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Model for Relative Evaluation of Quality of Public Utilities System for Housing Development Index in Thailand (PUSH Index)

By

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Abstract

The Land Development Act, B.E. 2543, is the primary law that governs Public Utilities System for Housing Development (PUSHD) in Thailand. According to the Land Development Act and Central Land Development Board, PUSHD can be categorized into 19 lists. However, as of now, Thailand lacks many criteria for indicators or indexes (Indicator or Index) that can define the quality level of PUSHD. The study is aimed to develop a model to determine the PUSH Index, which is made up of four factors: construction pricing factor, law, performance, and model for relative evaluation of the quality of the public utilities system for the housing development index (PUSH Index). As for the study results of the model for the evaluation quality of public utilities system for housing development index (PUSH Index), the researcher developed the criteria for finding factors of the model, and there were four indicators affecting the housing development public utility index: cost indicator (I_C), law indicator (I_L), performance indicator (I_P), and satisfaction indicator (I_S). It was also found that the PUSH Index of the Perfect Place housing development projects, Pandara 2 and Panacea Ville, was at a moderate level (C), while the PUSH index of the Arada Ville project was at a good level (B).

Author Keywords: Public utilities systems, Infrastructure, housing development**,** Land Development, Legal provisions.

Introduction

In Thailand, the government enacted the primary laws related to constructing a housing society. Land Development Act, B.E. 2543(2000)[1] (LDA), Land Development Act, (Issue 2) B.E. 2558(2015)[2], and Building Control Act B.E. 2522(1979)[3] (BCA) and announcement of the Central LandDevelopment Board B.E. 2544(2001)[4] states the leading law related to the housing project. However, the LDA has been in use for more than 22 years; there are still many problems in implementing the law today, and one of those issues is about "Public Utilities."

LDA is stipulated in clause 43 that "Public utilities provided by the land allocator for land allocation according to the plans and projects permitted, such as roads, gardens, playgrounds. It is defined in clause three as "Public utilities means facilities that land allocator provided for the purchaser allocated land to use together according to the contract or project plan that has been authorized. Therefore, what is considered a utility may vary from project to project. Depending on the project specified in the project plan that is permitted, what is the utility of that project, causing the overlap of lists and standard levels of public utilities of various projects.

Public Utilities System for Housing Development (PUSHD) together 19 lists (specifications) considered for this research. There are 12 essential utilities defined in the LDA, and was assigned an additional seven lists by the EIT experts for safety and ease of use. An index used as a measure of PUSHD quality that the researcher has developed is called PUSH Index.

Research Objectives

The objective of this research is to create a model for the relative evaluation of the quality of public utility systems for the housing development index (PUSH Index)**.**

The EIT expert

The experts appointed by the Engineering Institute of Thailand (EIT) were appointed as the Subcommittee of Public Utilities Standard for housing development B.E. 2555–2564 (2012–2021). They approved 19 specifications and set the PUSHD standards for Thailand.

Public utilities system for housing development in Thailand (PUSHD).

PUSHD (Damrinan and Thanyakit, (2023)[5] divided the PUSHD list into 19 specifications, with the approval of EIT experts, as shown in **Table 1**, which will be used as a variable to determine the PUSH Index of this research.

Table 1. *Specifications of PUSHD*

Item	List of Specifications of PUSHD
1	Road systems and footpath, bridge and box culvert.
2	Drainage systems and flood protection systems.
3	Electrical systems.
4	Water supply systems.
5	Telephone systems.
6	Wastewater treatment systems.
7	Solid waste management systems.
8	Fences around projects.
9	Parks, children's playgrounds, sports fields and activity area or multipurpose area.
10	Ventilation systems.
11	Public lighting systems.
12	Security systems.
13	Fire prevention systems.
14	Escape systems.
15	lightning protection systems.
16	Communication, television, and satellite systems.
17	Land excavation, land fill and retaining walls.
18	Parking, facilities for the disabled.
19	Other public utilities.

Analytic Hierarchy Process (AHP)

AHP (Thomas L. Saaty, 1980)[6] stated that decision-making could analyze appropriate alternatives in complex problems. This technique can be applied to both quantitative and qualitative criteria. It begins with comparing the "Emphasis" used in decision-making to find the "Weight" of each criterion first. Afterward, all the available "Alternatives" are evaluated to prioritize each alternative.

Each factor's importance was rated by pair comparison (PairWise Comparison Method). This method is a paired comparison to create a table of proportions using a predetermined scale from 1-9. It is related to the satisfaction between the two criteria of the assessor, as shown in **Table 2.**

Table 2. *The pair-wise comparisons scale.*

Numerical Value	Preference Level
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extremely importance

Case Studies of PUSH Index**.**
Case studies of evaluating PUSH index are from 4 projects of PUSHD based on LDA Specifications of PUSHD to find PUSH Index

The PUSH Index can be found from the variable total of 19 specifications of PUSHD which are shown in Table 1.

Indicators Factor

The factors affecting the PUSH Index consist of four indicators: cost, law, performance, and satisfaction, as shown in **Figure 1.**

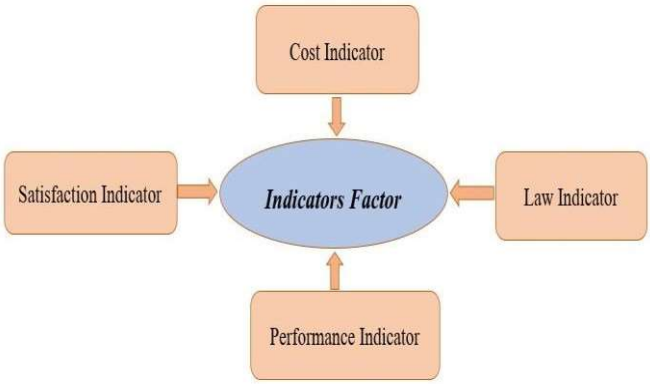


Figure 1. *Indicators Factor*

Cost Indicator (I_C) of PUSHD

The Cost indicator is the construction cost of the 19 PUSHD specifications. The respondents to the assessment form could be an operator or project owner, a project manager, or a project engineer.

Law Indicator (I_L) of PUSHD

The Law indicator is an evaluation form consisting of two requirements: (1) public utilities as enacted by law. (2) Public utilities recommended by EIT experts and other requirements by assessors, including engineers, architects, and PUSHD assessment specialists.

