Enhancing sustainable living in vietnamese tube houses through cross-disciplinary collaboration and big data analytics

Hong Loan Nguyen[1]

University of Architecture Ho Chi Minh City, 196 Pasteur, District 3, Ho Chi Minh City, 70000, Vietnam

Abstract. The increasing urbanization and population growth in Vietnam have led to a surge in demand for housing. As a result, tube houses have become a prevalent type of housing in Vietnam. Tube houses often face challenges related to inadequate living conditions, lack of space, and insufficient ventilation and natural light. Moreover, many families living in tube houses have limited access to sustainable and affordable housing solutions, which negatively impacts their quality of life. The goal of research is to enhance sustainable living in Vietnamese tube houses through cross-disciplinary collaboration and big data analytics. The study highlights the importance of integrating diverse expertise and stakeholders in the design process to address complex challenges such as urbanization and housing affordability. The article is completed in logical steps and uses the several research methods, such as: collection, analysis and synthesis of data; use diagrams and tables. The application of big data analytics and technology is also identified as a key factor in optimizing the design and construction of tube houses, as well as enhancing stakeholder participation and collaboration. However, the study also acknowledges the challenges associated with cross-disciplinary collaboration and big data analytics. The research highlights the collaborative and inclusive approach that integrates diverse expertise and stakeholders, while addressing challenges.

Keywords: sustainable architecture, stakeholders, cross-disciplinary collaboration, big data, tube house, Vietnam.

1 Introduction

1.1 Sustainable architecture

Sustainable architecture is an emerging field that focuses on creating buildings that are environmentally friendly, energy-efficient, and sustainable. Environmental sustainability,

[1] Corresponding author: loan.nguyenhong@uah.edu.vn

social sustainability, and economic sustainability are three key factors that architects and designers consider when creating sustainable buildings (Tab.1).

Table 1. Factors of sustainable architecture

Environmental sustainability	Social sustainability	Economic sustainability
Passive design strategies for indoor environment	Flexibility and adaptability for multi-generational and changing family needs	Affordability and cost-effectiveness over the building's lifecycle
Efficient energy use and renewable energy sources	Integration with community and cultural context	Durability and resilience for long-term use and maintenance
Water conservation and management	Accessibility and universal design	Local sourcing and economic development
Sustainable materials and construction	Health and well-being	
Green space		

One of the common issues in sustainable architecture today is the gap between design intent and actual performance. There are several research studies that have investigated the performance gap in sustainable architecture in Vietnam. For examples, T. H. H. Nguyen, T. T. Nguyen and T. Q. N. Ngo identified a significant performance gap in energy-efficient housing in Vietnam. The authors suggest that this gap could be addressed through the use of post-occupancy evaluations and more effective communication between designers, builders, and occupants [1]. T. B. T. Dang and T. T. Tran also found a significant performance gap in sustainable residential buildings in Hanoi. The gap could be addressed through more effective communication and collaboration between different stakeholders [2]. These studies explore the lack of proper building operation and maintenance, low occupant awareness and behaviour, and the use of substandard materials and construction practices.

1.2 Tube house in Vietnam

The tube house is a unique architectural style found in densely populated urban areas of Vietnam. It is characterized by its long and narrow shape, with a width of usually around 4 to 5 meters and a depth of 10-30 meters. The front facade often features a storefront or small business, while the upper floors are reserved for residential use.

One of the primary challenges is the limited space available in tube houses, that can make it difficult for families to live comfortably and for community activity. Another challenge is the lack of proper ventilation and natural light. Due to the small and narrow size of tube houses, sustainable living solutions must be compact and efficient.

There are many studies on the development of tube house architecture according to the sustainable architecture. Le et al. proposed a sustainable design framework for small houses in Vietnam that takes into account factors such as energy efficiency, use of local materials, and cultural appropriateness [3]. Research conducted by Nguyen et al. explores the implementation of green design strategies in Vietnamese tube houses and highlights the need for cross-disciplinary collaboration between stakeholders to develop effective green design strategies [4]. In a study conducted by Tran et al., the living conditions of Vietnamese tube house residents were investigated with problems of infectious diseases in tube house communities, in that improved ventilation and access to natural light can significantly improve residents' health [5]. Nguyen et al. examined the relationship between

housing quality and health outcomes in Vietnam. The authors recommend the implementation of policies and programs aimed at improving housing conditions to promote better health outcomes. Research conducted by Hoang et al. investigates the potential for smart technologies to enhance living conditions in Vietnamese tube houses [6].

