

Determination of Residential Type in Subdivision Projects by the Decision Tree Analysis

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Abstract: At present, to determine the residential type in a housing development project requires the experience and expertise of the project developers. This research aims to apply the Decision Tree Analysis to help analyze the residential type that will make the subdivision project achieve a good sales rate. The research process was conducted by collecting data from 179 residential subdivision projects from the market reports of real estate companies in Thailand, and then selected those projects with higher average monthly sales rates than those of all projects. A total of 59 projects were selected, comprising 31 townhouse, 22 detached house and 6 semi-detached house projects. Data for each project were collected. Then, these data sets and factors were analyzed using the Decision Tree Analysis. The results showed that the factors used in determining the residential type were the distance from the bus stations, land appraisal value and distance from parks. The model has an accuracy of 81.82% and is useful for those involved in the real estate development industry because it logically shows the decision-making process. It also demonstrates the potential for applying machine learning technique, as a technological innovation, to create models that aid real estate development decisions related to the customer's behavior.

Keywords: residential type, residential subdivision project, decision tree analysis, machine learning.

用決策樹分析確定細分項目中的住宅類型

摘要：目前，在房屋開發項目中確定住宅類型需要項目開發商的經驗和專業知識。本研究旨在應用決策樹分析來幫助分析使細分項目取得良好銷售率的住宅類型。研究過程是通過從泰國房地產公司的市場報告中收集179個住宅細分項目的數據進行的，然後選擇那些平均月銷售率高於所有項目的項目。共有59個項目入選，包括31個聯排別墅、22個獨立式住宅和6個半獨立式住宅項目。收集了每個項目的數據。然後，使用決策樹分析對這些數據集和因素進行分析。結果表明，決定住宅類型的因素是距公交車站的距離、土地評估價值和距公園的距離。該模型的準確率為81.82%，對房地產開發行業的相關人員很有用，因為它邏輯地顯示了決策過程。它還展示了應用機器學習技術作為技術創新的潛力，以創建有助於與客戶行為相關的房地產開發決策的模型。

关键词：住宅類型、住宅細分項目、決策樹分析、機器學習。

1. Introduction

At present, the development of housing projects in Thailand has begun to grow at an increasing rate, as the situation of the coronavirus outbreak tends to ease [1]. To develop a residential subdivision project, real estate developers need to be aware of the criteria for choosing

the right residential type to build with accuracy, so that the project achieves sales targets [2].

However, the process of selecting the residential type to develop on the entrepreneur's land today relies mainly on knowledge from both the experiences and skills of experts [3], [4]. Therefore, there is a limitation

of not having enough of the specialists due to the time required to accumulate experiences. And there is also a risk of easily making mistakes because the factors involved in the success of project development are greatly diverse. In particular, the physical properties of each land plot are different and unique. The people in the academic community are trying to fix the problem by creating a body of knowledge and various decision-supporting models to be used as a tool to support the decision-making in the development of residential subdivision projects. For example, [5] presented the determination of the residential type to correlate with the location of the residence and the population characteristics in each area. Another example is [6], showing that the quality and development of housing styles differ in different location contexts and can affect the development of cities and the success of a residential subdivision project.

However, when the researchers reviewed the relevant literature, it was found that the model used to determine the type of residence in the housing development project has not been applied to suit the physical factors of the project, which consists of the location and other features of the project. As a result, the researchers are interested in studying the application of Decision Tree Analysis, which is one of the machine learning technique to create a model for determining the residential type to generating good sales rates from the data that can be gathered from the sources in the possession of the entrepreneurs at the time of the project initiation. This is because the Decision Tree Analysis is a technique used to find the best alternatives by creating models based on clustering the training data set, to forecast the clusters of other data sets [7]. The developed model will be able to help real estate developers decide on the type of projects to build, meet the different needs of the buyers of housing, build a body of knowledge and tools used for feasibility analysis, as well and to create further competitiveness and success for the businesses.

