OPTIMIZING APARTMENT CHOICE BASED ON FUZZY-AHP

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ABSTRACT

Purchasing an apartment is an important decision of the residents. Unlike the previous research mainly focusing on housing choice based on the socio-economic and environmental factors, this study concentrates on the early stage of apartment choice. It means the apartment buyers need to consider many factors, including financial conditions, internal designs, legal conditions, external landscape, environment, etc., in making the purchase decision. Aiming at the fundamental problem of family apartment-purchase decision, this study attempted to create a multi-criteria apartment choice model based on the fuzzy Analytic Hierarchy Process (AHP). Notably, a hierarchical chart of apartment choice is developed based on nine critical factors, i.e., housing amenities; internal housing design; indoor environment, quality and safety; exterior design and landscape; social infrastructure; legal conditions; capability of an investor; Fengshui; and financial factor. By conducting the questionnaire survey with 45 experts working in the real estate companies in Vietnam, this study applied the fuzzy AHP to solve complex decision problems and rank the alternative housing choice. In addition, the findings enable us to propose some feasible solutions for managerial managers and government authorities to improve the real estate market's attractiveness.

Keywords: Apartment Choice, Apartment-Purchase Decision, Fuzzy AHP, Real Estate Companies

INTRODUCTION

The study of consumer behaviors in the real estate market is ambiguous. Many previous studies have explored many dimensions of tenure transition from renting to homeownership as an important decision of life event (Henderson & Ioannides, 1983; Huang, 2004; Huang & Clark, 2002). The selection of house choice relies on comparing structural, location, and neighborhood attributes (Liu & Li, 2018); or relating to residents' social-economic conditions (Liu & Li, 2018). Besides, whereas the most four significant influences on customers' intention to buy real estate are location, financial status, corporate reputation, and private living space in Ho Chi Minh City (Le-Hoang, 2021), that in the Philippines are evaluated based on price, location, safety and security, and facilities and amenities (Lee & Ong, 2020). Another study also identifies that several determinants influencing sustainable and affordable housing choice are in relation to income and other non-economic factors like security (safety), housing location, and building type in Nigeria (Ezennia & Hoskara, 2019).

Moreover, condominium units provide a more affordable path to homeownership, converting the city tenure construction from a city mainly characterized by tenants to a mix of homeowners with changing levels of responsibility for maintaining collective areas (Rosen &

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Walks, 2013). Overall, the combination of economic and socio-demographic literature on housing choice has provided a good explanation of house choices in developed countries (Huang & Clark, 2002). Additionally, social capital is broadly argued in the field study on housing affordability and housing choice (Liu & Li, 2018; Logan & Bian, 1999; Yi, Huang & Fan, 2016). Yates & de Oliveira (2016) show that the decision-making process is strongly correlated to cultural divergences. Culture plays an essential role in stimulating the demand for purchasing an apartment or a house. Also, property consumers normally look up several vital factors and do their weighing for decision making.

The residential sector can be broadly categorized into villages, houses, flats, condominiums, and apartments. The concentration of this study is in the apartment choice. In Vietnam, this market has faced many issues on land clearance for constructing, ownership, building management, and finance. Moreover, house buyers have become selective, demanding, requiring prime location, attractive characteristics and designs, and construction quality. Real estate companies have met such a high demand for taste and preference by providing complex facilities, contemporary features and designs, and selecting an attractive landscape. However, the vast creation of real estate projects with design solutions that are out of touch with consumer needs has resulted in several obstacles when companies re-launch this product. To keep up with the reviving real estate industry, real estate companies must understand their consumers' expectations, making consumer behavior research critical to the company's future.

For examining the problem of house-purchase decisions, many prior studies have explored the market factors impacting consumer intention to buy or predict the market demand for housing from the macro level. Furthermore, some scholars investigated the family house-buy throughout case studies, but they have not studied an integrated Multi-Attribute Decision Model (MADM) of housing choice. Therefore, this study attempted to fulfill this gap by building a model of apartment choice. MADM often occurs in an obscure and inaccurate environment. Soft computing codes such as fuzzy sets and system is used for deciding existing vague and inaccurate information (Taylan, Kaya & Demirbas, 2016). This study established an integrated fuzzy analytical hierarchy process approach to employ for apartment selection.

The paper's organization is structured as follows: Section 2 presents the literature review; the research method is presented in Section 3; Section 4 discusses the results and findings; while Section 5 concludes the paper.

LITERATURE REVIEW

AHP Model

Many analysts have suggested that incorporating sustainability into business strategies is critical to achieving long-term competitiveness and the benefits of stakeholders, employees, and general society (Engert, Rauter & Baumgartner, 2016). This case is also applied to the real estate industry when analyzing factors affecting customers' housing choices. As a result, sustainable practices regarding customer demand should be the top priority of businesses, which means that resources for these initiatives have to be fully committed (Calabrese, Costa, Levialdi & Menichini, 2019). Research by (Lloret, 2016) claims that in order to tackle sustainability boundaries, sustainable strategic management should combine various majors: a market-industry perspective, a resource-based approach, and an institutionally oriented view, all of which are related to stakeholders feasible leadership and corporate governance. AHP, in particular, is becoming increasingly popular among MCDM methods, owing to its theoretical simplicity and ease of application (Celik & Akyuz, 2018). AHP approach has been broadly applied to analyze complex problems of multi-criteria, multi-objectives and make a non-structure decision. It has also been used for evaluating operations management, modeling economic development, planning resources, analyzing accident causation, personnel safety, and quality (Khorasani, 2018).

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Criteria Impact on the Decision of Purchasing Houses or Apartments

It is crucial to gain a better understanding of how investors choose residential properties for investment. There would be a gap in the current literature if there lacked knowledge about the investors' satisfaction in buying an urban residential property (Shaidi & Lucian, 2016). Consumers' perceived worth is a psychological trade-off between the gains and sacrifices they expect in transactions, as the desirability of a property is determined by their requirements and purchasing power (*i.e.,* income). Furthermore, it is necessary to clarify the factors that influence buyers' perceptions of home adequacy and satisfaction in the context of properties. Residential property is a shelter or home that consumers seek for protection from hazards or that investors seek to purchase as an investment. In addition, apartments and flats are more common among tenants because most investors choose to invest in or buy a smaller house (Schoenwitz, Potter, Gosling & Naim, 2017).

Customer preferences are a complicated combination of individual personality traits, and determining preferences while customizing products is complicated (Ozaki, 2003). As a result, companies are required to develop various strategies that meet customers' needs and maintain the affordable cost for producing or building processes. Therefore, to deliver new product variety at an acceptable price and remain the lowest production cost, it is crucial to precisely understanding clients' preferences (Adair, Berry & McGreal, 1996; Hofman, Halman & Ion, 2006). For example, real estate companies have to develop suitable tools such as the fuzzy AHP to provide the best apartment quality which meets the customers' requirements. Besides, according to (Andersen, 2011), preferences for tenure vary substantially depending on life stage, but there also appear to be generational differences, with new generations favoring house ownership much more strongly.

