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Site Selection of Housing Development Projects in Thailand and Malaysia Border Trade Areas by Modified Sieve Analysis

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ABSTRACT

This study sought to select the appropriate sites for the housing projects in Thailand and Malaysia Border Trade areas. The Modified Sieve Analysis was adopted as the instrument for searching and selecting sites. The Modified Sieve Analysis is the technique used to assess the urban expansion, which has been modified from the traditional sieve analysis by overlaying the map with its scores and calculate the total scores for selecting the suitable sites for the urban and housing development. The findings from this study help identify the suitable sites to build housing projects in the four cities – three sites for each.

Keywords: *modified sieve analysis, site selection, housing project, border city*

INTRODUCTION

Sieve analysis or traditional sieve analysis is the most well-known procedure used to determine the appropriate site for housing development projects. It is a non-complicated technique and can be used to assess both large areas such as region or sub-region, and small areas such as cities or communities. Sieve analysis was first adopted by American Public Health Association in 1945, 1946 and 1950 to assess the quality of housing, and was then called American Health Appraisal Technique. After that, it was modified and applied by in Keeble (Principle and Practice of Town and Country Planning, 1969) and McHarg (Design with Nature, 1969) to select the most optimum site for housing development.

Modified sieve mapping is a tool which chosen for site selection process for housing projects under the research on management for urban and housing development in Thai-Malaysia border cities. This process aims to select the suitable site for housing project in 4 study cities in which consists of Sadao town, Samnakkham town, Padang Besar town in Songkla province and Betong town in Yala province. Otherwise, modified sieve mapping is a technical tool which adapted from traditional sieve mapping. It is a tool which combines map overlay technique with a scoring system for site selection and city expansion analysis. The modified sieve mapping was applied form traditional sieve mapping to analyze complicated infinity sets of data. It uses Microsoft Excel program for accurate calculation. And it can be applied for any scale of town or city.

The result of this research helps to make the decision making for site selection of housing projects in 4 study cities and 3 sites for each to select the most suitable site and conduced to housing project design in the next step.

The modified sieve analysis of sites for housing development in Thailand and Malaysia Border Trade areas is part of the analysis of the need for land use in the future and of the assessment of the optimal site for the future housing development. The key principle of land use analysis is the use of map overlay and future population growth as the basis for forecasting the future land use, by comparing with the Land Use Standards issued Department of Public Works and Town & Country Planning. Normally, need for land use is classified according to types of land use, public utilities and facilities, and transportation. After the suitable number of future land use is acquired, the analysis of optimal site for urban and housing development will be carried out, as shown in Figure 1. The technique that is suitable for developing into the standard model is the modified sieve analysis, which includes three core procedures: map overlay; variable weights; and penalty scoring system.

METHODS

The study comprises three procedures: 1) study of basic data and housing needs in the studied areas, using secondary data, field survey, in-depth interviews and questionnaires; 2) assessment for optimal sites for housing development in the studied areas, using secondary data, modified sieve analysis, and field survey; 3) community housing and architecture design. As the assessment for optimal sites for housing development is a complicated procedure, the modified sieve analysis was therefore adopted as the analysis model, which employs map overlay, variable weights and penalty scoring system. This technique is developed from the sieve analysis or traditional sieve analysis, which is a well-known technique for assessing the optimal sites for the future housing development.