This article consists of six sections, excluding acknowledgment and references. The authors illustrate the limitation in finding a specialist in selecting residential type in a subdivision project and how machine learning can help entrepreneurs in coping with this issue in the first section. Then, the necessary body of knowledge, such as the factors affecting the selection of housing types in the residential subdivision project during the project initiation period and Decision Tree Analysis technique, were reviewed in the second section. After that, the research methodology, the research results, such as the description of the project data and the input factors and the acquired decision tree were discussed in the third to the fifth sections, respectively. Finally, the authors summarized the important criteria in selecting the residential types and gave the suggestions to real estate entrepreneurs and academia according to the research results in the sixth

section.

2. Research Methodology

2.1. Factors of the Residential Type Determining

Determining the residential type is an important step in the development of a residential subdivision project because it is the fundamental step that defines the purpose of the work process in other operations. Defining the housing types of the project will help the entrepreneurs apply it as a policy to develop projects to be more responsive to the residents [8].

The quality factors used in determining the residential type of project must be able to indicate the long-term potential of the housing in the project, to create competitiveness and to represent the survival of the organization that is both profitable to entrepreneurs and beneficial to residents [9]. The residential type that is suitable for residents provides confidence in the purchase and acts as a guarantee of the quality of the houses [10]. This is consistent with [11], which found that the type of housing is the most important factor in home buying and the satisfaction of the residents. From the literature reviews, it was found that the factors in determining the style of housing within the project consisted of the following factors.

2.1.1. Project Factors

From the study of the project factors affecting the determination of residential type, it was found that the most important factors were (1) entrepreneurs and (2) land appraisal value. According to [12], the reputation and credibility of the entrepreneur is the most important factor for every type of home purchase since it depends on the trust and experience of the buyer to guarantee the quality because a house is a high-value asset. This agrees with [13], who mentioned that the proper determination of the project style leads to the closing of the sales. The influence of brands and entrepreneurs affects residents' choice of home purchases. Simultaneously, the real estate and land appraisal prices are one of the key influencing factors in the land plot selection process of the entrepreneurs because they have economic and legal effects on the determination of the residential type and the selection, as well as the purchase of people in the project area [14]. Similarly, [15] stated that the land appraisal price is a measure of the value of the area. It can indicate the profitability of the entrepreneurs, the environment, the economy and the society in that area. It is also an important factor in promoting the development of housing projects for the target group as planned by entrepreneurs.

Additionally, the literature review also suggested that land appraisal price and the entrepreneur itself are the factors related to determining house prices in future projects [2], [16]. Therefore, these factors are important in determining the type of housing because they can

measure the quality of the space within the project, affecting the purchase decisions of residents.

2.1.2. Location Factors

From the literature review, it was found that location is the most important factor that affects housing prices and residents' demand and is often used as the first factor in determining residential type [17], [18]. Therefore, in determining the type of housing within the project, the developers must focus primarily on the location factor. This is because it is a specific factor indicating the potential of the area that affects its future residents [19]. Several studies have revealed that the location selection criteria for determining the residential type within a project depend on the distance factor of the surrounding landmarks and legal requirements [20]. Additionally, the demographic characteristics of each area are different. So, entrepreneurs should pay attention to the location factor in determining the housing type [21].

Most studies have found that the impact of location on housing depends on the distance to workplaces or important locations, such as shopping malls, public transportation stations and utilities [22]. Here the researchers determined the characteristics of the location by using two groups of factors: (1) The project location group that consists of distances from important places and (2) The project zone, consisting of 10 zones in Bangkok and its vicinity, namely: (1) North Bangkok, (2) Inner Bangkok, (3) Eastern Bangkok, (4) Thonburi, (5) Central Business District (CBD), (6) Nakhon Pathom, (7) Nonthaburi, (8) Pathum Thani, (9) Samut Prakan and (10) Samut Sakhon [1].

From the literature researchers could collect 11 factors affecting the selection of housing types in the residential subdivision project during the project initiation period. A total of 11 factors can be divided into two groups – the project property factors and the project location factors, as shown in Table 1.