As a result, it is crucial to ask whether home builders can also obtain customer satisfaction by offering options (Huffman & Kahn, 1998; Obeidat, Qasim & Khanfar, 2018). The decision to limit choice in order to achieve economies of scale was initially successful in the last century (Bouyssou, Marchant, Pirlot, Perny & Tsoukias, 2000). However, before 1990, the concept of effective individualization (*i.e.,* the use of economies of scope) was considered appropriate for the house building industry, leading to customer dissatisfaction (García et al., 2014). After that, a significant number of studies show that there is a chance to enhance customer satisfaction and market penetration if houses can satisfy customers' needs and expectations more closely (Amiri & Asvadi, 2015; Erbıyık, Özcan & Karaboğa, 2012). However, providing an excessive amount of choice can cause confusion instead of satisfaction and influence customers and their purchasing decisions (Saracoglu, 2013). Thus, an acceptable level of choice must be provided to achieve customer satisfaction, and recognizing which attributes are important to customers is critical for this purpose.

In the last few decades, there was a few studies on using multi-criteria decision-making tools to choose an apartment for a family. However, some studies have used AHP to select a location for factories. For example, determining the best locations for new agricultural product warehouses, choosing a retail store location (Chevan, 1982; Mayer & Engelhardt, 1996), prioritizing natural disaster relief logistic center locations, and establishing new shipyard zones in Turkey (Jewkes & Delgadillo, 2010; Lau & Li, 2006); implementing a strategy for industrial company development based on energy-saving (Tetiana, Chernysh, Levchenko, Semenenko & Mykhailichenko, 2019). In general, the basic formula for selecting a site includes the following steps: analyzing candidate alternatives based on specific criteria, describing essential factors in the decision-making process, designing candidate options for site selection, evaluating the candidates, and making a decision by selecting the best alternative (Logan & Bian, 1999; Yi et al., 2016).

Many prior studies have examined the factors impacting housing choice. Others focus on the linkage between demographic factors and purchasing capacity (Liu & Li, 2018; Yates & de Oliveira, 2016). Several ones concentrate on the economic attributes such as income, saving, financial investment, etc., (Andrew & Larceneux, 2019). In addition, social capital is also

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broadly explored the relationship between housing affordability and housing choice (Levy, Murphy & Lee, 2008). Furthermore, according to (Lin, Lin, Wang, Chang & Lin, 2020), while the trade-offs between buyers and sellers in a real estate transaction are influenced by reference alternative conditions such as pricing and home performance, the seller's reference options rarely exactly match the buyer's. Indeed, the seller's reference alternatives apply the high priced alternatives, and opposition the buyer applies the lower-priced options due to loss aversion (Lin et al., 2020).

Other studies show that housing choice depends on cultural differences. Culture plays an essential role in initiating or stimulating the demand for purchasing a house, particularly regarding the importance of family (Jørgensen, 2016). In Poland, (Jancz & Trojanek, 2020) illustrates that seniors, preferred smaller units in multi-family housing construction, with a location in the city center. In contrast, pre-senior citizens were more likely to live in a single-family house located in a rural area or outside the city center.

Many scholars argue that models developed in the behavioral literature that relax rational cognition assumptions explain observed outcomes better than neoclassical models (Ackert, Church & Deaves, 2003). The literature on cultural economy explicitly acknowledges that markets include both passions and rationality (Hasanah & Yudhistira, 2018). Examining the role of emotions in understanding purchasing behavior reveals two strands: the first relates to the formation of house-price bubble form, and the second to a home as an emotional place (Hui & Liang, 2016). Previous research has provided supporting evidence of emotional attachment, emphasizing an emotion derived from homeownership status (Hui, Zhong & Yu, 2012; C. Wang, 2013). According to (Foti & Devine, 2019), conscious customers are regarded as a valued demographic that demonstrates diverse behaviors. (Auger, Devinney, Louviere & Burke, 2008; Creyer, 1997) When making purchasing decisions, they prefer to acquire things with socially responsible features and evaluate the ethical aspects of products. Moreover, the assessment of utilitarian benefits cognitively dominates buyer evaluations, but emotion plays a significant role among homebuyers as well as investors (Andrew & Larceneux, 2019).

Another factor influencing apartment choice is the view of the landscape. Several previous studies looked into the effect of views on apartment prices (Hou, 2010; Opoku & Muhmin, 2010). On the other hand, the impact varies depending on the viewpoint and location (Haddad, Judeh & Haddad, 2011). A study in Shenzhen, China, for example, discovered that gardens, urban parks, and bay views have an amenity effect on apartment prices (Adair et al., 1996; Daly, Gronow, Jenkins & Plimmer, 2003; Sengul, Yasemin & Eda, 2010). A similar study conducted in Guangzhou by (Razak, Ibrahim, Abdullah, Osman & Alias, 2013) found that park views also positively affected housing prices. According to these studies, spaces were consistently reported to boost apartment prices across different study areas. Landscape views provide an amenity to residents, and this can influence the house or apartment owners in their residence decisions (Hasanah & Yudhistira, 2018).

Several previous studies show that the financial factor is the most important factor in deciding whether or not to buy a property (Opoku & Muhmin, 2010; Reed & Mills, 2007). The disposable income, access to a mortgage loan, and financial assistance positively impact the purchase decision. Financial status refers to house buying as a mixture of house prices, mortgage loans, income, and repayment terms (Zainon, Rahim, Sulaiman, Abd-Karim & Hamzah, 2017). In other words, this meaning refers to mortgage availability, purchase terms, house price, property assessment value, the opportunity for rapid appreciation, and the waiting period (El-Nachar, 2011; Haddad et al., 2011; Sengul et al., 2010). The financial key attributes primarily considered for house purchasing decisions were mortgage interest rate, household income, housing costs, and ability to obtain financing. A study in China shows that governmental incentives had the strongest influence on purchasing intention (Zhang, Chen, Wu, Zhang & Song, 2018). Thus, the government can play a crucial role in guiding young consumers' purchase intention of greenhouses. Besides, another study indicates that in June 2013, the Vietnamese government launched the 30 Trillion Vietnamese dong Home Loan Package to enhance housing affordability for the middle-income class (Seo, Chung & Kwon, 2018). It was a subsidized mortgage program

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based on central bank regulations, with a maximum fixed annual interest rate of 6%, maximum loan tenure of 15 years, and a loan to the value of 70 to 80 percent of the purchase price for first-time buyers of social housing or apartments. According to (Samad et al., 2015), since the subsidized program was launched, around 80% of apartment buyers in HCMC have taken advantage of the package.

House features include house design, building quality, interior and exterior designs, and finishing, all of which are expected to influence an individual's decision to choose an apartment (Lonappan, 2013). According to Seo, et al., (2018), in contrast to horizontal corridor access, vertical shared access in apartments promotes an upward trend in housing prices since it provides both dwelling individuality and social intimacy with a manageable scale of neighbors. In addition, several scholars discovered that these house features are critical factors in determining a consumer's choice and purchase of a house (Anastasia & Suwitro, 2015). Besides, (Jancz & Trojanek, 2020) shows that differentiation of housing preferences was primarily visible when choosing the type of development and size of the dwelling. As a result, house features or house internal attributes such as building quality, design, and indoor and outdoor design are essential for consumers when selecting and purchasing a house. Most homebuyers desire to better their quality of life by purchasing in a specific place and indoor environment/situation (AbuSada & Thawaba, 2011; Jim & Chen, 2007).