Performance Indicator (I_P) of PUSHD

The indicator in this field is an assessment to score (Score) that indicates the performance or quality of the use of 19 specifications of PUSHD, which is consistent with the standard criteria of legal factors, such as engineers, architects, or appraisal experts.

The researchers divided the quality of PUSHD usage into five levels according to the Likert Scale (Likert,1987) which is defined in **Table 3.**

Table 3. *The interpretation criteria of score.*

Score	Range	Level of interpretation criteria
5	4.50 - 5.00	Very good
4	3.50 - 4.49	Good
3	2.50 - 3.49	moderate
2	1.50 - 2.49	Low
1	1.00 - 1.49	Very low

Satisfaction Indicator (I_S) of PUSHD

The satisfaction indicators were respondents from homeowners or residents of land allocation projects during the assessment period. The satisfaction level is divided into 5 levels according to Likert Scale which are very good, good, moderate, low and very low as shown in Table 3.

Weighting of Indicators.

The assessment form determined the weight of the factors in all four aspects. The "Emphasis" of the factors on each side is the pairwise comparison and brings it to the "weight" method Multiple Criteria Decision Making; MCDM by Analytic Hierarchy Process; AHP (Saaty, 1980) is a popular method used in social sciences, industry, and engineering (Vaidya & Kumar, 2006) The respondents of the assessment are the EIT expert.

Index modeling

PUSH Index $= \sum_{x=1}^{m} W_x I_x$ ……. (1)

Then ; PUSH Index $= W_c I_c + W_L I_L + W_P I_P + W_S I_S$ ….(2)

When $0 < W_x < 1$ and $W_c + W_L + W_p + W_s = 1$

Where; **PUSH index** is Public utilities system for housing development index.

W_x = Weight factor of PUSHD.

W_c = Cost weight factor of PUSHD.

W_L = Law weight factor of PUSHD.

W_P = Performance weight factor of PUSHD.

W_s = Satisfaction weight factor of PUSHD.

I_x = All kinds of indicators of PUSHD.

I_c = Cost indicator of PUSHD.

I_L = Law indicator of PUSHD.

I_p = Performance indicator of PUSHD.

I_s = Satisfaction indicator of PUSHD.

x = List of m factors that affect PUSHD.

j = Sequence of n specifications of PUSHD

m = Number of 4 different factors

n = 19 specifications of PUSHD

Determining of Weight Factors (W)

Finding Weight Factors consists of five steps, including examples of calculating the Weight Factors rated by The EIT expert as follows:

Geometric mean method analysis.

$$V_x = (\prod_{y=1}^{m} a_{xy})^{1/m} \quad \text{..... (3)}$$

Where V_x is geometric means of the factors, $a_{xy}$is numerical value in the matrix.

For example, a table matrix used in comparison criteria is a pair rated by the EIT expert as in **Table 4.**

Table 4. *Table matrix used to compare criteria in pairs (Pair wise comparison)*

Factors	Cost, C	Law, L	Performance, P	Satisfaction, S
Cost, C	1	1/9	1/3	1/4
Law, L	9	1	8	8
Performance, P	3	1/8	1	1/2
Satisfaction, S	4	1/8	2	1
Total	1	1/9	1/3	1/4

9	Extremely importance
7	Very strong importance
5	Strong importance
3	Moderate importance
1	Equal importance
1/3	Little Moderate importance
1/5	Little importance
1/7	Less importance
1/9	Least importance

2,4,6,8,1/2,1/4,1/6,1/8 The importance is between each level.

Analysis of the weight score of alternatives.

$$w_x = \frac{V_x}{\sum_{x=1}^{m} V_x} \quad \text{..... (4)}$$

and $\sum$

Consistency Analysis.

$$\lambda max = \sum_{x=1}^{m} [\ \sum_{y=1}^{m} a_{xy}\, W_y\ ] \quad \text{..... (5)}$$

As λmax is number of criteria used for comparison (m) if the matrix was100% consist with coherent reasons, λmax > number of criteria used for comparison (m) if the matrix was not consisting with coherent reasons.

Consistency Index (*CI*)

$$CI = \frac{(\lambda max - m)}{(m-1)} \quad \text{.... (6)}$$

Consistency Ratio (*CR*)

$$CR = \frac{CI}{RI} \quad \ldots.(7)$$

Where CR is acceptable value shall not exceed 0.08 for matrix sized 4 x 4 (Kabir & Hasin, 2011), RI (Random index) is the weight from experiment by random method (Kabir & Hasin, 2011) as shown in **Table 5.**

Table 5. *The table of random indices (RI)*

Random index(m)	**1**	**2**	**3**	**4**	**5**	**6**
RI	0.00	0.00	0.58	0.90	1.12	1.24

For the calculation example of weight factors and to check consistency ratio, it is as shown in Table 6.

Table 6. *Calculation of weight factors and consistency ratio.*

Factors	Cost, C	Law, L	Performance, P	Satisfaction, S	Total	Eigenvector (W)
Cost, C	0.059	0.082	0.029	0.026	0.196	0.049
Law, L	0.529	0.735	0.706	0.821	2.791	0.698
Performance, P	0.176	0.092	0.088	0.051	0.408	0.102
Satisfaction, S	0.235	0.092	0.176	0.103	0.606	0.152
Total	1.000	1.000	1.000	1.000	4.000	1.000

Consistency Analysis , λ_{max} = 4.2159

Consistency Index, CI =(L-m) / (m-1) = 0.0720

Consistency Rati, CR = CI / RI = 0.078 $\leq$ 0.08 => OK.