Table 1 Summary of factors

Factor Groups	Factors
1) Project Property	1. Entrepreneur 2. Appraisal Land Price
2) Project Location	1. Zoning of the Project Location 2. Distance from the Expressway 3. Distance from Express Train Station 4. Distance from Shopping Mall 5. Distance from Park 6. Distance from Bus Stop 7. Distance from Market 8. Distance from the hospital 9. Distance from Main Road 10. Distance from the Temple 11. Distance from Gas Station

2.1.3. Decision Tree Analysis

From the literature review, it was found that the Decision Tree Analysis model is a model that can efficiently categorize the data from the analysis of complex problems for both linear and non-linear types

[23], [24]. This is consistent with Britain [25], stating that the decision tree analysis is used for determining trends in long-term decision making. The Decision Tree model starts at the Root Node and then separates into branches with nodes as links in between. The forecast results are in the Terminal Node [24].

When reviewing the literature on the application of these machine learning techniques to the forecasting of residential subdivision projects in each model, Fan, Ong & Koh [26] stated that the Decision Tree model is a model that can accurately forecast house prices.

Similarly, Lee, Kim & Choi [27] found that the Decision Tree model can effectively correlate the factors that influence the home's characterization.

2.2. The Model Development Process

The model development process performed by the Decision Tree Analysis requires consideration of two groups of the key factors to be used as inputs to the forecast model. These groups of factors were acquired from reviews of literature and former research works. But because the format of real estate projects in each country is different [28], the factors of each group of factors affecting the residential type of the real estate project were selected from data obtained from the real estate market survey reports in Bangkok and its vicinity, published by the Agency for Real Estate Affair [29]-[32].

The data from 179 projects were collected from the market survey reports and the websites of residential subdivision projects and real estate developers to collect the projects' data, such as the average number of units sold per month (absorption rates) and nearby utilities and facilities, land appraisal prices, land sizes, land-use zones according to the law, and types of projects. The average absorption rate of all data was calculated and the 59 projects that have a higher monthly absorption rates than the average was selected.

The data from the selected 59 projects were then analyzed by the Decision Tree Analysis through RapidMiner, which is recommended by László & Ghous [33] for its high level of accuracy. The 59 data were divided into two groups: 47 (80%) data for model development and 12 (20%) data to provide data for validation of models based on Accuracy value. Finally, the researchers drew some conclusions and proposed suggestions to the stakeholders based on the research findings. Fig. 1 shows a flowchart of the research methodology.

3. Research Results

For the research results and the data selection results will be displayed, including details of factors that are used as variables in the process of machine learning techniques. The results obtained from the study can be presented in detail as follows:

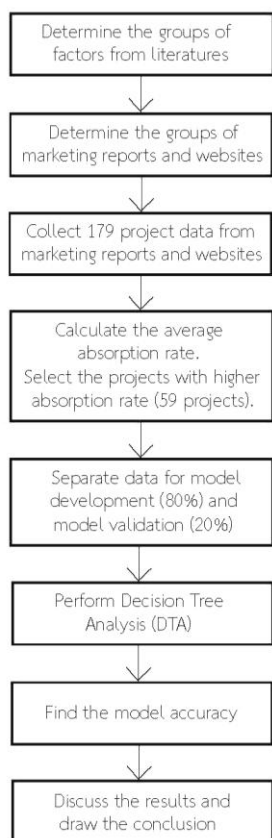


Fig. 1 Flowchart of research methodology

3.1. Proportion Before and After the Data Selection

The proportions of total project data collected by the researchers and selected project data of 179 and 59 projects, respectively, are shown in Table 2.

From Table 2, the amount of the data used to develop and examine the model for projects with above-average sales rates is approximately the same as the proportion of the total data collected.

Table 2 Data amount

House	All Data		Data Used to Develop and Examine the model	
	Amount	Percentage	Amount	Percentage
Detached	58	32.40	22	37.29
Semi-Detached	21	11.73	6	10.17
Townhouse	100	55.87	31	52.54
Total	179	100.00	59	100.00

3.2. Properties of the Projects with Above-Average Sales Rates

From Fig. 2, the majority of the projects were public companies, in accordance with the ratio of the projects developed by public companies in Thailand. Krungsri

Research [34] revealed that 60 – 70% of the new residential projects in Bangkok in 2019 were launched by public companies. This type of company has more budgets for marketing promotions, leading to the higher sales of projects [35].