Some studies of (Adair et al., 1996; Daly et al., 2003; Sengul et al., 2010; Xiao & Liu, 2010) described living space as a private living area, including the living room, the kitchen size, the number of restrooms, and the number of bedrooms. They claimed that these living space features are the most influential factors in consumer housing decisions. Homebuyers consider the apartment's condition depending on the family size (Le-Hoang, 2021). Other researchers agreed with (Opoku & Muhmin, 2010) Opuku and Abdul Muhmin's findings when they discovered a great connection between living space and consumers' house purchase decision making and pricing (Chun-Tung Lowe & Corkindale, 1998). Moreover, according to (Chia, Harun, Kassim, Martin & Kepal, 2016), the size of the bathroom and dining room influences the purchasing decision. Furthermore, several studies illustrate that 4.5 percent of interviewees chose the size of the house space as a critical factor in their purchase intention (Adair et al., 1996; Clark, Deurloo & Dieleman, 2006; Opoku & Abdul-Muhmin, 2010; Tu & Goldfinch, 1996; Wang & Li, 2006). Besides, according to (Kauko, 2006), the house size and the number of bathrooms or bedrooms are the top priorities for homebuyers.

Corporate reputation is also an important factor affecting customer's purchase intention. Corporate reputation is the belief and trust that the company brings to its customers, which significantly impacts their purchasing intentions (Chang & Chen, 2008). People in several cultures seek the opinions of others in their social group about corporate reputation (Razak et al., 2013). Ong (2013) discovered that these factors affect customers' purchasing intent, such as the company's reputation, which creates absolute trust for clients, a passionate and highly qualified customer service attitude, knowledge of the business brand from relatives and friends, and timely accurate guidance.

Previous research found that location was one of the most significant factors influencing an individual's decision to buy a house (Azmi, Salleh & Nawawi, 2013). A study of (Źróbek, Trojanek, Sokolnik & Trojanek, 2015) surveyed in Helsinki and discovered that the location is far more important than the house itself. Notably, the distance from various points of interest is closely related to location. Customers usually consider the distance from the apartment's location to different interest points such as central business district, school, work, and retail outlets (Natasha & Hassan, 2015). Mariadas, Abdullah & Abdullah (2019) discovered that 46.7 percent of respondents strongly agree that the distance between their home and amenities is their primary concern. Furthermore, the proximity of schools, grocery stores, and shopping centers influences homebuyers' purchasing decisions (Jonsson, 2014). According to a study by (Rachmawati, Shukri, Azam & Khatibi, 2019; San Ong, 2013), approximately 48.4 percent of residents are interested in the property's accessibility with amenities. According to (Ong, 2013), a position is generally defined by a set of parameters in order to make it more valuable and

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important. The locational element has a positive relationship with property purchasing decisions (Jayantha & Man, 2013). According to the previous report, locational factors positively influence urban housing investment decisions (Popoola, Jinadu, Liman & Abd'Razack, 2015). For other attributes, (Seo et al., 2018) found that since many workplaces in HCMC are concentrated in the downtown districts like District 1, accessibility and proximity are critical for housing choice. Housing options' geographical factors include areas under urban master plan, traffic conditions (Næss, 2013), infrastructure configuration (Drezner, 1995; Huang & Humphreys, 2014), and so on.

Another factor that affects apartment purchase decisions is environmental satisfaction. Other studies (Rachmawati et al., 2019; Źróbek et al., 2015) discovered that the level of environmental satisfaction is directly related to the property's traffic noise, ecological balance, cleanliness, safety, and scenic view. Simultaneously, an excellent scenic view can raise the social class of residents (Fung, Jeng & Liu, 2010). However, environmental contamination has increased in China's urban and rural areas as industry and urbanization have accelerated (Zhang, 2020). As a result, developers are being urged to incorporate environmentally friendly design and promote sustainable building practices to balance economic, social, and environmental performance in implementing construction projects (Akadiri, Chinyio & Olomolaiye, 2012). The increase in the indoor and surrounding environment can significantly increase customer's apartment-purchase decisions. Furthermore, it will lead to a rise in the property's commercial value. Developers believe that spending in such a green business will help a real estate company become more sustainable and valuable (Adair, Berry & McGreal, 1996). According to (Le-Hoang, 2021), a green environmental property can enhance the house's value by up to 20%.

Neighborhood security and safety also play an essential role in homebuyers' decisions, including homeowner's safety and well-being (Yam & McGreal, 2010). People would rather not stay in areas with a high noise level (Chia et al., 2016). The environment includes the neighborhood, view, noise from surrounding districts, and general security, all of which can influence a household's purchasing decision (Jonsson, 2014). Moreover, the environmental condition includes infrastructure quality, nearby neighbors, surrounding landscape, region security situation, surrounding noise, and surrounding environment pollution (Hamdan, Yusof & Marzukhi, 2014). According to (Dettling & Kearney, 2014), the environment is the security requirements, security, and surrounding space. Another research also concluded that the surrounding living environment influences customers' purchasing intentions (Mahendran, Moorthy & Saravanan, 2014) since better homes are concentrated in better neighborhoods.

Besides, some other studies concentrate on different house-owning circumstances. According to (Murphy & Staples, 1979), changes in family composition and lifestyle such as marital status and family size highlight that an individual or family's initial housing purchase will be unique. The results from other studies find that real estate price is significantly related to intention to have a baby for both potential first-time homeowners and current homeowners who need to upgrade to a larger apartment (Bouyssou, Marchant, Pirlot, Perny & Tsoukias, 2000). The current owner and potential owner have quite distinct constraints and alternatives regarding the apartment choice. Thus, this research will further investigate different potential factors.

RESEARCH METHOD

Data Collection

We conducted in-depth interviews with experts in the real estate industry. They have experienced in constructing buildings and selling apartments to customers. Data was collected from two different groups in Ho Chi Minh City, Vietnam. The first group included 15 experts working in real estate companies related to apartment specifications that customers have searched. The second one included 30 apartment buyers. It took five months, from October 2019 to February 2020, to complete data collection.

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Fuzzy AHP

In this study, a fuzzy expansion of AHP was developed to fix the hierarchical fuzzy issues. In the fuzzy AHP procedure, the pairwise comparisons in the judgment matrix are fuzzy numbers instead of exact ones, indicating the linguistic expressions in the fuzzy AHP (Kahraman, Cebeci & Ruan, 2004; Khan & Jayant, 2015). Furthermore, the fuzzy AHP technique takes into account both qualitative and quantitative decision-making metrics, enabling a multi-dimensional assessment of sustainability decisions.

Fuzzy set theory, a branch of traditional logic that captures the meaning of words, human thinking, and decision-making, allows decision-makers to incorporate incomplete or partially acquired data into the problem's solution model (Turskis & Zavadskas, 2010). The fuzzy linguistic approach can account for decision-makers' optimism/pessimism rating attitudes and linguistic values. Therefore, those membership functions are typically characterized by fuzzy triangular numbers, should be used to assess preference ratings rather than the traditional numerical equivalence method. The use of triangular membership functions (Figure 1) for "pairwise comparison scale of fuzzy AHP" and synthetic extent value of the pairwise comparisons is considered a new approach for handling AHP (Gumus, 2009).

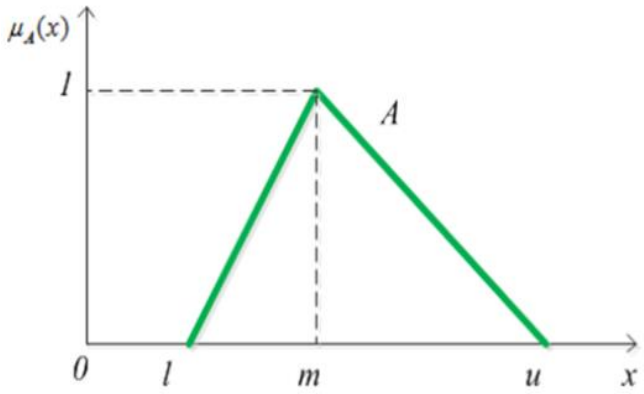

FIGURE 1
THE MEMBERSHIP FUNCTION OF THE TRIANGULAR FUZZY NUMBER

Linguistic terms are compared to the corresponding triangular fuzzy numbers as in Table 1 (Buckley, 1985).