Results of the weight factors Analysis

The Average of weight factors (W) that has been rated by EIT experts is as shown in **Table 7** and **Figure 2.**

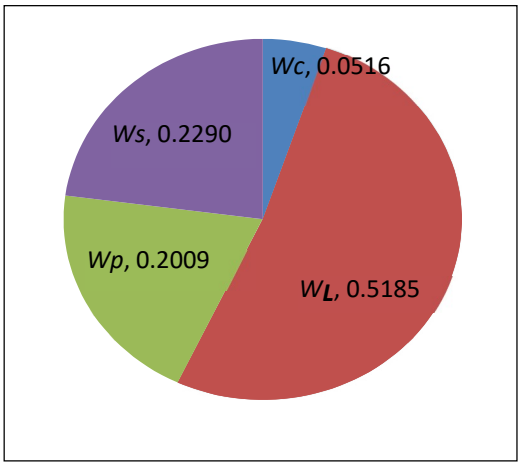


Figure 2. *The average of weight factors (W)*

Table 7. *The average of weight factors (W)*

Name of the EIT experts	Wc	WL	Wp	Ws	*CR*
Assoc.Prof. Dr.Jirawat Damrianant.	0.049	0.698	0.102	0.151	0.078
Assoc.Prof. Dr.Kraiwood Kiattikomol	0.057	0.411	0.337	0.195	0.078
Dr.Vithool Jearkjirm	0.066	0.347	0.186	0.401	0.080
Mr.Atip Bijanonda	0.044	0.554	0.310	0.092	0.080
Mr.Thongchai Chantratip	0.048	0.690	0.143	0.119	0.080
Mr.Supasit Tangtrongjit	0.048	0.530	0.130	0.292	0.080
Mr.Suporn Teachaiya	0.035	0.469	0.275	0.221	0.080
Mr. Veravit Sattayanon.	0.066	0.449	0.124	0.361	0.076
Total	0.415	4.152	1.569	1.864	-
Average(W)	**0.0516**	**0.5185**	**0.2009**	**0.2290**	-

Finding of 4 Indicators of PUSHD

Indicators of PUSHD, all 4 of these were developed by researchers. By the indicator maximum value, each item of PUSHD will not have a maximum value of more than five according to the Likert Scale. The procedure for determining the value of all four indicators is as follows:

Cost Indicator (I_c)

Calculation for Cost Indicator (I_c) has 7 steps as follows:

1) The construction cost of PUSHD information can be obtained from the project staff, and the cost of the Pandara 2 project is shown in **Table 8.**

Table 8. *Construction cost of Pandara 2.*

Item (n)	List of 19 specifications of PUSHD	Cost (Baht)
1	Road Systems and Footpath, Bridge and Box Culvert.	
1.1	Road Systems, Bridge and Box Culvert.	13,790,400
1.2	Footpath system.	4,369,068
1.3	Traffic Signs and Reflectors.	-
1.4	Speed hump and Speed bump.	40,000
1.5	The entrance and exit to the public road.	500,000
Total		***18,699,468***

2) Sub-specs Cost Weight.

$$Fc1_{jb} = \frac{c_{jb}}{\sum_{b=1}^{d} c_{jb}} \quad \ldots\ldots (8)$$

Where; $Fc1_{jb}$ = Sub-specs cost weight of b sequence under j sequence of PUSHD.
c_{jb} = Sub-specs cost of b sequence.
b = Sub- specs of j sequence have values of 1 to d.
d = Number of sub-specs of j sequence.

An example of how to calculate for it is $Fc1_{jb}$ of Pandara 2 project as shown in **Table 9.**

Table 9. *Calculation of $Fc1_{jb}$ for Pandara 2.*

Item (n)	List of 19 specifications of PUSHD	Amounts (Baht)	Fc1
1	Road Systems and Footpath, Bridge and Box Culvert.		
1.1	Road Systems, Bridge and Box Culvert.	13,790,400	0.737
1.2	Footpath system.	4,369,068	0.234
1.3	Traffic Signs and Reflectors.	-	-
1.4	Speed hump and Speed bump.	40,000	0.002
1.5	The entrance and exit to the public road.	500,000	0.027
Total		***18,699,468***	*1.000*

3) Construction cost point criteria *(Cp)*

Using the criteria unit price of materials used in PUSHD, each item divides the price quality level into five levels according to the Likert scale, as shown in **Table 10.**

Table 10. *Construction cost point criteria (Cp).*

Item (n)	List of 19 specifications of PUSHD	Specs	Unit price	Unit	Cp
1	Road Systems and Footpath, Bridge and Box Culvert.				
1.1	- Road	Reinforced concrete 0.15 m. thk.	965	Sq. m.	5
		Reinforced concrete 0.12 m. thk.	750	Sq. m.	3
		Asphalt pavement 0.05 m. thk.	350	Sq. m.	1
	- Bridge	Reinforced concrete	15,000	Sq. m.	5
	- Box culvert	Reinforced concrete (Size 1.80 x 1.80 m.)	20,000	m.	5
	- Culvert	Reinforced concrete with TIS.	3,000	m.	5
1.2	Footpath System	Reinforced concrete 0.10 m. thk.	495	Sq. m.	5
		Reinforced concrete 0.075 m. thk. or Asphalt pavement 0.05 m. thk.	350	Sq. m.	3
		Grass crab or other.	150	Sq. m.	1
1.3	Traffic signs and reflective devices.	Traffic signs and reflective devices.	6,000	Set	5
		Traffic signs.	2,800	Set	3

4) Sub-specs cost indicator of each specification of PUSHD.

$$sub\ i_{cj} = \sum_{b=1}^{d} \mathrm{Fc1}_{jb} \,.\, Cp_{jb} \quad \ldots\ldots (9)$$

Where; $sub\ i_{cj}$ = Sub-specs cost indicator of j sequence of PUSHD.

Cp_{jb} = Construction cost point criteria of b sequence under j sequence of PUSHD.

Calculation example $sub\ i_{cj}$ of Pandara 2 project as shown in **Table 11.**

Table 11. *Calculation for sub i_{cj} of Pandara 2.*

Item (n)	List of 19 specifications of PUSHD	Cost (Baht)	Fc1	Cp	*sub* i_{cj}
1	Road Systems and Footpath, Bridge and Box Culvert.				
1.1	Road Systems, Bridge and Box Culvert.	13,790,400	0.737	5	3.687
1.2	Footpath system.	4,369,068	0.234	3	0.701
1.3	Traffic Signs and Reflectors.	-	-	-	-
1.4	Speed hump and Speed bump.	40,000	0.002	3	0.006
1.5	The entrance and exit to the public road.	500,000	0.027	3	0.080
Total		***18,699,468***	*1.000*		*4.475*

5) Cost weight of each specification of PUSHD.

$$Fc2_j = \frac{c_j}{\sum_{j=1}^{n} c_j} \ldots\ldots\ldots (10)$$

Where; $Fc2_j$ = Cost weight of j sequence of PUSHD and c_j = Cost of j sequence of PUSHD.

6) Cost Indicator of each specification of PUSHD.

$$I_{cj} = sub\ i_{cj} \,.\, Fc2_j \ldots. (11)$$

Where; Ic_j = Cost Indicator of j sequence of PUSHD.