1.3 The Role of Cross-Disciplinary Collaboration in Architecture

1.3.1 Integrated Design

Integrated design is an approach to architecture that emphasizes collaboration and communication between the various disciplines involved in designing and constructing a building. The goal of integrated design is to create buildings that are not only visually appealing but also functional, efficient, and sustainable. By working together, the design team can identify potential issues and find creative solutions for the project's objectives.

There are various researchers who have studied the application of integrated design in the context of housing in Vietnam. For example, the study of T. Le, C. Lewis and M. Zaretsky focuses on the design of affordable housing in Ho Chi Minh City and explores how integrated design can be used to incorporate sustainable strategies into the design process [7].

1.3.2 Cross-Disciplinary Collaboration in Architecture

The role of cross-disciplinary collaboration in urban planning and design has become increasingly important in recent years. It can lead to more creative and innovative ideas, a better understanding of complex issues, and the development of more sustainable and resilient cities. Furthermore, cross-disciplinary collaboration can help to break down silos and create a more inclusive and equitable planning process. In addition, the architectural design of tube houses in Vietnam is an excellent example of the benefits of cross-disciplinary collaboration in urban planning and design.

A study by Vu et al. explored the application of a community-based participatory approach in improving the housing conditions of low-income families in Vietnam [8]. Nguyen et al. investigated the challenges of sustainable urban development in Vietnam and emphasizes the importance of cross-disciplinary collaborations to achieve sustainable development [9].

A study conducted by Le et al. examines the effectiveness of cross-disciplinary collaboration between architects, urban planners, and engineers in Vietnam [10]. K. Lee and colleagues examine the role of community participation in sustainable urban development. The authors identify three key benefits of community participation: (1) Increased buy-in and support; (2) Local knowledge and expertise; (3) Greater accountability and transparency [11].

Tran et al. conducted a review of sustainable housing solutions for low-income communities in developing countries, including Vietnam. The study highlights the need for interdisciplinary collaborations to create sustainable and affordable housing. The authors suggest that incorporating big data and technology can help to identify and address key challenges in housing design and construction [12]. I. Ahmed, J. Sager and V.C. Le explores the challenges and opportunities of low-income urban housing in Vietnam with the role of public-private partnerships, community participation, and innovative technologies [13]. Y. Li and E. Talen argue that cross-disciplinary collaboration is essential for addressing complex urban challenges and achieving sustainable development [14].

1.3.3 Big Data Analytics for Architecture in Vietnam

The use of big data analytics in urban planning and design has become increasingly important in recent years as cities face complex and interconnected challenges related to sustainability, climate change, population growth, and more. By analyzing large amounts of data collected through sensors, satellites, social media, and other sources, urban planners and designers can make more informed decisions about how to design and manage cities.

The application of big data to tube house design can offer significant benefits, including improved energy efficiency, increased comfort, and better resource management. With sensors and other monitoring devices installed throughout the house, data can be collected on the residents' behaviour, activities, and energy consumption.

A study by T. H. H. Nguyen, & T. T. Nguyen explores the potential for big data analytics in urban planning in Vietnam. The research demonstrates how big data can be used to improve transportation systems, energy efficiency, and environmental sustainability in urban areas. The study also highlights the need for cross-disciplinary collaboration between urban planners, data scientists, and policy-makers to effectively integrate big data analytics into urban planning [15]. Vu et al. explored the potential of using big data analytics in urban planning and management in Vietnam. The study suggests that the integration of data from different sources can help to provide a more comprehensive understanding of urban issues and inform evidence-based policy decisions [16].

The study of M. T. Tran, T.T. Nguyen and T. T. D. Pham aims to explore the potential of using big data analysis in the design of tube houses for low-income people in Hanoi. The researchers collected data on the living conditions of low-income families in Hanoi, including their housing preferences, habits, and daily activities. The study found that big data analysis can provide valuable insights into the needs and preferences of low-income families, which can be used to inform the design of tube houses that meet their specific needs [17].

The World Bank Group conducted a project in 2018 on "Big Data Analytics for Smart and Sustainable Cities in Vietnam" which explored the potential of using big data analytics to improve the design of housing in urban areas. The project also highlighted the importance of cross-disciplinary collaboration between stakeholders to effectively integrate big data analytics into urban planning and design processes [18].

2 Methods

The article is completed in logical steps and uses the several research methods:

- Collection and analysis of data on existing literature of existing literature on tube houses, sustainable living, cross-disciplinary collaboration, and big data analytics. This may include collecting data on living conditions in tube houses, as well as conducting social network analysis to identify patterns of collaboration and communication among stakeholders.
- The article uses a diagram of the process of designing and operating tube house in Vietnam with the goal of achieving sustainable architecture through integrated design, which clarifies the role of cross-disciplinary collaboration and big data analytics (Fig.1).