Table 1
LINGUISTIC TERMS AND FUZZY SCALES

Saaty	Definition	Fuzzy Triangular Scales
1	Equally important	(0.5, 1, 2)
3	Weakly important	(2, 3, 4)
5	Fairly important	(4, 5, 6)
7	Strongly important	(6, 7, 8)
9	Absolutely important	(9, 9, 9)
2	The intermittent values between two adjacent scales	(1, 2, 3)
4		(3, 4, 5)
6		(5, 6, 7)
8		(7, 8, 9)

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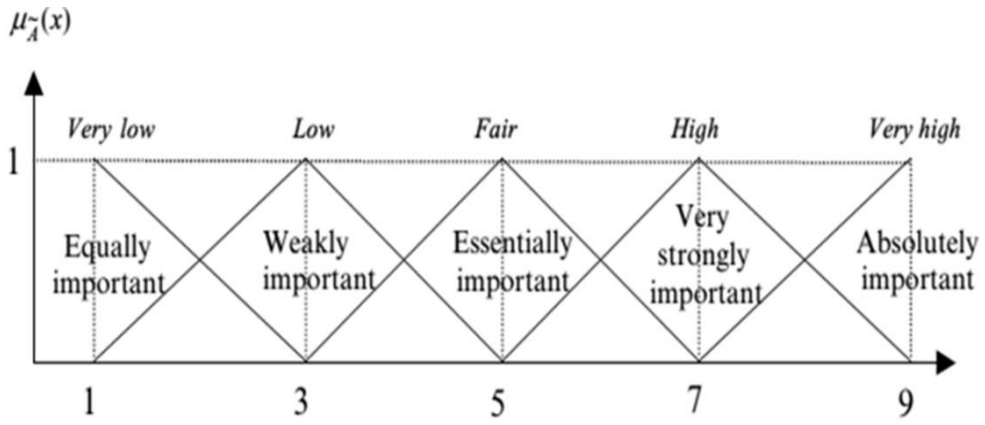

FIGURE 2
THE MEMBERSHIP FUNCTION FOR THE FIVE LEVELS OF LINGUISTIC VARIABLES OF FUZZY ANALYTIC HIERARCHY PROCESS

The weights of both criteria and alternatives would be calculated as following procedure:
Step 1: The pairwise contribution matrices equation for each decision-maker:

$$\tilde{A}^k = \begin{bmatrix} \tilde{d}_{11}^k & \cdots & \tilde{d}_{1n}^k \\ \cdots & \ddots & \cdots \\ \tilde{d}_{n1}^k & \cdots & \tilde{d}_{nn}^k \end{bmatrix}$$

Where $\tilde{\boldsymbol{d}}_{\boldsymbol{11}}^{\boldsymbol{k}}$ indicates the k[th] decision maker' preference of the i[th] criterion over j[th] criterion.
Step 2: The preferences of the decision-makers would be averaged as follows:

$$\tilde{\boldsymbol{d}}_{\boldsymbol{ij}}^{\boldsymbol{k}} = \frac{\sum_{\boldsymbol{1}}^{\boldsymbol{k}} \tilde{\boldsymbol{d}}_{\boldsymbol{ij}}^{\boldsymbol{k}}}{\boldsymbol{k}}$$

Step 3: The geometric mean of fuzzy comparison triangular values of each criterion $\tilde{\boldsymbol{r}}_{\mathrm{i}}$

$$\tilde{\boldsymbol{r}}_{\boldsymbol{i}} = \left(\prod_{\boldsymbol{j=1}}^{\boldsymbol{n}} \tilde{\boldsymbol{d}}_{\boldsymbol{ij}} \right)^{\boldsymbol{1/n}}$$

Step 4: Estimate fuzzy weights of each criterion by multiply each $\tilde{\boldsymbol{r}}_{\boldsymbol{i}}$ with its reversed vector

$$\tilde{\boldsymbol{w}}_{\boldsymbol{i}} = \tilde{\boldsymbol{r}}_{\boldsymbol{i}} \otimes (\tilde{\boldsymbol{r}}_{\boldsymbol{1}} \oplus \tilde{\boldsymbol{r}}_{\boldsymbol{2}} \oplus \ldots \tilde{\boldsymbol{r}}_{\boldsymbol{i}})^{\boldsymbol{-1}} = (\boldsymbol{lw}_{\boldsymbol{i}}, \boldsymbol{mw}_{\boldsymbol{i}}, \boldsymbol{nw}_{\boldsymbol{i}})$$

Step 5: Defuzzying $\tilde{\boldsymbol{w}}_{\boldsymbol{i}}$by taking geometric mean of $(\boldsymbol{lw}_{\boldsymbol{i}}, \boldsymbol{mw}_{\boldsymbol{i}}, \boldsymbol{nw}_{\boldsymbol{i}})$

RESULTS

The first step of the multiple-criteria decision-making procedure based on FAHP is to define the main attributes and alternatives for apartment selection. First, the overall objective of the apartment category prioritization problem has been identified. That was "prioritization of the most appropriate and satisfactory apartment category for selecting and purchasing". In the real estate field, many criteria should be taken into account because the competition is high. All of the possible important criteria, which could affect the purchase decision of the potential consumers, have been discussed with a group of experts and professionals who have a broad knowledge and high seniority. By combining the attributes that have been determined by the expert and the attributes that have been used in the literature, the main attributes and the alternatives in the study are determined. Nine main attributes and three decision alternatives have been identified. The main determining attributes are housing amenities, internal housing design, indoor environment, quality and safety, building exterior design and landscape, social

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infrastructure, legal conditions, the employer's capability, Fengshui, and financial factors. The alternatives attributes are three apartment categories with the different areas of 45 m^2-55 m^2, 70 m^2-90 m^2, and 100 m^2.

After determining the main attributes and alternatives, the hierarchy of the apartment category prioritization problem is structured. The following figure shows the structuring of the apartment category of selection problem hierarchy of four levels. The top level of the hierarchy represents the ultimate goal of the problem: prioritizing an apartment category. The second level of the hierarchy is grouped into nine primary criteria, with the primaries' subsidiary criteria. Finally, the bottom level of the hierarchy represents the three decisions of the alternative apartment category. They are categorical apartments with areas of 45 m^2-55 m^2, 70 m^2-90 m^2, and 100 m^2. Figure 3 shows the hierarchical structure for FAHP.