7) Cost Indicator of specifications of PUSHD.

$$I_c = \sum_{j=1}^{n} I_{cj} \quad \ldots\ldots\ldots\ldots (12)$$

Where; I_c = Cost Indicator of PUSHD.

Calculation example Cost Indicator of housing projects Pandara 2 that the total construction cost 50,653,264 THB. which is have W_c= 0.0516 (**From Table 7**) which will get I_c = 3.7125 as in **Table 12.**

Table 12. *Calculation of I_c for "Pandara 2.*

PUSH index $= W_c I_c + W_L I_L + W_P I_P + W_S I_S$		W_c	0.0516		
		Cost , C			
		Ic			
Item (n)	List of 19 specifications of PUSHD	Cost (Baht)	*Sub Ic ,*	*Fc2*	*Ic j = Ic jb. Fc2*
1	Road Systems and Footpath, Bridge and Box Culvert	18,699,468	4.475	0.3694	1.6530
2	Drainage System and Flood Protection System	8,671,092	3.000	0.1713	0.5139
3	Electrical Systems	1,000,000	5.000	0.0198	0.0988
4	Water Supply Systems	1,500,000	5.000	0.0296	0.1482
5	Telephone Systems	-	-	-	-
6	Wastewater Treatment Systems	2,175,000	5.000	0.0430	0.2148
7	Garbage Eradication Systems	66,000	3.000	0.0013	0.0039
8	Ventilation Systems	-	-	-	-
9	Public Lighting Systems	30,000	1.000	0.0006	0.0006
10	Security Systems	100,000	3.000	0.0020	0.0059
11	Fire Prevention Systems	4,000	3.000	0.0001	0.0002
12	Escape Systems	-	-	-	-
13	Protection Against Lightning Systems	-	-	-	-
14	Fences Around Projects	7,452,000	3.000	0.1472	0.4416
15	Excavation , Embankment and the retaining walls	9,720,000	3.000	0.1920	0.5760
16	Communication , Television and Satellite Systems	-	-	-	-
17	Parks, Children's Playgrounds , Sport Fields and Multipurpose area	705,704	3.142	0.0139	0.0438
18	Parking, road connection and Facilities for the Disabled	-	-	-	-
19	Other Public Facilities	500,000	1.200	0.0099	0.0119
Total		**50,623,264**		**1.0000**	**3.7125** *Ic*

Law Indicator (I_L)

Calculation of Law Indicator (I_L) have together 6 steps as follows:

1) Standard gauge criteria terms of law factors are defined in **Table 13.**

Table 13. *Standard criteria terms of law factors.*

Description	Law Gauge(g)
Law, requirement and related standards. (g1)	2
Recommended by the EIT expert and others. (g2)	1

2) Standard gauge of each specification of PUSHD.

$$Gst_j = [\ \sum_{b=1}^{d} g1_{j\,b}\ ] + [\ \sum_{b=1}^{d} g2_{j\,b}] \quad \ldots\ldots(13)$$

Where; Gst_j = Standard gauge of each specification of PUSHD.

3) Law weight of each specification of PUSHD.

$$FL3_j = \frac{Gst_j}{\sum_{j=1}^{n} Gst_j} \quad \ldots\ldots\ldots (14)$$

Where; $Fc3_j$ = Law weight of j sequence of PUSHD.

Calculation example of Gst_j and $FL3_j$ of 1st specification of PUSHD as in **Table 14.**

Table 14. *Calculation of Gst_j and $FL3_j$ of 1st specification of PUSHD.*

Item (n)	List of 19 specifications of PUSHD	Law gauge			FL3
		g1 =2	g2=1	Gst j =(g1jb+g2jb)	
1	Road Systems and Footpath, Bridge and Box Culvert				
1.1	Road Systems, Bridge and Box Culvert.	2	-	2	
1.2	Footpath system.	2	-	2	
1.3	Traffic Signs and Reflectors.	2	-	2	
1.4	Speed hump and Speed bump.		1	1	
1.5	The entrance and exit to the public road.	2	-	2	
Total		8	1	9	0.129
2	.....	.....	.....	....	
2.1	.....	....			
Grand total of 19 specifications of PUSHD		56	14	70	

4) Law gauge of each specification of PUSHD that the project of Pandara 2 take theactual process compared to standard gauge and adjust accordingly to the Likert scale.

$$G_j = \frac{5 \cdot g_j}{G_{stj}} \quad \ldots\ldots\ldots (15)$$

Where; G_j = Law gauge of each specification of PUSHD that the project of Pandara 2 take the actual process compared to Standard gauge.

g_j = Law gauge of each specification of PUSHD that the project of Pandara 2 take theactual process compared to.

5 = Constant to adjust the G_j has a maximum number of not more than 5 according tothe Likert scale.

5) Law Indicator of each specification of PUSHD.

$$I_{Lj} = G_j \,.\, FL3_j \quad \ldots..(16)$$

Where; I_{Lj} = Law Indicator of each specification of PUSHD.

6) Law Indicator of specifications of PUSHD.

$$I_L = \sum_{j=1}^{n} I_{Lj} \quad \ldots\ldots (17)$$

Where; I_L = Law Indicator of specifications of PUSHD.

Calculation example of Law Indicator for housing projects "Pandara 2" which has g_j =50 that compared to Gst = 70 and have W_L = 0.5185 (from **Table7**.) and I_L = 3.571 as in **Table15.**

Table 15. *Calculation of I_L for the housing project Pandara 2.*

PUSH index $= W_c I_c + W_L I_L + W_P I_P + W_S I_S$		W_L				0.5185
		Law , L				
Item (n)	List of 19 specifications of PUSHD	Calculation for I_L				
		Gst_j	$FL3$	g_j	$G_j = \frac{5\ .\ g_j}{G_{stj}}$	$I_{Lj} = G_j\ .\ FL3_j$
1	Road Systems and Footpath, Bridge and Box Culvert	9	0.129	7	3.89	0.500
2	Drainage System and Flood Protection System	5	0.071	4	4.00	0.286
3	Electrical Systems	2	0.029	2	5.00	0.143
4	Water Supply Systems	2	0.029	2	5.00	0.143
5	Telephone Systems	2	0.029	2	5.00	0.143
6	Wastewater Treatment Systems	6	0.086	4	3.33	0.286
7	Garbage Eradication Systems	3	0.043	3	5.00	0.214
8	Ventilation Systems	2	0.029	-	0.00	0.000
9	Public Lighting Systems	3	0.043	3	5.00	0.214
10	Security Systems	3	0.043	2	3.33	0.143
11	Fire Prevention Systems	3	0.043	3	5.00	0.214
12	Escape Systems	2	0.029	-	0.00	0.000
13	Protection Against Lightning Systems	1	0.014	-	0.00	0.000
14	Fences Around Projects	2	0.029	2	5.00	0.143
15	Excavation , Embankment and the retaining walls	4	0.057	4	5.00	0.286
16	Communication , Television and Satellite Systems	2	0.029	1	2.50	0.071
17	Parks, Children's Playgrounds , Sport Fields and Multipurpose area	4	0.057	4	5.00	0.286
18	Parking, road connection and Facilities for the Disabled	2	0.029	-	0.00	0.000
19	Other Public Facilities	13	0.186	7	2.69	0.500
Total		**70**	**1.000**	**50**		**3.571**
						I_L