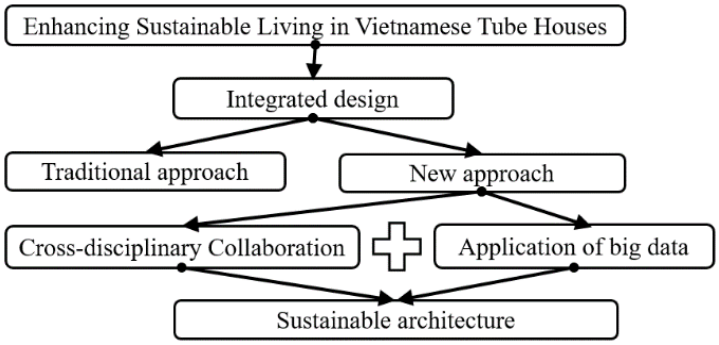

Fig. 1. The process of designing and operating tube house in Vietnam with the goal of achieving sustainable architecture through integrated design.

- Through literature review, the author identifies stakeholders involved in the design, construction and operation of townhouses in Vietnam. Stakeholders cover all aspects of building architecture, thereby ensuring generality and accuracy in conclusions.
- In the next step, the paper identifies roles and participation of stakeholders in the design of tube houses in Vietnam with big data and sustainable architecture.
- The paper contributes to determining the role and potential to enhance sustainable living in Vietnamese tube houses through cross-disciplinary collaboration and big data analytics. The cross-disciplinary collaboration is considered the suitable methods and big data is considered the new material for application for tube house in Vietnam.
- The discussion was conducted with the following contents: (1) Reflection on the effectiveness of the cross-disciplinary and big data approach; (2) Identify limitations and challenges; (3) Suggestions for further research and improvement.

3 Results

A cross-disciplinary and big data approach can be used to enhance sustainable living in Vietnamese tube houses. This approach involves collaboration between all stakeholders to gather data on energy use, behaviour, and other factors that affect sustainability. By analyzing this data, designers can make informed decisions about the layout and organization of the tube house, as well as the selection of materials and building systems. This can help to improve energy efficiency, reduce environmental impact, and enhance the quality of life for residents. Additionally, this approach can help bridge the gap between design intent and real-world application-based performance of big data.

The results of the paper also contribute to determining the role and potential to participate in enhancing sustainable living in Vietnamese tube houses through cross-disciplinary collaboration and big data analytics (Tab.2).

Table 2. The role and potential to participate in enhancing sustainable living in Vietnamese tube houses through cross-disciplinary collaboration and big data analytics

Stake-holders	Roles and Participation in the Design of Tube Houses	Application of Big Data	Goal of Sustainable Architecture

Govern-ment agencies and local autho-rities	Promoting policies and regulations and collaborating with stakeholders to ensure compliance with sustainable architecture and big data-informed design	Collecting and analyzing data on environmental factors, energy use and community needs to support design	Minimizing negative environmental impact while promoting economic and social sustainability.
Urban planners	Collaborating on urban design principles to optimize space and resources in tube house design and ensure alignment with overall urban planning vision.	Collecting and analyzing data on urban development and infrastructure to inform urban planning	Creating a sustainable and livable urban environment.
Architects	Leveraging big data to create sustainable and energy-efficient tube house design through cross-disciplinary collaboration with engineers, contractors, and developers.	Collecting and analyzing data on energy use, behaviour, and environmental factors to inform design decisions	Creating a sustainable and functional living space that meets the needs of the occupants and minimizes negative impact
Engineers (Structural and MEP)	Integrating technical expertise and big data analysis to optimize the architectural design for structural integrity, energy efficiency, and environmental sustainability.	Collecting and analyzing data on energy use and building systems to inform design decisions	Creating a structurally sound and energy-efficient building that minimizes negative impact
Contrac-tors	Efficiently executing the architectural design, while adhering to regulations and standards, and optimizing the construction process using big data to reduce waste and improve sustainability.	Collecting and analyzing data on construction materials and methods to inform construction	Building a sustainable building that minimizes negative environmental impact
Deve-lopers	Advising on design feasibility and marketability, utilizing big data to inform decisions based on consumer preferences and market trends.	Collecting and analyzing data on costs and financial feasibility to inform project management	Creating a sustainable project that meets its goals and minimizes negative impact
Building occupants	Collaborating with architects and occupants to ensure that the architectural design prioritizes health and wellbeing while meeting user needs and preferences.	Collecting and analyzing data on occupant behaviour and preferences to inform design	Creating a functional and aesthetically pleasing living space
Interior designers	Optimizing interior design through collaboration with architects and big data analysis to enhance occupant health and wellbeing.	Collecting and analyzing data on occupant behaviour and preferences to inform design	Creating a functional and aesthetically living space that meets the needs of the occupants