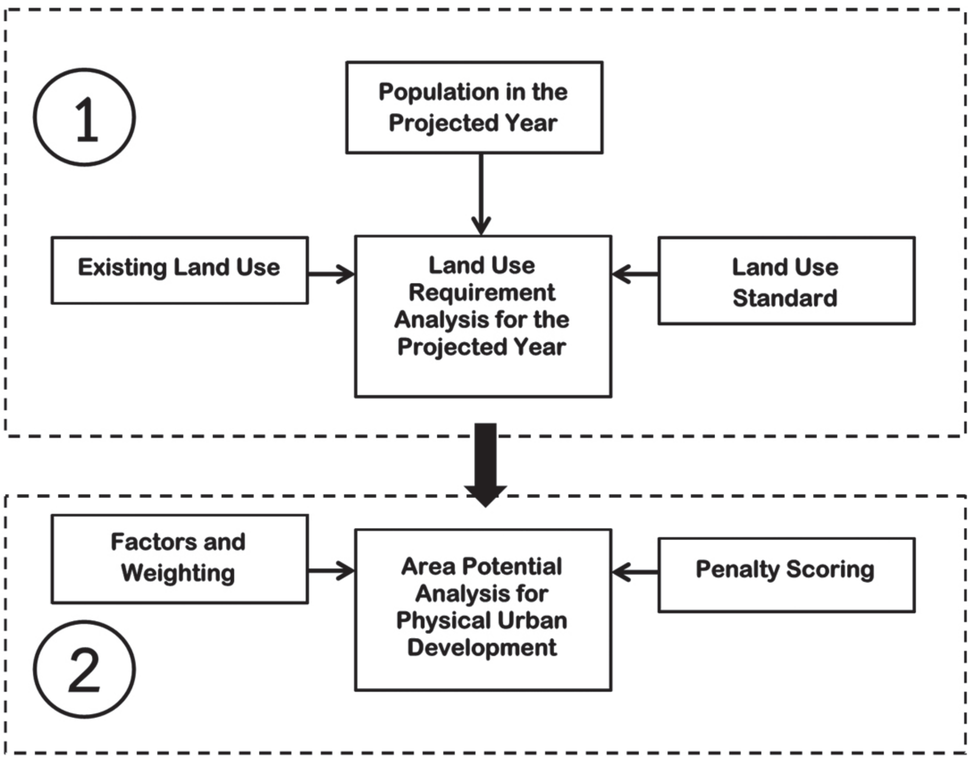


Figure 1:
Land use analysis conceptual framework
Source: National Housing Authority, 2017

The key principle of sieve analysis is the identification of the areas that have limitations or obstacles for future development, by considering variables in order to select optimal sites for development by map overlay. The procedures include:

1) make a list of variables that pose limitations or obstacles for area development e.g. flood-risk zones, areas with water-release issues, or security-risk zones;

2) conduct a survey, in order to identify the boundaries of areas that have limitations or obstacles for future development;

3) overlay the results from 2) on the base map, which was set on a transparent background;

4) overlay all maps of variables of limitation/obstacles in order to acquire the composite picture of the areas that have limitations or obstacles for future development.

Table 1: Factors for penalty scoring in modified sieve analysis

Factors	Most Suitable (Penalty Score =0)	Moderately Suitable (Penalty Score =1)	Less Suitable (Penalty Score =2)
1) Topography and Location			
Flood	No Problem	Rarely	Often
Land Slope	< 12.50%	12.50 – 18.50%	> 18.50%
Water Drainage Problem	No Problem	Rarely	Often
Underground Water Level	> 2.00 m.	1.00-2.00 m.	< 1.00 m.
2) Economy and Society			
Population Density	< 20 man/rai	21-40 man/rai	> 40 man/rai*
3) Infrastructure			
Distance from Highway	< 500 m.	501-1,000 m.	> 1,000 m.
Distance from Main Road	< 500 m.	501-1,000 m.	> 1,000 m.
Distance from Main Water Body	< 500 m.	501-1,000 m.	> 1,000 m.
Distance from Water Drainage System	< 500 m.	501-1,000 m.	> 1,000 m.
Distance from Main Electricity Supply	< 500 m.	501-1,000 m.	> 1,000 m.
4) Public Urban Service			
Distance from School	< 500 m.	501-1,000 m.	> 1,000 m.
Distance from Public Park	< 500 m.	501-1,000 m.	> 1,000 m.
Distance from Hospital	< 1,000 m.	1,000 – 2,000 m.	> 2,000 m.
Distance from Police Station	< 500 m.	501-1,000 m.	> 1,000 m.
Distance from Fireman Station	< 500 m.	501-1,000 m.	> 1,000 m.
Distance from Transportation node	< 500 m.	501-1,000 m.	> 1,000 m.
Distance from Central Business District	< 500 m.	501-1,000 m.	> 1,000 m.

* Rai is one of Thai traditional measurement unit (1 rai = 1,600 square meters)

Source: Department of Public Works and Town & Country Planning, 2008

The areas that pose least limitations or obstacles for future development are regarded as the most potential areas for future development or urban expansion (Department of Public Works and Town & Country Planning, 2008)

The modified sieve analysis is a way to strengthen the sieve analysis by giving score to each variable according to its degree of impact on the land's future development. For example, given the scores ranging from 0 to 2, the variable that is most likely to pose the limitation or obstacle for the future development of an area will be scored as 2, while the variable that is less likely to do so will be given lower scores. The least one will be marked as 0.