Performance Indicator (I_P)

Calculation of Performance Indicator (I_P) has 6 steps as follows:

1) Terms of performance factor score of PUSHD by dividing the quality of performance into 5 levels according to the Likert Scale as in **Table 16.**

Table 16. *Terms of performance factor score.*

Performance level of PUSHD.	Usability percentage of PUSHD.	Performance Score (Sc)
Very good	91-100	5
Good	81-90	4
Moderate	71-80	3
Low	61-70	2
Very low	1-60	1
Not have	0	0

2) The average performance score from sub check lists.

$$sc_{jb(avg)} = \frac{Sum\ scores\ from\ sub\ check\ lists.}{u} \quad \ldots\ldots\ldots (18)$$

Where; $sc_{jb(avg)}$ = The average performance score from sub checklists.
u = Numbers of sub checklists.

3) Total performance score of each specification of PUSHD.

$$TSc_j = \sum_{b=1}^{d} G_{j\,b} \,.\, sc_{jb(avg)} \quad \ldots\ldots\ldots (19)$$

Where; TSc_j = Total performance score of each specification of PUSHD.

4) The average performance score of each specification of PUSHD that takes the actual process according to law factors.

$$Sc_{j(avg.)} = \frac{TSc_j}{g_j} \quad \ldots\ldots\ldots (20)$$

Where; $Sc_{j(avg.)}$ = The average performance score of each specification of PUSHD that takes the actual process according to law factors.

Example of calculation for TSc_j and $Sc_{j(avg.)}$ about the housing project "Pandara 2" as in **Table 17.**

Table 17. *Calculation of TSc_j and $Sc_{j(avg.)}$ for housing project "Pandara 2"*

Item (n)	List of 19 Specifications of PUSHD	Calculation of gauge from law factors.			Calculation of scores to performance indicators.								
		Gauge from law, requirement and related standards. (g_1)	Gauge from recommended by subcommittee EIT and other. (g_2)	Gj $=(g_{1b}+g_{2b})$	Check list no.1	Check list no.2	Check list no.3	Check list no.4	Performance Score Average. ($Sc_{jb(avg)}$)	$Sc_{jb(avg)}$ x g_1	$Sc_{jb(avg)}$ x g_2	TSc_j	$Sc_{j(avg.)}$
1	Road Systems and Footpath, Bridge and Box Culvert.												
1.1	Road Systems, Bridge and Box Culvert.	2	-	2	5	5	5	2	4.25	8.5	-	8.5	-
1.2	Footpath system.	2	-	2	2	5	-	-	3.50	7.0	-	7.0	-
1.3	Traffic Signs and Reflectors	-	-	-	0	-	-	-	-	-	-	-	-
1.4	Speed hump and Speed bump	-	1	1	5	0	-	-	2.50	-	2.5	2.5	-
1.5	The entrance and exit to the public road.	2	-	2	4	-	-	-	4.00	8.0	-	8.0	-
Total		6	1	7						23.5	2.5	26.0	3.714
2	.....												
2.1	.....												

5) Performance Indicator of each specification of PUSHD.

$$I_{Pj} = Sc_{j(avg.)} \,.\, FL3_j \quad \ldots\ldots\ldots (21)$$

Where; I_{Pj} = Performance Indicator of each specification of PUSHD.

6) Performance Indicator of specifications of PUSHD.

$$I_P = \sum_{j=1}^{n} I_{Pj} \quad \ldots\ldots\ldots (22)$$

Where; I_P = Performance Indicator of specification of PUSHD.

Example of calculation Performance Indicator about the housing project "Pandara 2" which has WP=0.2009 (from **Table 7.**) and get Ip = 2.728 as in **Table 18.**

Table 18. *Calculation for I_P of the "Pandara 2"*

PUSH index $= W_C I_C + W_L I_L + W_P I_P + W_S I_S$		W_L				W_P 0.2009		
		Law , L				Performance ,P		
Item (n)	List of 19 specifications of PUSHD	Calculation for I_L				Calculation for I_P		
		FL3	(g1)	(g2)	gj = (g1jb+g2jb)	TScjb	Scj(avg)	Ipj = Sc(avg) . FL3
1	Road Systems and Footpath, Bridge and Box Culvert	0.1286	6	1	7	26	3.71	0.478
2	Drainage System and Flood Protection System	0.0714	4	-	4	3	0.75	0.054
3	Electrical Systems	0.0286	2	-	2	10	5.00	0.143
4	Water Supply Systems	0.0286	2	-	2	10	5.00	0.143
5	Telephone Systems	0.0286	2	-	2	10	5.00	0.143
6	Wastewater Treatment Systems	0.0857	4	-	4	10	2.50	0.214
7	Garbage Eradication Systems	0.0429	2	1	3	13	4.33	0.186
8	Ventilation Systems	0.0286	-	-	-	-	0.00	0.000
9	Public Lighting Systems	0.0429	2	1	3	3	1.00	0.043
10	Security Systems	0.0429	-	2	2	7	3.50	0.150
11	Fire Prevention Systems	0.0429	2	1	3	7	2.33	0.100
12	Escape Systems	0.0286	-	-	-	-	0.00	0.000
13	Protection Against Lightning Systems	0.0143	-	-	-	-	0.00	0.000
14	Fences Around Projects	0.0286	2	-	2	8	4.00	0.114
15	Excavation , Embankment and the retaining walls	0.0571	4	-	4	12	3.00	0.171
16	Communication , Television and Satellite Systems	0.0286	-	1	1	4	4.00	0.114
17	Parks, Children's Playgrounds , Sport Fields and Multipurpose area	0.0571	4	-	4	12	3.00	0.171
18	Parking, road connection and Facilities for the Disabled	0.0286	-	-	-	-	0.00	0.000
19	Other Public Facilities	0.1857	6	1	7	19	2.71	0.504
Total		1.000	**42**	**8**	**50**			**2.728**
								Ip