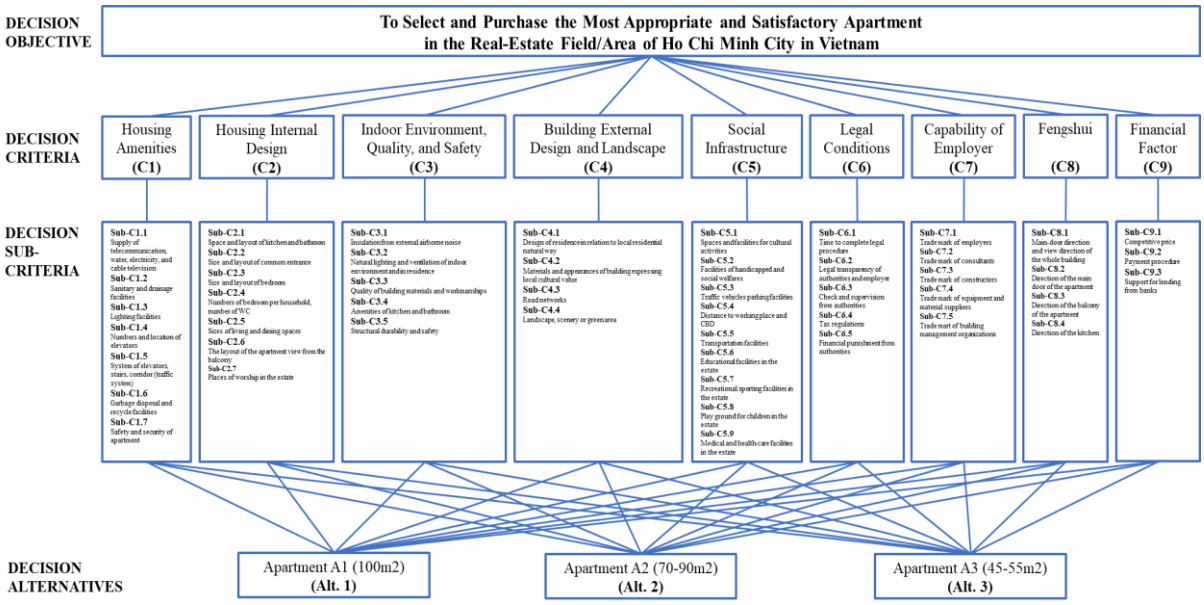

FIGURE 3
HIERARCHICAL STRUCTURE FOR FUZZY AHP AS THE CONCEPTUAL FRAMEWORK

In accordance with the developed pairwise comparison matrix tables for the nine primary criteria, the fuzzy weights and non-fuzzy weights for factor evaluation of the primary criteria are calculated using the basic arithmetic of fuzzy numbers and the geometric mean approach. Table 2 illustrates the results of data analysis based on the FAHP approach.

Table 2
CALCULATION OF FUZZY WEIGHTS AND NON-FUZZY WEIGHTS FOR FACTOR EVALUATION OF PRIMARY CRITERIA

PRIMARY CRITERIA	Factor Evaluation of Primary Criteria		
	Fuzzy Weights	Non-Fuzzy Weights	Percentage (%)
C1 (Housing amenities)	(0.0595, 0.1253, 0.1870)	0.1117	11.17%
C2 (Housing internal design)	(0.0432, 0.0718, 0.0961)	0.0668	6.68%
C3 (Indoor environment, quality and safety)	(0.0571, 0.1146, 0.1622)	0.1020	10.20%
C4 (Building external design and landscape)	(0.0384, 0.0470, 0.0536)	0.0459	4.59%

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C5 (Social infrastructure)	(0.0747, 0.0844, 0.0924)	0.0835	8.35%
C6 (Legal conditions)	(0.2314, 0.2560, 0.2696)	0.2518	25.18%
C7 (Capability of employer)	(0.1281, 0.1494, 0.1580)	0.1446	14.46%
C8 (Fengshui)	(0.0808, 0.0548, 0.0454)	0.0586	5.86%
C9 (Financial factor)	(0.1607, 0.0967, 0.0802)	0.1076	10.76%

After calculating the fuzzy weights and non-fuzzy weights for the priorities of the primary criteria, the consistency of each matrix is checked (Gumus, 2009). First, determining the weighted sum vector and consistency vector. Then, the consistency index (CI) for the matrix is calculated from (〖□□〗 _max-n)/(n-1). Randomly generated consistency index (RI) values are shown in the following table 3.

Table 3
RANDOM INDICES (RI) FOR PAIRWISE COMPARISON MATRIX

Size (*n*)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Acceptability of alternative is measured in terms of Consistency Ratio (CR), CR=CI/RI. The calculation of the consistency ratio for the pairwise comparison matrix table of the primary criteria are shown as follows:

(λ_{max}=0.9551, CI=0.0319, RI=1.45, CR=0.0220=2.20%)

The final step of the evaluation procedure of the FAHP approach is to compare the decision alternatives under each subsidiary and primary criterion separately. Table 4 shows that the best apartment choice was Apartment A2.

Table 4
THE OVERALL RANKING

DECISION ALTERNATIVES	**TOTAL WEIGHTED EVALUATION**			
	Fuzzy Weights	**Non-Fuzzy Weights**	**Percentage (%)**	**Overall Ranking**
Apartment A1 (100 m^2)	(0.0337, 0.3573, 1.7233)	0.2749	27.49%	3
Apartment A2 (70 m^2-90 m^2)	(0.1388, 0.3289, 1.1094)	0.3700	37.00%	1
Apartment A3 (45 m^2-55 m^2)	(0.1105, 0.3152, 1.0453)	0.3314	33.14%	2

The overall ranking shows the three real-estate product categories' ranking depending on the values of composite weights. The apartment with a living area of 70 m^2-90 m^2 is determined as the most appropriate and satisfactory alternative to choose. The purchasing options are based on the perspectives of the enrolled experts and professionals. In the ranking, the apartment category with 45 m^2-55 m^2 and 100 m^2 are determined second and third, respectively. It is worth noting that any changes in any criteria might change the result. For instance, the result shows that the apartment with a living area of 70-90 m^2 is selected as the best decision alternative to choose, considering the competitive price of the financial factor. However, if the customers or investors have no problem with the financial aspects, then the optimum result may switch to the other apartment category. Applying the proposed methodology to the case study of finding the most appropriate and satisfactory led to the following conclusion. First, the method provided

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decision support to the potential customers and investors for choosing and purchasing an apartment. Second, the different perspectives of customers or investors lead to various levels concerning decision criteria.

DISCUSSIONS

This study concentrates on the early stage of apartment choice. The apartment buyers need to consider many factors, including financial conditions, internal designs, external landscape, etc., in making the purchase decision. First, purchasing real estate would be difficult without preparation and economic balance. Customers are choosing a venue that better matches their budget and consumer orientation and preferences might expect to purchase real estate beyond their financial means. Today, many loan support policies from investors or banks, such as interest rate support or flexible payment policies, would significantly affect real estate options consideration (Seo et al., 2018). From the form of payment, the apartment buyers pay more attention to the payment period suitable for each family's budget. Therefore, real estate companies need to create suitable products for customers, especially maximum support for customers financially, thereby helping customers solve financial problems (Le-Hoang, 2021).

Regarding internal designs, customers' real estate investments can be seen as long-term investments for themselves and their families. The investor should select suitable, knowledgeable design units to optimize the area of the apartment, arrange flexible space, create more space to increase visibility, fresh view, and cleanliness. To fully comprehend the customers' preferences, businesses and consultants must understand the market and compare apartments in the same category in various locations so that consumers can get a sense of the unit's advantages and potential (Le-Hoang, 2021). Also, businesses must devise multiple techniques to fulfill customers' requirements while maintaining a low cost of production or construction (Adair et al., 1996; Hofman et al., 2006). Real estate businesses, for example, must create appropriate tools such as FAHP in order to give the greatest apartment quality that matches the needs of their consumers.

Besides, family composition and lifestyle changes, such as marital status and family size, highlight the fact that an individual's or a family's first home purchase will be unique (Murphy & Staples, 1979). Cultural differences play an essential role in initiating or stimulating the demand for purchasing a house (Jørgensen, 2016). Other factors that can be mentioned, like corporate reputation, customer preferences, and demographic characteristics, also affect customers' purchase intention. Additionally, emotion can guide and enhance individuals' ability to make rational investment decisions (Ackert et al., 2003). This might also be a valuable resource for potential investors and developers looking for suitable areas in Vietnam for their housing construction projects. Because of Vietnam's urbanization, they must take into account a variety of market circumstances and factors that influence apartment prices (Seo et al., 2018). Additionally, as roads and transportation infrastructure are gradually upgraded all over Vietnam, investors have progressively been motivated by the real estate market.