Fig. 2 Project data, classified by company types

Additionally, the majority of the projects were located in Thonburi and Eastern Bangkok, the zones that were expanding because of the express train construction. Note that there is no project located in the Central Business District (CBD) and Nakhon Pathom.

Fig. 3 shows the numbers and ratios of the projects with above-average sales rates.

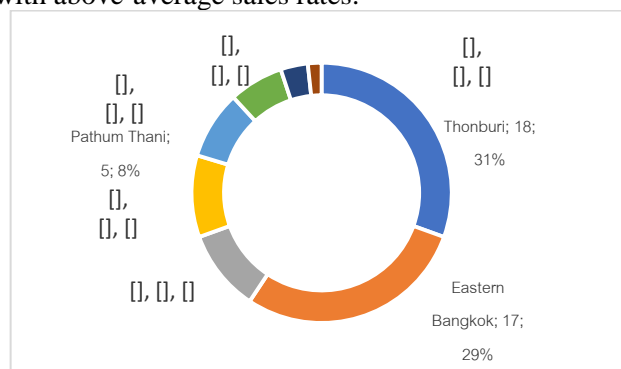


Fig. 3 Project data classified by location zones

Table 3 shows the means and standard deviations of 59 projects with above-average sales rates, showing the prices and locations of the land appropriate for developing a residential subdivision project.

3.3. The Model for Determining the Residential Type within a Residential Subdivision Project

From the analysis of 59 selected data, the researchers could create a decision-making model in the form of a decision tree model as shown in Fig. 4.

The factors of 59 above-average-sales-rate projects were analyzed and presented as shown in Fig. 2, Fig. 3, and Table 3, respectively.

Table 3 Means and standard deviations of data

Factors	Mean	Standard Deviation
1) Appraisal Land Price	\$703,916.41 / Acre (23,745.76 Baht/Sq.wa)	\$361,957.75 / Acre (12,210.22 Baht/Sq.wa)
2) Distance from the Gas Station	2.12 km.	1.53 km.
3) Distance from Hospital	2.58 km.	1.46 km.
4) Distance from Market	2.73 km.	2.09 km.
5) Distance from Main Road	3.00 km.	2.32 km.
6) Distance from Park	3.93 km.	4.33 km.
7) Distance from Temple	5.57 km.	3.71 km.

Continuation of Table 3

8) Distance from Shopping Mall	6.25 km.	4.64 km.
9) Distance from Bus Stop	7.33 km.	5.21 km.
10) Distance from Expressway	7.36 km.	4.14 km.
11) Distance from Express Train Station	10.07 km.	6.50 km.

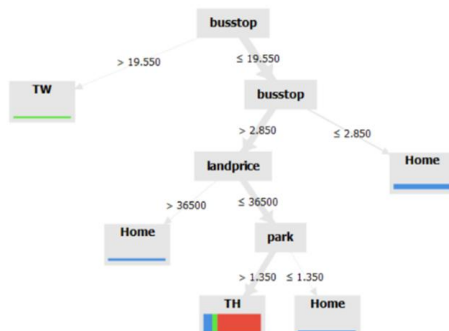


Fig. 4 Decision tree model

From the analysis done using the Decision Tree Analysis, there are three factors that can be used in determining an appropriate residential type in a residential subdivision project: bus stop factor, park factor and appraisal land price factor, with the weights of 53.70%, 24.10%, and 22.20%, respectively.

It was found that the distance to the bus station affects the project type. That is, if the distance is more than 19.55 kilometers from the bus station, the land

would be suitable for developing a semi-detached housing project. If the distance is not more than 2.85 km, it is suitable for developing a detached house project. If the land is between 2.85 – 19.55 kilometers from bus station, in the condition that the land price is appraised above \$1.082 million/acre (36,500 baht per square wah – Thai unit of land area measurement, calculated from the exchange rate of 34.101 baht/dollar of Bank of Thailand [36]), that area would also be suitable for developing a detached house project. Finally, if the land is located between 2.85 – 19.55 kilometers from the bus station and has an appraised land value of less than \$1.082 million/acre; it would be suitable to be developed into a detached house project, on the condition that it is less than 1.35 kilometers from the park. Otherwise, if the land is located farther than 1.35 kilometers from the park, it is then suitable for the development of a townhouse project, respectively. Table 4 shows the performance indicators of the acquired model.