Another way to strengthen the sieve analysis is by creating scoring scales according to the severity of the limitation or obstacle of each variable. For example, given the accessibility to the school within 500-meters radius of walk, the severity of the limitations or obstacles of the areas with 501-1000 meters outer of radius of school walk is less than that of the areas which are located between 1,001-1,500 meters outer of radius of school walk. In this regards, it is practical to set a score range of limitations or obstacles, which is the same procedure with the modified sieve analysis or the penalty scoring system. The procedure for setting a score range includes: 1) Define the boundary of the studied area; 2) Draw the grids, setting the grid size according to the size of the city. In this study the 50 x 50 meters grid size was used in the study of all four cities; 3) Define the variables that pose limitations or obstacles for the area development; 4) Choose a weight for each variable and set the

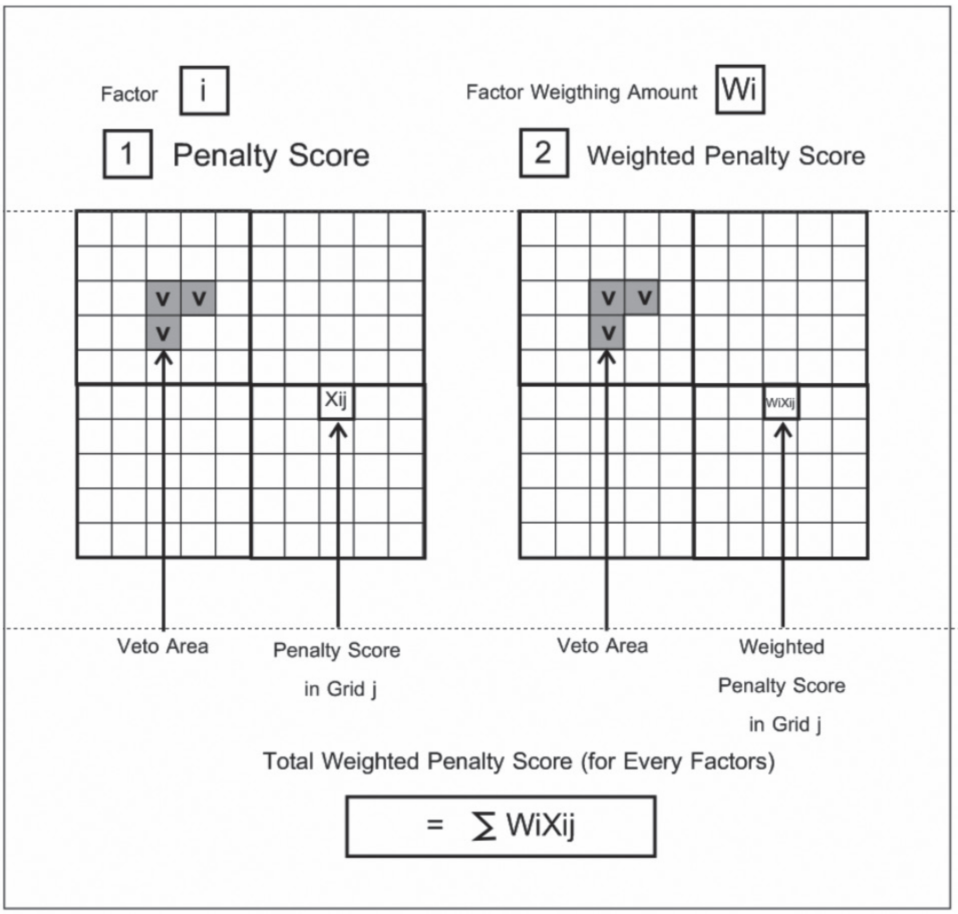


Figure 2:
Penalty scoring calculation method
Source: Department of Public Works and Town & Country Planning, 2008

degree of severity of limitations or obstacles from each variable; 5) Collect data and draw the map showing the factor with its limitations or obstacles for development, using the same base map; 6) Convert the map to penalty scores multiplied by the weight of the variable; 7) Calculate the total weighted penalty scores of each grid from all the variables; 8) Draw a map of total weighted scores of each grid; and 9) Group the areas according to their geographical locations and suitability for future development. How the variables that pose limitations or obstacles for the area development were defined is illustrated in Table 1.

In addition to the penalty scores, the variable weight is also used by giving more weight to the variable with more severe impact on the area development, which normally depends on real conditions of the areas; vision and policy relevant to city development plan; and the suitability and significance of each area. The labelling of the variable weight should be conducted the same way with the labeling of variables. The criteria used are by consulting local administration agencies and locals in that community.