Satisfaction Indicator (Is)

Calculation of satisfaction indicator (I_S) has 7 steps as follows:

1) Terms of satisfaction score of PUSHD rated by residents in housing development projects, dividing the quality of performance into five levels according to the Likert scale, as shown in **Table 19.**

Table 19. *Term of satisfaction score of PUSHD.*

Satisfaction level of residence to PUSHD	Satisfaction Score(S)
Very good	5
Good	4
Moderate	3
Low	2
Very low	1

2) Average satisfaction score for each specification of PUSHD rated by residents in housing development projects.

$$S_{j(avg)} = \frac{\sum_{t=1}^{q} S_{jt}}{q} \qquad \ldots\ldots (23)$$

Where; $S_{j(avg)}$= Average satisfaction Score on each specification of PUSHD rated by residents in housing development projects.

S_j = Satisfaction score on each specification of PUSHD.

t = Respondents arranged as respectively

q = Total number of respondents to the satisfaction survey.

3) Terms of important weight (Fs4) on each specification of PUSHD be rated by residentsin housing development are defined in **Table 20.**

Table 20. *Terms of important weight (Fs4) on specification.*

Important weight (Fs4)	Number of active days per week	Description
5	every day	Must have, necessary for living.
4	5-6	
3	3-4	
2	1-2	
1	less than 1 day	Have or no have, does not affect everyday life.

4) Important weight of each specification of PUSHD.

$$Fs4_{j(avg)} = \frac{\sum_{t=1}^{q} Fs4_{jt}}{5 \,.\, q} \quad \ldots\ldots (24)$$

Where; $Fs4_{j(avg)}$ = Important weight of each specification of PUSHD.

$Fs4_j$ = Important weight score of each specification of PUSHD rated by residents inhousing development projects.

5 = Constant to adjusting $Fs4_{j(avg)}$ to get it not more than 5 according to the Likertscale.

5) Satisfaction weight of each specification of PUSHD.

$$Fs5_j = \frac{Fs4_j}{\sum_{j=1}^{n} Fs4_j} \quad \ldots\ldots\ldots (25)$$

Where; $Fs5_j$ = Satisfaction weight of each specification of PUSHD.

6) Satisfaction Indicator of each specification of PUSHD.

$$I_{Sj} = S_{j(avg)} \,.\, Fs5_j \quad \ldots\ldots (26)$$

Where; I_{Sj} = Satisfaction Indicator of each of the specifications of PUSHD.

7) Satisfaction Indicator of specifications of PUSHD.

$$I_S = \sum_{j=1}^{n} I_{Sj} \quad \ldots\ldots\ldots (27)$$

Where; I_S = Satisfaction Indicator of specifications of PUSHD.

Example of calculation about Satisfaction Indicator for housing project "Pandara 2" which has W_S = 0.2290 (from **Table 7.**) that get I_S = 2.342 as in **Table 21.**

Table 21. *Calculation for I_S of the project "Pandara 2"*

PUSH index $= W_c I_c + W_L I_L + W_P I_P + W_S I_S$		W_S			0.2290
		Satisfaction , S			
Item (n)	List of 19 specifications of PUSHD	Calculation for I_S			
		$S_{j(avg)}$	$Fs4_{(avg)}$	$Fs5$	$I_{Sj} = S_{j(avg)} . Fs5$
1	Road Systems and Footpath, Bridge and Box Culvert	2.95	0.960	0.066	0.193
2	Drainage System and Flood Protection System	3.00	0.950	0.065	0.195
3	Electrical Systems	3.20	0.960	0.066	0.21
4	Water Supply Systems	2.55	0.970	0.066	0.169
5	Telephone Systems	2.70	0.560	0.038	0.103
6	Wastewater Treatment Systems	2.80	0.810	0.055	0.155
7	Garbage Eradication Systems	3.35	0.870	0.059	0.199
8	Ventilation Systems	0.00	0.560	0.038	-
9	Public Lighting Systems	3.35	0.860	0.059	0.197
10	Security Systems	2.55	0.890	0.061	0.155
11	Fire Prevention Systems	2.30	0.770	0.053	0.121
12	Escape Systems	0.00	0.530	0.036	-
13	Protection Against Lightning Systems	0.00	0.550	0.038	-
14	Fences Around Projects	2.25	0.820	0.056	0.126
15	Excavation , Embankment and the retaining walls	2.20	0.820	0.056	0.123
16	Communication , Television and Satellite Systems	2.85	0.700	0.048	0.136
17	Parks, Children's Playgrounds , Sport Fields and Multipurpose area	2.75	0.760	0.052	0.143
18	Parking, road connection and Facilities for the Disabled	0.00	0.630	0.043	-
19	Other Public Facilities	2.55	0.680	0.046	0.118
Total			14.650	1.000	2.342 Is

Public utilities system for housing development index (PUSH index)

We can find the PUSH index from Equation 2 by PUSH index = $W_c I_c + W_L I_L + W_P I_P + W_S I_S$, which PUSH index is the public utilities system for housing development index. Therefore, PUSH index of Pandara Project 2 = (0.0516 x 3.7125) + (0.5185 x 3.571) + (0.2009 x 2.728) +(0.2290 x 2.342) = **3.128**

PUSH index quality level.