Table 4 Performance indicators

House	True Detached House	True Semi-detached House	True Townhouse	Class Precision
Predicted Detached House	3	0	0	100.00%
Predicted Semi-detached House	0	1	1	50.00%
Predicted Townhouse	1	0	5	83.33%
Class Recall	75.00%	100.00%	83.33%	

The model has an accuracy value of $9/11 = 81.82\%$, higher than 72.73% of the Gradient Boosted Tree Model with higher explainability of the decision-making process [7], reflecting that the Decision Tree model has a high efficiency in forecasting. Additionally, the model has recall and precision values ranging from 50.00% to 100.00%, as shown in the table. However, note that the number of test datasets is quite small, especially the number of semi-detached house data, leading to the sensitive performance indicator values.

4. Discussion of Research Results

From the research results, there are two types of lands suitable for developing a detached house project. The first is land plot has high potential and convenience to travel, as it is located close to a bus station, which is usually along the main road. The price of this type of land suitable for detached housing projects is therefore also quite high. This agrees with Khan et al. [22] and Rymarzak & Siemińska, [20], who stated that the factor of distance to the landmarks in each area is important in determining the project housing type. Simultaneously, another type of detached housing project will develop on land with less potential

and lower price, but still also located near the areas that promote quality of life, such as parks. As for the land suitable for developing townhouse projects, it will be similar to that suitable for developing the second type of detached house projects, but may be located further away from areas that promote quality of life, due to the price limitation of land that can be used for development. This is consistent with the research by Li et al. [37], which suggested that the value and potential of a location depends on the distance to the city centers and green areas or parks. As for the land suitable for developing into a semi-detached housing project, the Decision Tree model obtained from the analysis did not show any conditions other than the distance from bus stations (main road), in consistency with the behavior of home buyers in this group, who tend to have private cars and consider the price of housing as an important factor.

5. Conclusion

From the model developed using the Decision Tree Analysis technique, it was found that the variables affecting project type determination from the decision tree plan were 1) bus station, 2) public park and 3) land appraisal price. The entrepreneurs can apply these data

according to the discussion of research results, which is a guideline for project development as follows.

1) Detached house project type: This type of project is suitable for: (1) a location with high potential and price, situated close to a bus station or a spot to get to important places with ease; (2) locations with moderate potential but also close to places that enhance the quality of life, such as parks or green space.

2) Townhouse project type: This type of project is suitable for a location with potential and medium price. It may be far from some important places but still is necessarily accessible to transport to various locations via public transportation without much difficulty.

3) Semi-detached house project type: This type of project is suitable for a location with medium potential and price. It can be a long distance from a bus station as semi-detached home buyers tend to travel by private vehicle.

The findings can demonstrate the ability to use the machine learning techniques, as a technological innovation, to analyze real estate problems concerning the customer's behavior. The accuracy of the acquired model supports that it can be used as an effective decision-making tool. Although Decision Tree Analysis is good at explainability and illustrating the researchers how the decision was made, interested researchers can apply other types of the machine learning techniques that may provide a higher accuracy model such as Gradient Boosted Tree, Support Vector Machines, Random Forest, or the combination of several machine learning techniques, Ensemble Classification.

The study limitations were in the amount of data obtained in this study because data on absorption rate (average number of units sold per month) the project staff usually considers as competitive advantage data, which makes it difficult to obtain data. However, from the potential of the Decision Tree Analysis technique, the limited data acquired from the secondary sources of data such as market survey reports, project websites, and developer's websites can be used to develop a model with high accuracy and is useful for decision supporting purpose of real estate developers. Finally, interested researchers may try collecting and use the primary data as the inputs of the model, making the research leans to the scientific aspect more than this research that uses the data from reports and websites.

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