The key principle of labeling variable weights is by giving value 1 to the less important variable while the value given to the most important variable is given not higher than half of total variables. For example, if there are ten variables in total, the value given to the most important variable is given not higher than 5. After that the rest of the variables are given values based on their significance. (Figure 2)

RESULTS

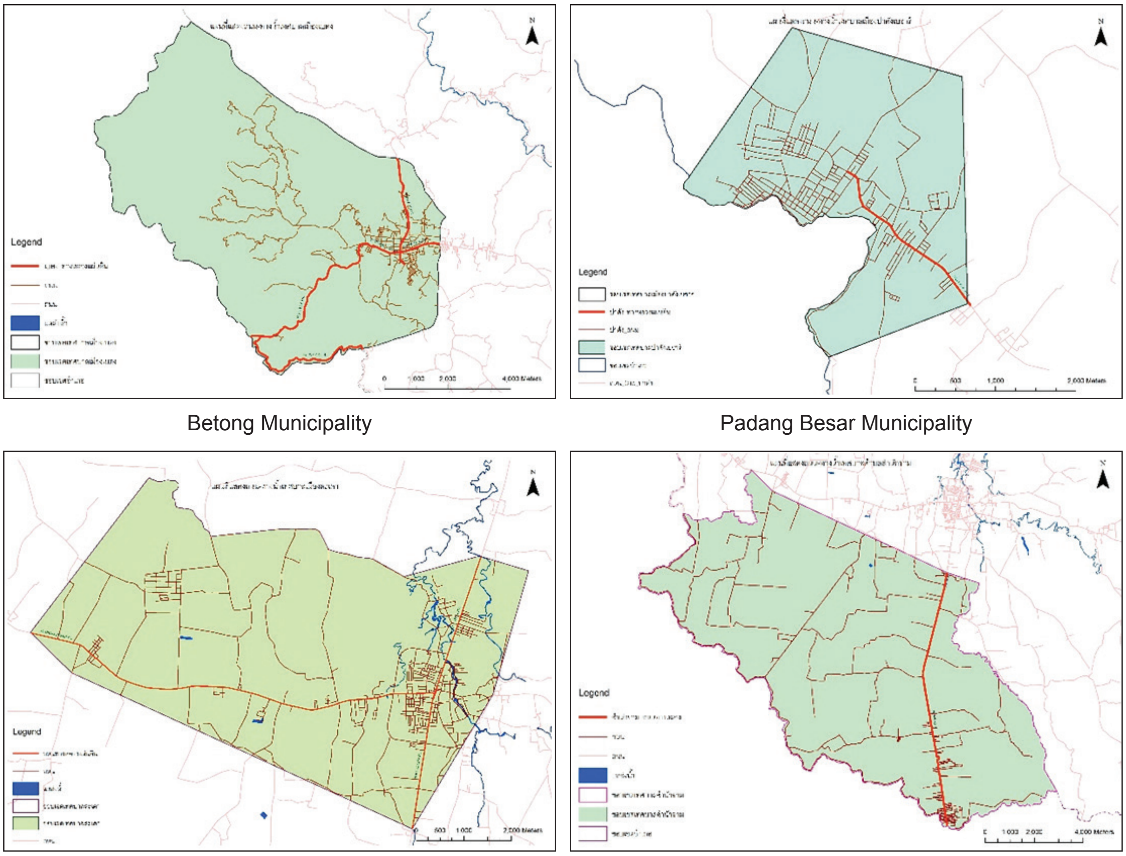
The assessment of the potentiality for land development of four cities located in Thailand-Malaysia Border Trade areas, including Sadao, Samnakkham, Padang Besar, Betong, is illustrated in Figure 3. The assessment was conducted using the modified sieve analysis. Variables were set for the calculation of penalty scores of basic data collected from field survey and secondary data from the National Housing Authority, and Songkhla's and Yala's Offices of Public Works and Town & Country Planning. Variables and scores were set as in Table 1 and weight variables were set as presented in Table 2. Stakeholder meetings were held in order to brainstorm ideas for setting weights of variables.

The research aims to select the suitable sites for housing project in 4 study cities in which consists of Sadao town, Samnakkham town, Padang Besar town in Songkla province and Betong town in Yala

Table 2: Applied Weight of Factor for Urban Development Proposed Area

Foctors	Average Weighting Amount
1) Infrastructure	
Distance from Highway	2
Distance from Main Road	3
Distance from Main Water Body	1
2) Public Urban Service	
Distance from School	2
Distance from Public Park	1
Distance from Hospital	1
Distance from Police Station	1
Distance from Fire Station	1
Distance from Transportation Node	1
Distance from Central Business District	3

Source: National Housing Authority, 2017



Betong Municipality — Padang Besar Municipality

Sadao Municipality — Samnakkham Municipality

Figure 3:
Study areas in 4 Towns
Source: National Housing Authority, 2017 / Betong Town Municipality, 2015 / Padang Besar Town Municipality, 2015 / Sadao Town Municipality,2015 / Samnakkham Town Municipality, 2015

province. These mentioned cities are the expected area for special economic improved along Thailand – Malaysia broader. Thai government planned to develop this area to special economic hub for international trading in the near future. Because of mentioned national policy, urban expansion in the 4 cities rapidly grow. Housing development projects shoud be considered as an immediate regional policy.