From the case study of the four land allocation projects, in addition to finding the PUSH index of each project, we can also find the PUSH index of each project when Sc and S are equal, that is, 1, 2, 3, 4, and 5. Further, being able to find the average PUSH index for four projects (when Sc and S are equal), as shown in **Table 22** and **Figure 3.**

Table 22. *4 land development projects case studies.*

No.	Name of Village	PUSH index (When Sc and S are equal.)					PUSH index
		1	2	3	4	5	
1	Pandara 2	2.418	2.792	3.166	3.541	3.915	3.128
2	Arada Ville	2.466	2.844	3.222	3.601	3.979	3.377
3	Perfect Place	2.293	2.656	3.019	3.382	3.745	3.269
4	Pannacia Ville	2.216	2.581	2.946	3.311	3.676	3.204
PUSH index avg.		**2.348**	**2.718**	**3.088**	**3.459**	**3.829**	

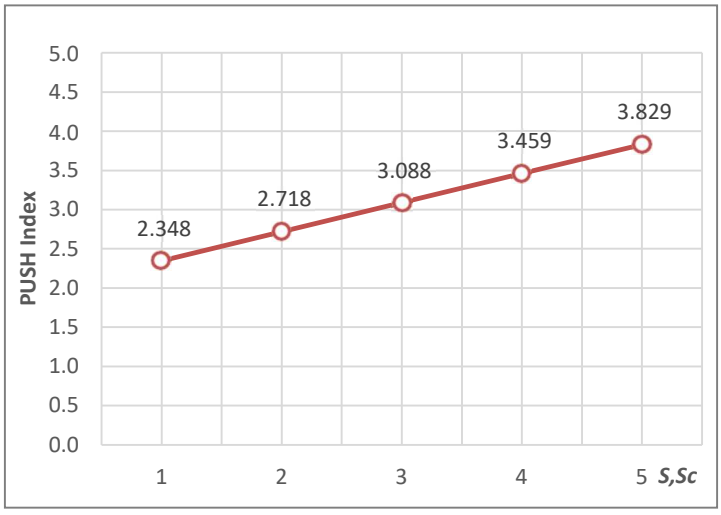


Figure 3. *Average PUSH index of 4 land developments projects case studies.*

PUSH index value at Sc and S other

Results From Linear Equations ($Y-Y_0 = M\ (X-X_0)$) The Slope (M) Can Be Found As 0.370125 And Can Also Find The Push Index At Sc And S Then Get Results As 1.5, 2.5, 3.5 And 4.5 From The Mentioned Linear Equation (Y = Mx + C) As In **Table 8.4** Which Have Push Index At Sc And S From 1 To 5 As In **Table 23.**

Table 23. *PUSHD Index value at Sc and S other.*

Sc and S	PUSH index
1.5	2.533
2.5	2.903
3.5	3.274
4.5	3.644

PUSH Index Quality Rating and Explanation of its Meaning.

From the average PUSH index of 4 case study projects as **Figure 4** and **Table 17,** the value of PUSH index can be plotted with Sc and S values ranging from 1 to 5 as in **Figure 4.**

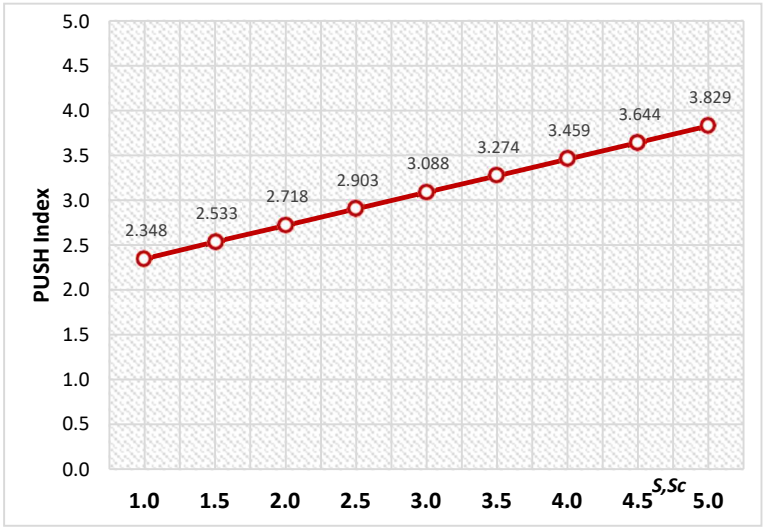


Figure 4. *PUSH index of land developments project case studies.*

Explaining the meaning of the PUSH index of the case study.

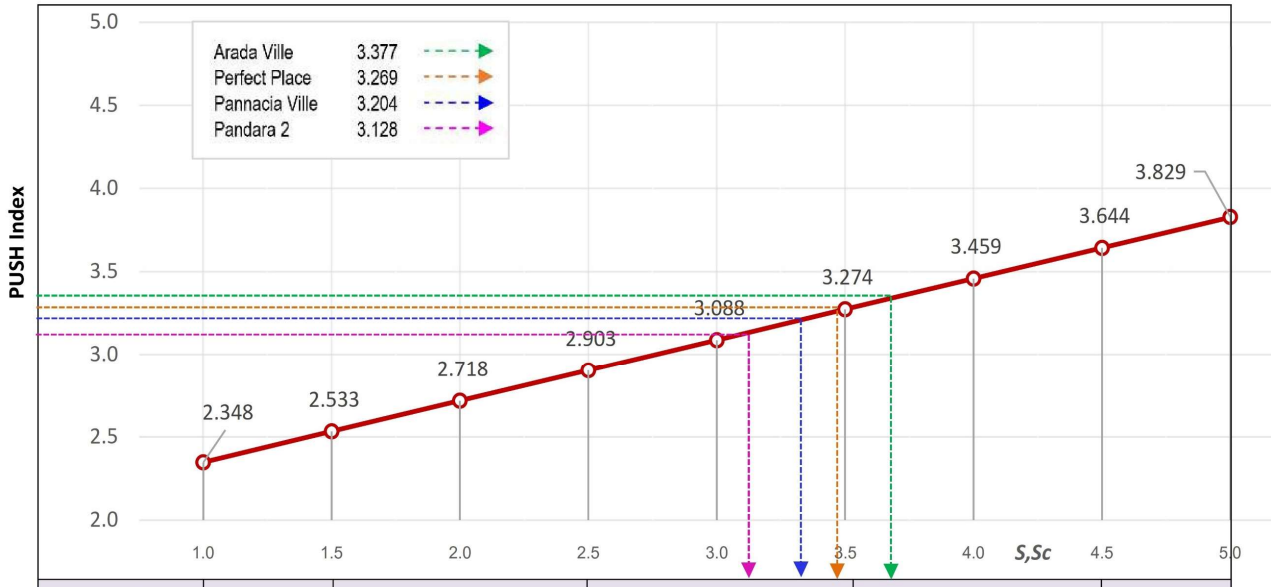
From this case study, it was found that Arada Ville had a PUSH index of 3.377. Therefore, it had a good PUSH Index (B). The overall performance of PUSHD is between 81-90 % and that PUSHD may need to improve, repair, or provide more is between 10-19 % and have a level of satisfaction purchaser of allocated land continue to use PUSHD is in a good level, which states that the project Perfect Place, Pannacia Ville, and Pandara 2 have PUSH indexes of 3.269, 3.204, and 3.128, respectively. Therefore, it has a PUSH index at a fair level (C), meaning that the overall performance of PUSHD is between 71-80 % which PUSHD may have to improve, repair, or arrange to get it up–20-29 %. The level of satisfaction of the allocated land purchasers continued to use PUSHD at a fair level, as shown in **Table 24.**