CONCLUSION

This study explored the actual problem of family apartment-purchase decisions and built a family apartment-choice decision based on FAHP. It also offers the purchase process to select the appropriate apartment based on nine factors (decision criteria) and 48 sub-factors (decision sub-criteria). This paper found some interesting results based on the data collected from experts and apartment buyers from Ho Chi Minh, Vietnam. Residential developers might use the multi-criteria option to influence citizens' preferences on apartment purchasing rather than just complying passively. Furthermore, all of these weighted criteria can be used to determine what types of apartments should be built to meet the community's specific needs.

The findings highlighted some managerial implications for managers, policymakers, and apartment buyers. First of all, legal conditions are essential in deciding to buy an apartment for

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the most overall effect; meanwhile, the capability of real estate companies is the second critical criterion to evaluate an apartment choice. Apartment buyers consider four other factors: financial, housing amenities, indoor environment, quality and safety, and social infrastructure as the third essential decision criteria. Besides, Fengshui and building exterior design and landscape are the least important criteria for purchasing an apartment. Secondly, the findings also highlight the trend of apartment choice of the young generation in modern society. The results provide significant evidence to motivate policymakers to improve the legislation and law system of the real estate market in Vietnam. Furthermore, real estate companies should pay more attention to customers' concerns when purchasing an apartment to meet their demand.

LIMITATION

This research model is much more developed than previous studies, which are only based on the socio-economic and environmental factors for multi-criteria apartment decision-making. Nevertheless, it still has several limitations. Firstly, the fuzzy approach should extend in-depth to acquire more psychological effects for better comprehensiveness for future research. Secondly, the risk factors of living in apartments during natural disasters as well as influenza pandemic like Covid -19 suffering health inequities and disrupting necessary services should be extended in the model of apartment choice.

REFERENCES

AbuSada, J., & Thawaba, S. (2011). Multi criteria analysis for locating sustainable suburban centers: A case study from Ramallah Governorate, Palestine. *Cities, 28*(5), 381–393.

Ackert, L.F., Church, B.K., & Deaves, R. (2003). Emotion and financial markets. *Federal Reserve Bank of Atlanta Economic Review, 88*(2), 33–41.

Adair, A., Berry, J., & McGreal, S. (1996). Valuation of residential property: Analysis of participant behaviour. *Journal of Property Valuation and Investment, 14*(1), 20–35.

Adair, A.S., Berry, J.N., & McGreal, W.S. (1996). Hedonic modelling, housing submarkets and residential valuation. *Journal of Property Research, 13*(1), 67–83.

Akadiri, P.O., Chinyio, E.A., & Olomolaiye, P.O. (2012). Design of a sustainable building: A conceptual framework for implementing sustainability in the building sector. *Buildings, 2*(2), 126–152.

Anastasia, N., & Suwitro, A. (2015). The rational and irrational factors underlying property buying behavior. *Journal of Economics and Behavioral Studies, 7*, 183–191. https://doi.org/10.22610/jebs.v7i2(J).576

Andersen, H.S. (2011). Motives for tenure choice during the life cycle: The importance of non-economic factors and other housing preferences. *Housing, Theory and Society, 28*(2), 183–207. https://doi.org/10.1080/14036096.2010.522029

Andrew, M., & Larceneux, F. (2019). The role of emotion in a housing purchase: An empirical analysis of the anatomy of satisfaction from off-plan apartment purchases in France. *Environment and Planning: A Economy and Space, 51*(6), 1370–1388.

Auger, P., Devinney, T.M., Louviere, J.J., & Burke, P.F. (2008). Do social product features have value to consumers? *International Journal of Research in Marketing, 25*(3), 183–191.

Azmi, A.S.M., Salleh, W.A.R.W.M., & Nawawi, A.H. (2013). Cognitive behaviour of residents toward living in landslide prone area: Ulu Klang. *Procedia-Social and Behavioral Sciences, 101*, 379–393.

Bouyssou, D., Marchant, T., Pirlot, M., Perny, P., & Tsoukias, A. (2000). Evaluation and decision models: a critical perspective. *Springer Science & Business Media, 32*.

Amiri, A., & Asvadi, S. (2015). A prioritization model for locating relief logistic centers using analytic hierarchy process with interval comparison matrix. *Knowledge-Based Systems, 86*, 173–181.

Buckley, J.J. (1985). Fuzzy hierarchical analysis. *Fuzzy Sets and Systems, 17*(3), 233–247.

Calabrese, A., Costa, R., Levialdi, N., & Menichini, T. (2019). Integrating sustainability into strategic decision-making: A fuzzy AHP method for the selection of relevant sustainability issues. *Technological Forecasting and Social Change, 139*, 155–168.

Celik, E., & Akyuz, E. (2018). An interval type-2 fuzzy AHP and TOPSIS methods for decision-making problems in maritime transportation engineering: The case of ship loader. *Ocean Engineering, 155*, 371–381.

Chang, H.H., & Chen, S.W. (2008). The impact of online store environment cues on purchase intention: Trust and perceived risk as a mediator. *Online Information Review*.

Chevan, A. (1982). Age, housing choice, and neighborhood age structure. *American Journal of Sociology, 87*(5), 1133–1149. https://doi.org/10.1086/227558

Chia, J., Harun, A., Kassim, A.W.M., Martin, D., & Kepal, N. (2016). Understanding factors that influence house purchase intention among consumers in Kota Kinabalu: An application of buyer behavior model theory. *Journal of Technology Management and Business, 3*(2).

Lowe, C.T.A., & Corkindale, D.R. (1998). Differences in "cultural values" and their effects on responses to marketing stimuli. *European Journal of Marketing, 32*(9/10), 843–867. https://doi.org/10.1108/03090569810232291

Clark, W., Deurloo, M., & Dieleman, F. (2006). Residential mobility and neighbourhood outcomes. *Housing Studies, 21*(3), 323–342.

Creyer, E.H. (1997). The influence of firm behavior on purchase intention: Do consumers really care about business ethics? *Journal of Consumer Marketing, 14*(6), 421–432.

Daly, J., Gronow, S., Jenkins, D., & Plimmer, F. (2003). Consumer behaviour in the valuation of residential property. Property Management.

Dettling, L.J., & Kearney, M.S. (2014). House prices and birth rates: The impact of the real estate market on the decision to have a baby. *Journal of Public Economics, 110*(1), 82–100. https://doi.org/10.1016/j.jpubeco.2013.09.009

Drezner, Z. (1995). Facility location: A survey of applications and methods. Springer Series in Operations.

El-Nachar, E. (2011). Design quality in the real estate market: Clients' preferences versus developers' interests. *International Journal of Architectural Research, 5*(2), 77–90.

Engert, S., Rauter, R., & Baumgartner, R.J. (2016). Exploring the integration of corporate sustainability into strategic management: A literature review. *Journal of Cleaner Production, 112*, 2833–2850.

Erbıyık, H., Özcan, S., & Karaboğa, K. (2012). Retail store location selection problem with multiple analytical hierarchy process of decision making an application in Turkey. *Procedia-Social and Behavioral Sciences, 58*, 1405–1414.