Field surveys conducted in the study help locate 10 variables that have impacts on the urban sprawl. The map was prepared; each variable had three service areas: major, sub-major, and outside service area radius. The radiuses of variables are shown in Table 3. The map displays the radius-around-point of all ten variables and can be classified into two groups: service area radius of line variables i.e. highways and main streets (as shown in Figure 4); service area radius of dot variables i.e. water body, schools, parks, hospitals, police stations, fire stations/offices of Disaster Prevention and Mitigation, and bus station/train station (as shown in Figure 4).

After the radius maps of all ten variables in Table1 are drawn, the map was overlaid in Microsoft Excel, which the cells can be used as grids. Each grid is 50 x 50 meters based on the actual size of the areas. Penalty scores were input in the grids. The grids that fall within the boundary of major service area radius will get zero (0) point for penalty score while the ones within the sub-major service area radius will get one (1) point for penalty score. The grids that fall outside service area radius will get two (2) points for penalty score. The interpretations of variable scores fall into two categories: the interpretation of line variables

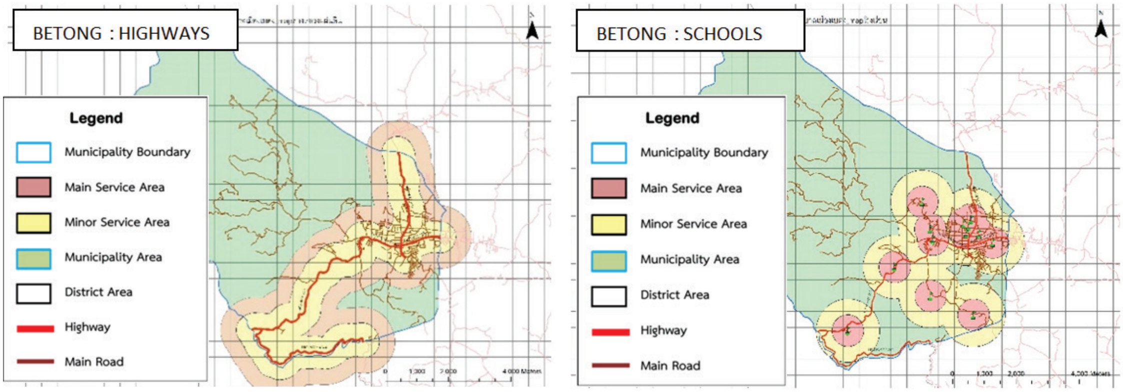


Figure 4:
Service Area of highways and schools in Betong town
Source: National Housing Authority, 2017 / Betong Town Municipality, 2015

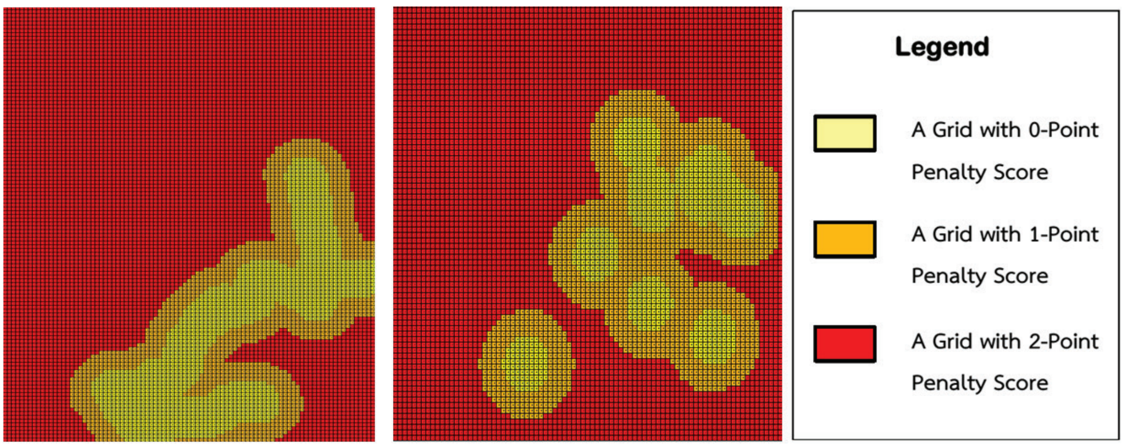


Figure 5:
Weighted penalty scoring followed in service area of highways and schools in Betong town
Source: National Housing Authority, 2017

and the interpretation of dot variables, as presented in Figure 5.

