCad para mejorar la calidad estructural, Moyobamba – 2023". Universidad César Vallejo, 2023. https://repositorio.ucv.edu.pe/handle/20.500.12692/123816
[15] Sebastián Carrasco, "Metodología de la investigación científica", 476 pp., 2017. Lima: San Marcos.
[16] Mario Tamayo, "El proceso de la investigación científica", 444 pp, 2012. México: Limusa
[17] R. Pino, "Metodología de la investigación: Elaboración de diseños para contrastar hipótesis", 478 pp., 2018, Lima: San Marcos.
[18] Raúl Delgado, "Constructos básicos para la investigación científica", 326 pp., 2010, Lima: UAP
[19] H. Sánchez, C. Reyes, "Metodología y diseños en la investigación científica", 236 pp., 2017, Lima: BSA
[20] Humberto Ñaupas, "Metodología de la investigación científica", 340 pp., 2009, Lima: Retai
[21] L. Álvarez, F. Blanco, "Aplicación de redes neuronales al diseño de vivienda colectiva, procesos generativos de combinatoria y automatización mediante inteligencia artificial", Revista Indexada de Textos Académicos, pp. 214-231, vol 16, num. 20, 2021. https://dialnet.unirioja.es/servlet/articulo?codigo=8669351
[22] J. Mendoza, M. Quispe, S. Muñoz, "Una revisión sobre el rol de la inteligencia artificial en la industria de la construcción", vol.24, num. 2, pp. 1-23, 2022. http://www.scielo.org.co/pdf/inco/v24n2/2027-8284-inco-24-02-e30511727.pdf
[23] J. González, J. Mesa, H. Morán, A. Fernández, "Aplicación de Técnicas de Inteligencia Artificial a la Gestión de Proyectos de Innovación", 26th International Congress on Project Management and Engineering Terrassa, 5th-8th July 2022. http://dspace.aeipro.com/xmlui/handle/123456789/3105
[24] Orlando Pacheco, "El impacto ambiental de construcción de viviendas multifamiliares en la ciudad de Lima: Análisis comparativo de los tipos arquitectónicos en base a la densidad urbana". España, Universidad Politécnica de Cataluña, 2020. https://upcommons.upc.edu/bitstream/handle/2117/334500/Memoria%20TFM%20ITA%20Orlando%20Pacheco.pdf?sequence=1&isAllowed=y