Ezennia, I.S., & Hoskara, S.O. (2019). Exploring the severity of factors influencing sustainable affordable housing choice: Evidence from Abuja, Nigeria. *Sustainability, 11*(20), 1–25. https://doi.org/10.3390/su11205792

Foti, L., & Devine, A. (2019). High involvement and ethical consumption: A study of the environmentally certified home purchase decision. *Sustainability, 11*(19), 1–11. https://doi.org/10.3390/su11195353

Fung, H.G., Jeng, J.L., & Liu, Q.W. (2010). Development of China's real estate market. *Chinese Economy, 43*(1), 71–92.

García, J.L., Alvarado, A., Blanco, J., Jiménez, E., Maldonado, A.A., & Cortés, G. (2014). Multi-attribute evaluation and selection of sites for agricultural product warehouses based on an analytic hierarchy process. *Computers and Electronics in Agriculture, 100*, 60–69.

Gumus, A.T. (2009). Evaluation of hazardous waste transportation firms by using a two-step fuzzy-AHP and TOPSIS methodology. *Expert Systems with Applications, 36*(2), 4067–4074. https://doi.org/10.1016/j.eswa.2008.03.013

Haddad, M., Judeh, M., & Haddad, S. (2011). Factors affecting buying behavior of an apartment an empirical investigation in Amman, Jordan. *Research Journal of Applied Sciences, Engineering and Technology, 3*(3), 234–239.

Hamdan, H., Yusof, F., & Marzukhi, M.A. (2014). Social capital and quality of life in urban neighborhoods high density housing. Procedia - *Social and Behavioral Sciences, 153*, 169–179. https://doi.org/https://doi.org/10.1016/j.sbspro.2014.10.051

Hasanah, A.N., & Yudhistira, M.H. (2018). Landscape view, height preferences and apartment prices: evidence from major urban areas in Indonesia. *International Journal of Housing Markets and Analysis, 11*(4), 701–715.

Henderson, J.V., & Ioannides, Y.M. (1983). A model of housing tenure choice. *American Economic Review, 73*(1), 98–113.

Hofman, E., Halman, J.I.M., & Ion, R.A. (2006). Variation in housing design: Identifying customer preferences. *Housing Studies, 21*(6), 929–943.

Hou, Y. (2010). Housing price bubbles in Beijing and Shanghai? *International Journal of Housing Markets and Analysis, 3*(1), 17–37.

Huang, H., & Humphreys, B.R. (2014). New sports facilities and residential housing markets. *Journal of Regional Science, 54*(4), 629–663.

Huang, Y. (2004). The road to homeownership: A longitudinal analysis of tenure transition in urban China (1949-94). *International Journal of Urban and Regional Research, 28*(4), 774–795. https://doi.org/10.1111/j.0309-1317.2004.00551.x

Huang, Y., & Clark, W.A.V. (2002). Housing tenure choice in transitional urban China: A multilevel analysis. *Urban Studies, 39*(1), 7–32. https://doi.org/10.1080/00420980220099041

Huffman, C., & Kahn, B.E. (1998). Variety for sale: Mass customization or mass confusion? *Journal of Retailing, 74*(4), 491–513.

Hui, E.C.M., & Liang, C. (2016). Spatial spillover effect of urban landscape views on property price. *Applied Geography, 72*, 26–35.

Hui, E.C.M., Zhong, J.W., & Yu, K.H. (2012). The impact of landscape views and storey levels on property prices. *Landscape and Urban Planning, 105*(1–2), 86–93.

Citation Information: Ma, K.V., Nguyen, P.V., Trieu, H.D.X., & Vo, N.T.T. (2021). Optimizing Apartment Choice Based on Fuzzy-AHP. *Journal of Management Information and Decision Sciences, 24*(S1), 1-15.

Jancz, A., & Trojanek, R. (2020). Housing preferences of seniors and pre-senior citizens in Poland. A case study. *Sustainability, 12*(11), 1–20. https://doi.org/10.3390/su12114599

Jayantha, W.M., & Man, W.S. (2013). Effect of green labeling on residential property price: A case study in Hong Kong. *Journal of Facilities Management, 11*(1), 31–51.

Jewkes, M.D., & Delgadillo, L.M. (2010). Weaknesses of housing affordability indices used by practitioners. *Financial Counseling and Planning, 21*(1), 43–52.

Jim, C.Y., & Chen, W.Y. (2007). Consumption preferences and environmental externalities: A hedonic analysis of the housing market in Guangzhou. *Geoforum, 38*(2), 414–431.

Jørgensen, C.J. (2016). The space of the family: emotions, economy and materiality in homeownership. *Housing, Theory and Society, 33*(1), 98–113.

Kahraman, C., Cebeci, U., & Ruan, D. (2004). Multi-attribute comparison of catering service companies using fuzzy AHP: The case of Turkey. *International Journal of Production Economics, 87(*2), 171–184. https://doi.org/10.1016/S0925-5273(03)00099-9

Kauko, T. (2006). Expressions of housing consumer preferences: Proposition for a research agenda. *Housing, Theory and Society, 23*(2), 92–108.

Khan, M., & Jayant, A. (2015). Multi-criteria supplier selection using Fuzzy-AHP Approach : A case study of manufacturing company. *International Journal of Research in Mechanical Engineering & Technology (IJRMET), 5*(1), 73–79.

Khorasani, S.T. (2018). Green supplier evaluation by using the integrated fuzzy AHP model and fuzzy copras. *Process Integration and Optimization for Sustainability, 2*(1), 17–25.

Lau, K.M., & Li, S.M. (2006). Commercial housing affordability in Beijing, 1992-2002. *Habitat International, 30*(3), 614–627. https://doi.org/10.1016/j.habitatint.2005.02.004

Le-Hoang, P.V. (2021). Behavior intention to purchase real estate: An empirical study in Ho Chi Minh City. *Independent Journal of Management & Production, 12*(1), 080–094. https://doi.org/10.14807/ijmp.v12i1.1262

Lee, J.M.M., & Ong, E.G. (2020). Consumers' choice factors for buying residential property in the Philippines: An empirical investigation. *International Journal of Research in Business and Social Science (2147-4478), 9*(4), 271–276.

Levy, D., Murphy, L., & Lee, C.K.C. (2008). Influences and emotions: Exploring family decision-making processes when buying a house. *Housing Studies, 23*(2), 271–289.

Lin, J.K., Lin, H.L., Wang, W.Y., Chang, C.H., & Lin, C.T. (2020). An evaluation model for property-purchasing plans based on a hybrid multi-criteria decision-making model. *Mathematics, 8*(6), 1–18. https://doi.org/10.3390/math8060860

Liu, Y., & Li, Z. (2018). Determinants of housing purchase decision: An empirical study of the high education cohort in urban China. *Journal of Asian Architecture and Building Engineering, 17*(2), 299–305. https://doi.org/10.3130/jaabe.17.299

Lloret, A. (2016). Modeling corporate sustainability strategy. *Journal of Business Research, 69*(2), 418–425.

Logan, J.R., & Bian, F. (1999). Family values and residence with married children in urban China. *Social Forces, 77*(4), 1253–1282. https://doi.org/10.1093/sf/77.4.1253

Lonappan, J. (2013). An evaluation of factors influencing customer‟ s home buying decision‟. *Indian Journal of Research, 2*(11), 158–160.