After the analysis and interpretation of penalty scores of all ten variables based on the weight of variables as set in Tables 2, the total scores of all the variables in the grids were then calculated, in order to identify which area of the city has the highest penalty scores. The area with the highest penalty scores are regarded as not suitable for housing development, while the one with the lowest total penalty scores are considered as suitable for the city's housing development. This procedure grouped scores into eight ranges, as presented in Table 3.

After the modified sieve analysis was conducted in order to identify the suitable sites for future development, the land use classification was then applied in the studied cities and the areas with expected urban growth, based on the analyzing the future land use together with other data e.g. transportation, public utility systems etc. The preliminary use of the analysis result was by overlaying the grid table of the total penalty scores over the current land use map. After that the areas supportive to the city's future development were located by selecting the grid with the lowest penalty scores, and the second and the third lowest penalty scores accordingly. This selection was continued

Table 3: Penalty score ranking

Rank	Weighted Penalty Score Percentage	Suitability for Housing Development	Color of a Grid
1	0.00 – 10.00%	Most	White
2	10.01 - 20.00%	Much	Light Yellow
3	20.01 – 30.00%	Average Much	Yellow
4	30.01 – 40.00%	Average	Orange Yellow
5	40.01-50.00%	Average Less	Light Orange
6	50.01 – 60.00%	Less	Orange
7	60.01 – 70.00%	Least	Orange Red
8	> 70.00%	Not Suitable	Red

Source: National Housing Authority, 2017

until reaching the expected number of sites for Year 2027's future land use planning, as calculated and presented in Table 4.

The mapping of sites of each land utilization type can be conducted by using the table of the compatibility matrix, as presented in Table 5. The table is a 2-way matrix demonstrating the relationships that exist between one land use and another. The "+" that appears at the intercept of two types of land use signifies that both types of land uses are compatible. Likewise, the "0" means that two types land use are conditionally compatible e.g. Commercial (5) is compatible with Cultural Landscape (18) as long as the area is an old commercial district, or an old town with which has been rehabitated by tourism activities and the new buildings or the renovated ones are done in accordance with conservation principles and guidelines. On the other hand, the "-" means that both types of land use are incompatible, signifying the land use conflicts and each of them should be isolated.

The mapping of land use in an area or a city can be based on the land use compatibility matrix, as presented in Table 5. The table is a 2-way matrix demonstrating the relationships that exist between one land use and another. The "+" that appears at the intercept of two types of land use signifies that both types of land uses are compatible. Likewise, the "0" means that two types land use are conditionally compatible.

Results from the modified sieve analysis conducted on Microsoft Excel, as presented in Figure 6, were filtered and focused only on the grid cells with the penalty scores not higher than 20% of the highest penalty scores. The scores are grouped into 4 ranges; grid cells in different ranges are identified by colors, as presented in Table 6.

After that, overlay the map, which has been filtered, over the land use map which is depicted in the master plan of all four cities. This step was undertaken to identify the grid cells which have scores appropriate for future housing development and assess the area's compatibility with the surrounding area. If the compatibility of the studied area with its surrounding area is low or is in conflict in terms of land use, other areas will be considered instead. Results from the modified sieve analysis and the map overlay are steps taken for site search and selection for future housing development; the criteria for this search and selection are based on results from the questionnaire. Finally, three sites were selected in each city. Advantages and disadvantages of each site are to be studied in conjunction with the consideration of land price and opinion from public meetings so that only one site will be finally selected. The main finding from public hearing conforms to consequences of modified sieve analysis. Results from the mentioned procedures are as follows:

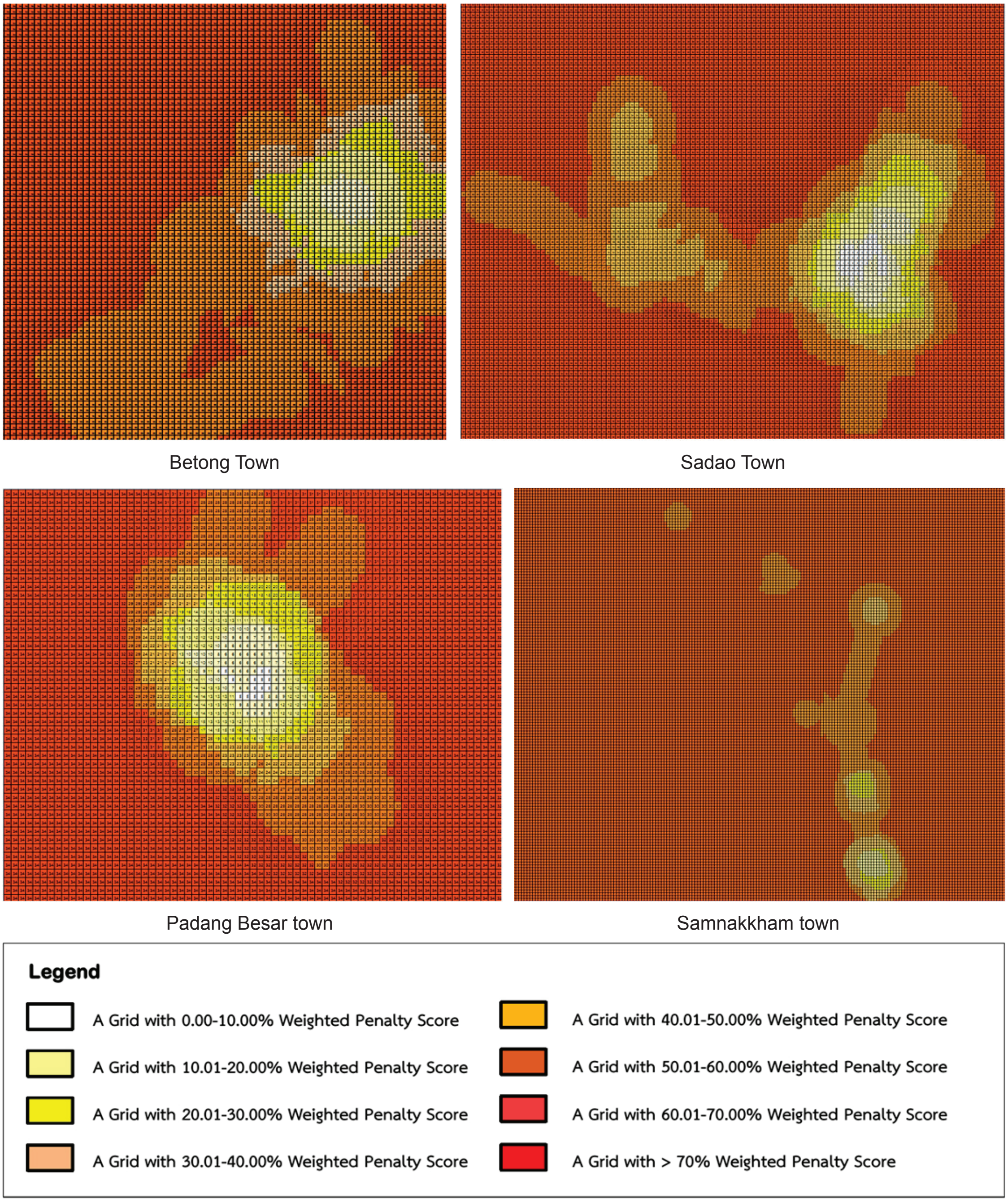


Figure 6:
Total weighted penalty scoring followed in every factor in study towns
Source: National Housing Authority, 2017

Table 4: Proposed land Use area of study towns in 2027

Land Utilization Type	Land Use Area (Rai*)			
	Sadao	Padang Besar	Samnakkham	Betong
1) Residential Area	2,087.16	1,666.20	3,682.68	293.04
Low Density	1,159.53	925.67	2,045.93	162.80
Medium Density	579.77	462.83	1,022.97	81.40
High Density	347.86	277.70	613.78	48.84
2) Commercial Area	217.41	173.56	383.61	30.53
3) Industrial Area	230.46	183.98	406.63	32.36
4) Public and Open Space	57.98	46.28	102.30	8.14
5) Area for Transportation	345.69	275.96	609.94	48.53
6) Area for Public Utility System	230.46	183.98	406.63	32.36
7) Area for Urban Growth	869.65	694.25	1,534.45	122.10
Total Development Area	**4,038.80**	**3,224.21**	**7,126.24**	**567.05**

** Rai is one of Thai Traditional Measurement Unit. (1 Rai = 1,600 square meters)*

Source: National Housing Authority, 2017

1) Suitable Site to Build Housing Development in Sadao Municipality

The overlay of the grid map and Sadao Municipality's master plan indicates that the grids that have the potential for development, ranging from the best to mediocre, are shown on the commercial zones; most-, medium-, and low- crowded areas, which are highly suitable for the future housing development. Three sites are selected for build housing development and illustrated in Figure 7.

2) Suitable Site to Build Housing Development in Padang Besar Municipality

The overlay of the grid map and Padang Besar Municipality's master plan indicates that the grids that have the potential for development, ranging from the best to mediocre, is shown on the commercial zones; most-, medium-, and low- crowded areas, which are highly suitable for the future housing development. Three sites are selected for build housing development and illustrated in Figure 8.