Cultural experts	Collaborating on culturally appropriate architectural design to ensure sensitivity to local customs, traditions, and identity.	Collecting and analyzing data on cultural values and practices to inform design	Creating a building that respects and reflects the cultural heritage
Big data analysts	Data-driven insights and recommendations to create sustainable and energy-efficient designs based on the analysis of energy use, occupant behavior, and environmental factors.	Analyzing data to identify opportunities for energy efficiency and reducing negative impact	Creating a sustainable and energy-efficient building that minimizes negative impact
Sustai-nability experts	Integrating sustainable practices and principles into architectural design and construction through collaboration and data analysis.	Collecting and analyzing data on sustainable practices and the effectiveness to inform design and construction	Creating a sustainable and environmental building that meets the needs and minimizes negative impact.

4 Discussion

4.1 Cross-Disciplinary Collaborations in architectural design of tube house in Vietnam, considering the application of big data and the goal of sustainable

4.1.1 *Methods of Cross-Disciplinary Collaborations*

The architectural design of tube houses in Vietnam has been greatly enhanced through the use of cross-disciplinary collaborations, such as: methods co-creation workshops (CRW) and design charrettes (DC) facilitate collaboration between stakeholders, resulting in more inclusive and culturally appropriate designs. Methods integrated project delivery (IPD) and building information modelling (BIM)allow for the optimization of resources and the seamless coordination of design, construction, and operation phases. Method lean construction (LC) promotes efficient construction practices and reduces waste, while method post-occupancy evaluation (POE) evaluates the effectiveness of design solutions after occupancy. Method virtual and augmented reality (VAR), along with method evidence-based design (EBD), offer opportunities for visualization and testing of design solutions before construction. Methods sustainable design frameworks (SDF) and life cycle assessment (LCA) ensure that designs are environmentally responsible and economically feasible. Their role and potential for tube house in Vietnam can summarized for considering (Tab.3).

Table 3. Methods of cross-disciplinary collaborations and its potential for tube house in Vietnam. (Levels: High – H; Medium – M: Low – L)

Methods	CRW	IPD	BIM	DC	POE	LC	VAR	EBD	SDF	LCA
Potential	H	H	H	H	M	M	M	L	L	L

4.1.2 *Role of Cross-Disciplinary Collaboration*

At the core of integrated design in architecture, including tube house, is the collaboration and communication between different design disciplines to create a cohesive and sustainable design that is functional, effective and visually appealing. With limited available land and a high population density, architects have turned to collaboration with professionals from different fields to find innovative solutions to enhance living environment. The use of involvement of local communities and government authorities in the design process have also facilitated this collaborative approach, leading to the development of more sustainable, affordable, and culturally appropriate housing solutions.
The use of technology in cross-disciplinary collaboration, as well as big data has enabled architects and other professionals to collaborate more effectively and efficiently. This has opened up opportunities for cross-disciplinary collaboration on a bigger scale and has facilitated the exchange of knowledge and expertise.

By bringing together experts from different disciplines, innovative solutions can be developed that take into account a range of factors, from environmental sustainability to social and cultural considerations. Meanwhile, the use of big data analytics can provide valuable insights into energy consumption patterns and other factors that can inform policy decisions and sustainable housing solutions. Therefore, can be determined the potential participation of stakeholders in methods collaboration for the architectural design of tube house in Vietnam, considering the application of big data and the goal of sustainable (Tab.4).