Mahendran, P., Moorthy, M.B.K., & Saravanan, S. (2014). A fuzzy AHP approach for selection of measuring instrument for engineering college selection. *Applied Mathematical Sciences, 8*(44), 2149–2161. https://doi.org/10.12988/ams.2014.44232

Mariadas, P.A., Abdullah, H., & Abdullah, N. (2019). Factors Affecting Purchasing Decision of Houses in the Urban Residential Property Market in Klang Valley, Malaysia. *E-Bangi, 16*(4), 1–9.

Mayer, C.J., & Engelhardt, G.V. (1996). Gifts, down payments, and housing affordability. *Journal of Housing Research, 7*(1), 59–77.

Murphy, P.E., & Staples, W.A. (1979). A modernized family life cycle. *Journal of Consumer Research, 6*(1), 12–22. https://doi.org/10.1086/208744

Næss, P. (2013). Residential location, transport rationales and daily-life travel behaviour: The case of Hangzhou Metropolitan Area, China. *Progress in Planning, 79*, 1–50.

Natasha, I., & Hassan, Z. (2015). Factors that influencing property investment decisions among Employees in Felcra Bhd. *International Journal of Accounting & Business Management, 3*(2), 1–19.

Obeidat, M.S., Qasim, T., & Khanfar, A. (2018). Implementing the AHP multi-criteria decision approach in buying an apartment in Jordan. *Journal of Property Research, 35*(1), 53–71.

Opoku, R., & Muhmin, A. G. (2010). Housing preferences and attribute importance among low-income consumers in Saudi Arabia. *Habitat International, 34*(2), 219–227.

Ozaki, R. (2003). Customer-focused approaches to innovation in house building. *Construction Management and Economics, 21*(6), 557–564.

Popoola, N.I., Jinadu, M.A., Liman, H.S., & Abd'Razack, N.T.A. (2015). Effect of environmental quality on property rental values in Peri-Urban neighbourhoods of Minna, Nigeria. *ATBU Journal of Environmental Technology, 8*(2), 42–51.

Citation Information: Ma, K.V., Nguyen, P.V., Trieu, H.D.X., & Vo, N.T.T. (2021). Optimizing Apartment Choice Based on Fuzzy-AHP. *Journal of Management Information and Decision Sciences, 24*(S1), 1-15.

Rachmawati, D., Shukri, S., Azam, S., & Khatibi, A. (2019). Factors influencing customers' purchase decision of residential property in Selangor, Malaysia. *Management Science Letters, 9*(9), 1341–1348.

Razak, I., Ibrahim, R., Abdullah, N., Osman, I., & Alias, Z. (2013). Purchasing intention towards real estate development in Setia Alam, Shah Alam: Evidence from Malaysia. *International Journal of Business, Humanities and Technology, 3*(6), 66–75.

Reed, R., & Mills, A. (2007). Identifying the drivers behind housing preferences of first-time owners. *Property Management*.

Rosen, G., & Walks, A. (2013). Rising cities: Condominium development and the private transformation of the metropolis. *Geoforum, 49*, 160–172.

Samad, T., Hoang, H.T., Brhane, M., Mcvitty, J.E., Nguyen, H.M., Harrison, D.H., … & Huynh, D. (2015). Vietnam-affordable housing: A way forward. The world bank.

San Ong, T. (2013). Factors affecting the price of housing in Malaysia. *Journal of Emerging Issues in Economics, Finance and Banking, 1*, 414–429.

Saracoglu, B.O. (2013). Selecting industrial investment locations in master plans of countries. *European Journal of Industrial Engineering, 7*(4), 416–441.

Schoenwitz, M., Potter, A., Gosling, J., & Naim, M. (2017). Product, process and customer preference alignment in prefabricated house building. *International Journal of Production Economics, 183*, 79–90.

Sengul, H., Yasemin, O., & Eda, P. (2010). The assessment of the housing in the theory of Maslow's hierarchy of needs. *European Journal of Social Sciences, 16*(2), 214–219.

Seo, D., Chung, Y.S., & Kwon, Y. (2018). Price determinants of affordable apartments in vietnam: Toward the public–private partnerships for sustainable housing development. *Sustainability, 10*(1), 1–17. https://doi.org/10.3390/su10010197

Shaidi, N., & Lucian, C. (2016). Condominiums, gated communities and housing estates: An Investigation into the factors influencing house buying decision: A case of Dar Es salaam. *The International Journal of Social Sciences and Humanities Invention-Valley International Journals, 3*(10), 2804–2818.

Taylan, O., Kaya, D., & Demirbas, A. (2016). An integrated multi attribute decision model for energy efficiency processes in petrochemical industry applying fuzzy set theory. *Energy Conversion and Management, 117*(June), 501–512, https://doi.org/10.1016/j.enconman.2016.03.048

Tetiana, H., Chernysh, O., Levchenko, A., & Semenenko, O., & Mykhailichenko, H. (2019). Strategic solutions for the implementation of innovation projects. *Academy of Strategic Management Journal, 18*(1), 1–6.

Tu, Y., & Goldfinch, J. (1996). A two-stage housing choice forecasting model. *Urban Studies, 33*(3), 517–537.

Turskis, Z., & Zavadskas, E.K. (2010). A new fuzzy additive ratio assessment method (ARAS-F). Case study: The analysis of fuzzy multiple criteria in order to select the logistic centers location. *Transport, 25*(4), 423–432. https://doi.org/10.3846/transport.2010.52

Wang, C. (2013). Family house-purchase decision model based on analytic hierarchy process. *Applied Mechanics and Materials*, 423–426, 2973–2976. https://doi.org/10.4028/www.scientific.net/amm.423-426.2973

Wang, D., & Li, S. (2006). Socio-economic differentials and stated housing preferences in Guangzhou, China. *Habitat International, 30*(2), 305–326.

Xiao, Q., & Liu, Y. (2010). The residential market of Hong Kong: Rational or irrational? *Applied Economics, 42*(7), 923–933. https://doi.org/10.1080/00036840701720960

Yam, L.H.S., & McGreal, W.S. (2010). House-buyers' expectations with relation to corporate social responsibility for Malaysian housing. *International Journal of Housing Markets and Analysis, 3*(2), 132–145.

Yates, J.F., & de Oliveira, S. (2016). Culture and decision making. *Organizational Behavior and Human Decision Processes, 136*(September), 106–118. https://doi.org/10.1016/j.obhdp.2016.05.003

Yi, D., Huang, Y., & Fan, G.Z. (2016). Social capital and housing affordability: Evidence from China. *Emerging Markets Finance and Trade, 52*(8), 1728–1743. https://doi.org/10.1080/1540496X.2016.1181856

Zainon, N., Mohd-Rahim, F.A., Sulaiman, S., Abd-Karim, S.B., & Hamzah, A. (2017). Factors affecting the demand of affordable housing among the middle-income groups in Klang Valley Malaysia. *Journal of Design and Built Environment, 17*, 1–10.

Jonsson, Z.A. (2014). Parameters contributing to occupants' satisfaction. Facilities, 32(7/8), 411–437. https://doi.org/10.1108/F-03-2013-0021

Zhang, J. (2020). Environmental problems of human settlements and countermeasures based on ecological engineering. *In Study of Ecological Engineering of Human Settlements*, 1–39, Springer.

Zhang, L., Chen, L., Wu, Z., Zhang, S., & Song, H. (2018). Investigating young consumers' purchasing intention of green housing in China. *Sustainability, 10*(4), 1–15. https://doi.org/10.3390/su10041044

Źróbek, S., Trojanek, M., Źróbek-Sokolnik, A., & Trojanek, R. (2015). The influence of environmental factors on property buyers' choice of residential location in Poland. *Journal of International Studies, 7*(3), 163–173.

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