Work comparison photos of PUSHD

Work comparison photos of PUSHD regarding project case studies between the Arada Ville project and Pandara 2 are shown in **Figure 5.**

Figure 5. *work comparison photos of PUSHD about case study project.*

Table 24. *PUSHD index of 4 land developments project case studies.*



คะแนน *Sc, S*	1	2	3	4	5
Description of the **PUSH index**	- Overall PUSHD efficiency is less than 60 percent	-Overall PUSHD efficiency are 61-70 percent.	-Overall PUSHD efficiency are 71-80 percent.	-Overall PUSHD efficiency are 81-90 percent.	- Overall PUSHD efficiency are between 91-100 percent.
	-Overall PUSHD that may need to be improved, repaired, or increased more than 40 percent	-Overall PUSHD that may need to be improved, repaired, or increased 30-39 percent.	-Overall PUSHD that may need to be improved, repaired, or increased 20-29 percent.	-Overall PUSHD that may need to be improved, repaired, or increased 10-19 percent.	- Overall PUSHD that may need to be improved, repaired, or increased not more than 9 percent.
	-The level of satisfaction of buyers in using PUSHD is very low.	-The level of satisfaction of buyers in using PUSHD is low.	-The level of satisfaction of buyers in using PUSHD is fair.	-The level of satisfaction of buyers in using PUSHD is good.	-The level of satisfaction of buyers in using PUSHD is very good.
Overall quality level of PUSHD.	Very low **(F)**	Low **(D)**	Moderate **(C)**	**Good (B)**	Very good **(A)**

Thailand has recently witnessed an increase in housing development, resulting in a significant demand for effective public utility systems. Regulatory practices and management tools must be implemented to ensure safe and reliable supply of utilities.

The first step in establishing a successful public utility system for the housing development index in Thailand is to develop a set of regulatory practices. These practices should define the roles and responsibilities of all stakeholders, scope of services, and quality standards for the public utility system. In addition, it should address any potential issues or risks that could disrupt the system and create an environment of accountability.

Effective management tools must be implemented, in addition to regulatory practices. These tools should include monitoring and reporting systems to ensure that the public utility system meets the standards set out in regulations. They should also include predictive tools to anticipate and address potential issues before they occur as well as budgeting tools to ensure that the system is financially viable.

Ultimately, the effectiveness of the public utilities system for the housing development index in Thailand depends on the successful implementation of both regulatory practices and management tools. By establishing a robust regulatory framework and appropriatemanagement tools, the system can provide a safe and reliable supply of utilities to customers.

Ecovillages are designed to bring people together, creating communities that are sustainable and environmentally friendly. To achieve these goals, certain criteria must be met when designing and developing energy-efficient and eco-friendly houses.

The first criterion is to ensure that homes are built using materials that are renewable and sustainable, such as bamboo, stone, and wood. These materials should be sourced locally so that the village can reduce its carbon footprint. Additionally, homes should be built with energy-efficient appliances, fixtures, and insulation to reduce the amount of energy required to heat or cool them.

The second criterion is to design homes that are energy-efficient and make use of renewable energy sources. These include the use of solar panels, wind turbines, and geothermal energy. Additionally, homes should be well insulated and have efficient air conditioning and heating systems, including energy-efficient lighting. The third criterion is the creation of landscaping that is environmentally friendly. This includes the use of native plants, trees, and shrubs, which are drought-tolerant and require minimal maintenance. There should also be focus on creating green spaces and walkways that can be enjoyed.

Operational guidelines are essential for providing housing, care, and a better quality of life for people in a community. By designing and building houses that are suitable for all ages and providing affordable rental housing, residents can access basic amenities. This can lead to improved education and employment opportunities as well as improved access to health and social services.

Developing the environment is another important factor in operational guidelines. Not only does this help maintain the health of the local environment, it also has the potential to create new jobs and increase the number of businesses in the area. This can also attract new visitors to the community, bringing more money and resources to the area.

Creating operational guidelines that focus on building careers is beneficial for people in the community. This can help improve the quality of life of everyone, as people are able to gain more qualifications and experience. This, in turn, can lead to better job prospects and higher wages, allowing people to provide for their families better. Overall, operational guidelines provide a range of benefits for people in a community. By creating housing for all ages, offering cheap rental housing, and building careers.

Conclusions

Model for Relative Evaluation of Quality of Public Utilities System for Housing Development Index (PUSH Index) in Thailand has been developed from the researcher which is PUSH index = $W_c I_c + W_L I_L + W_P I_P + W_S I_S$. It has four indicators to assess the quality level of 19 specifications of PUSHD, consisting of cost indicator, law indicator, performance indicator, and satisfaction indicator by the average weight value *(W)*, and each factor was evaluated by EIT experts which are W_c, W_L, W_P and W_S Equal to 0.0516, 0.5185, 0.2009 and 0.2290 respectively.

The PUSH index of the 4 projects case studies could be divided into five levels of PUSH index values: very low (F, PUSH index less than 2.532), low (D, PUSH index = 2.533 – 2.902), fair (C, PUSH index = 2.903 – 3.273), good (B, PUSH index = 3.274 – 3.643), and very good (A, PUSH index more than 3.644).

References

[1] Royal Thai Government Gazette, The land development act, B.E.2543 (2000), 2000, Vol. 117 / 45 a.
[2] Royal Thai Government Gazette, The land development act (Issue 2), B.E.2558 (2015), 2015, Vol.117 / 45 a.
[3] Royal Thai Government Gazette, building control act B.E. 2522 (1979), 1997, Vol.96 / 80
[4] Royal Thai Government Gazette, the Announcement of the Central Land Development Commission in terms of land development policy for residential and commercial B.E.2544 (2001),2001, Vol. 118 / s 61d.
[5] Jirawat Damrianant and Boonsong Thanyakit, Public utilities system for housing development in Thailand (PUSHD), Baltic Journal of Law and Politics, 2023.
[6] Saaty Thomas, L ,1980, The Analytic Hierarchy Process, McGraw Hill Company, New York