Table 4. The potential participation of stakeholders in method collaboration for the architectural design of tube house in Vietnam, considering the application of big data and the goal of sustainable (Levels: Very High – VH; High – H; Medium – M: Low – L; Very Low – VL)

Stakeholders	CRW	IPD	BIM	DC	POE	LC	VAR	EBD	SDF	LCA
Government agencies and local authorities	VL	H	M	H	L	L	L	L	H	H
Urban planners	M	H	H	H	L	L	H	L	H	H
Architects	H	H	VH	H	M	M	H	H	VH	H
Engineers	H	VH	VH	H	M	M	H	H	H	H
Contractors	H	H	H	H	M	H	M	M	H	H
Developers	H	H	H	H	M	H	M	M	H	H
Building occupants	L	M	L	M	H	M	L	H	L	L
Interior designers	M	H	VH	H	L	M	H	H	VH	M
Cultural experts	M	M	L	M	M	M	L	H	L	M
Big data analysts	H	VH	VH	H	L	H	VH	H	H	H
Sustainability experts	H	VH	VH	H	M	H	M	H	VH	H

However, there are also challenges associated with cross-disciplinary collaboration and big data analytics that must be addressed. One challenge is the need to effectively communicate across different disciplines and ensure that all stakeholders are on the same page. Another challenge is the potential for data privacy issues, particularly as more and more personal data is collected and analyzed in the pursuit of more sustainable living solutions. For example, D. Gkoumas, S. Porta and Y. Jin discuss the challenges that arose during the project, including issues related to data privacy, data quality and cross-disciplinary collaboration [19]. Study of F. Caprotti and colleagues discuss the challenges and opportunities of using big data for urban sustainability, including the need for cross-disciplinary collaboration and addressing privacy concerns [20]. Despite challenges, the potential benefits of cross-disciplinary collaboration and big data analytics in enhancing sustainable living in tube houses are significant.

4.2 Application of Big Data for Architecture of Tube House in Vietnam

4.2.1 Role of Big Data in Cross-Disciplinary Collaboration

In the context of sustainable living, big data can be used to gather information on energy consumption, air quality, and other environmental factors that affect living conditions in tube houses. Additionally, big data can be used to monitor and control the use of resources in real-time, allowing for quick adjustments to optimize energy efficiency and reduce waste. This can be especially important in a country like Vietnam, where energy costs are high and resources are limited.

Big data can help architects design tube houses in Vietnam by providing them with valuable insights into the living habits and energy consumption patterns of the residents. Additionally, big data can also be used to optimize the construction and maintenance of the house. In addition, a very important step in working with big data is sharing information and visualizing data to facilitate data interpretation [21]. The application of big data and technology can also enhance stakeholder participation and collaboration by providing new tools and platforms for engagement and knowledge exchange.

4.2.2 Limitation in Process of Application of Big Data to Tube House

While big data has the potential to improve the sustainability and liveability of tube houses, there are several challenges, such as:

- The limited space available for sensors and other data-gathering devices. Due to their narrow and compact nature, it can be challenging to install sensors that can capture data on various aspects of the building's performance, such as temperature, humidity, lighting, and energy consumption.
- Another challenge is the lack of standardization in tube house designs. The optimal placement and installation of sensors may vary from house to house, making it more difficult to develop standardized approaches to data collection and analysis.
- Application of big data can affect individual design creative decisions and activities that do not rely on data but rather on intuition or expertise enable more disruptive opportunities for using big data [22].
- Furthermore, many tube houses in Vietnam are older and may not have the necessary infrastructure to support the installation and operation of sensors and other data-gathering devices. Retrofitting these houses to accommodate new

technology can be expensive and may require significant modifications to the building's existing systems and infrastructure.

4.3 The Future

As urbanization and population growth continue to increase the demand for affordable housing in Vietnam, there will be a need for innovative and sustainable solutions. Advancements in digital design tools and software may further enhance the capacity for collaboration and innovation.

Big data requires collaboration among various disciplines, which often have different languages, methodologies, and priorities, maybe making effective collaboration difficult. Therefore, research about application of big data and choosing of suitable method collaboration in design, construction and operation of tube house should be continuing in larger scale and higher speed, that can be catch up with the rapid change of Vietnamese society. Social, human and environmental issues will be studied further in a larger overall model of Big data and a strong connection of stakeholders.

5 Conclusion

In the sustainable development strategy of Vietnamese architecture, integrated design is widely selected and used, including tube houses in urban areas. Suitable method collaboration for the architectural design of tube house in Vietnam requires a cross-disciplinary approach that involves engaging various stakeholders, integrating diverse knowledge and expertise, and leveraging technology and big data to create sustainable and inclusive urban environments.

A cross-disciplinary collaboration and the use of big data also can improve communication and knowledge sharing between professionals and ensure that all relevant parties are involved in the design process and that the resulting tube house reflects the needs and aspirations of the occupants. The paper also suggests that the integration of cross-disciplinary collaboration and big data analytics can enhance sustainable living in tube houses in Vietnam and provide valuable insights for similar projects in other contexts. It calls for further research and exploration of these approaches to address complex societal challenges in urban environments.

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