3) Suitable Site to Build Housing Development in Samnak Kham Municipality

The overlay of the grid map and Samnakkham Municipality's master plan indicates that most of the grids that have the potential for development, ranging from the best to mediocre, are shown on the commercial zones; most-, medium-, and low- crowded areas. However, some of the sites with mediocre potential are also found in general industrial zones- which do not cause pollution to environment or community- and in warehouse zones. Given this fact, areas located near industrial zones are avoided; instead three areas located near the commercial zones are selected for build housing development and illustrated in Figure 9.

Table 5: Compatibility matrix

ประเภทการใช้ประโยชน์ที่ดิน		ประเภทการใช้ประโยชน์ที่ดิน																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Low Density Residence	+																			
2	Medium Density Residence	+	+																		
3	High Density Residence	0	+	+																	
4	Commercial and Residence	0	0	+	+																
5	Commercial Use	0	0	0	+	+															
6	CBD	0	0	0	+	+	+														
7	Industry	-	-	-	-	-	-	+													
8	Specific Industry	-	-	-	0	0	0	+	+												
9	Warehouse	-	-	-	-	-	-	+	+	+											
10	Governmental Place	0	0	0	+	+	0	-	0	-	+										
11	School	+	+	+	+	0	0	-	0	-	0	+									
12	College / University	+	+	+	+	0	0	-	-	-	0	+	+								
13	Public Park	+	+	+	+	+	+	-	-	-	0	+	+	+							
14	Public Urban Service	0	0	0	0	0	0	0	0	0	0	0	0	0	+						
15	Religious Place	+	+	+	0	0	0	-	-	-	0	+	+	+	0	+					
16	Open Space for Recreation	+	+	+	+	+	+	-	-	-	+	+	+	+	+	+	+				
17	*Open Space for Fishery	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	+	+			
18	* Cultural Preservative Area	0	0	0	0	0	0	-	-	-	0	0	0	0	0	+	+	+	+		
19	*Suburb Preservative Area	0	-	-	-	-	-	-	-	-	0	0	-	-	0	0	+	+	+	+	
20	Agricultural Area	0	-	-	-	-	-	-	-	-	0	0	0	0	0	0	+	+	+	+	+

Symbols : "+" = compatible "0" = conditionally compatible "– " = incompatible " * " = important item

Source : Department of Public Works and Town & Country Planning

Table 6: Rank of selected grids followed in total weighted penalty score

Rank	Weighted Penalty Score (%)	Color of a Grid's Boundary
Best	0.00 – 5.00	Yellow
Very Good	5.01 – 10.00	Green
Good	10.01 – 15.00	Orange
Average Good	15.01 – 20.00	Blue

Source: National Housing Authority, 2017

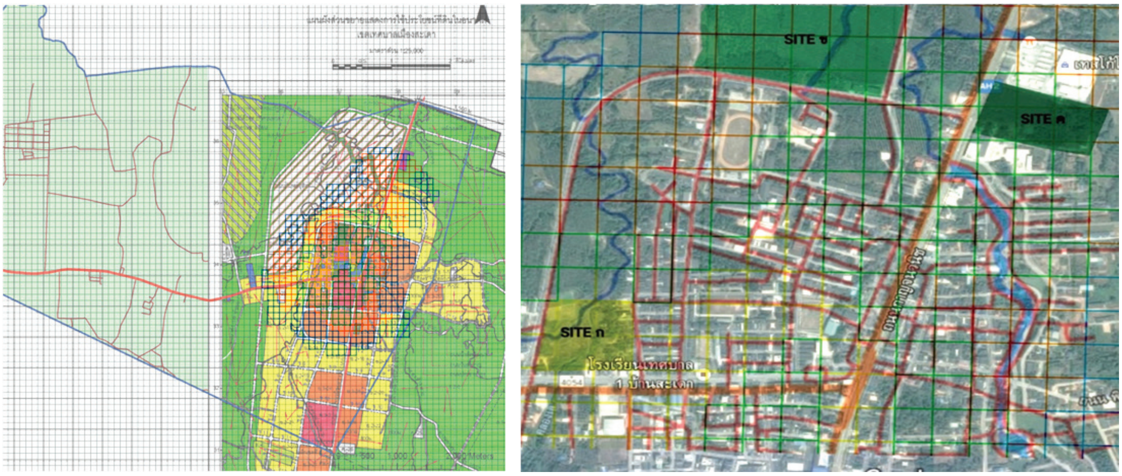


Figure 7:
Potential grids and 3 proposed lots for dwelling development in Sadao town
Source: National Housing Authority, 2017

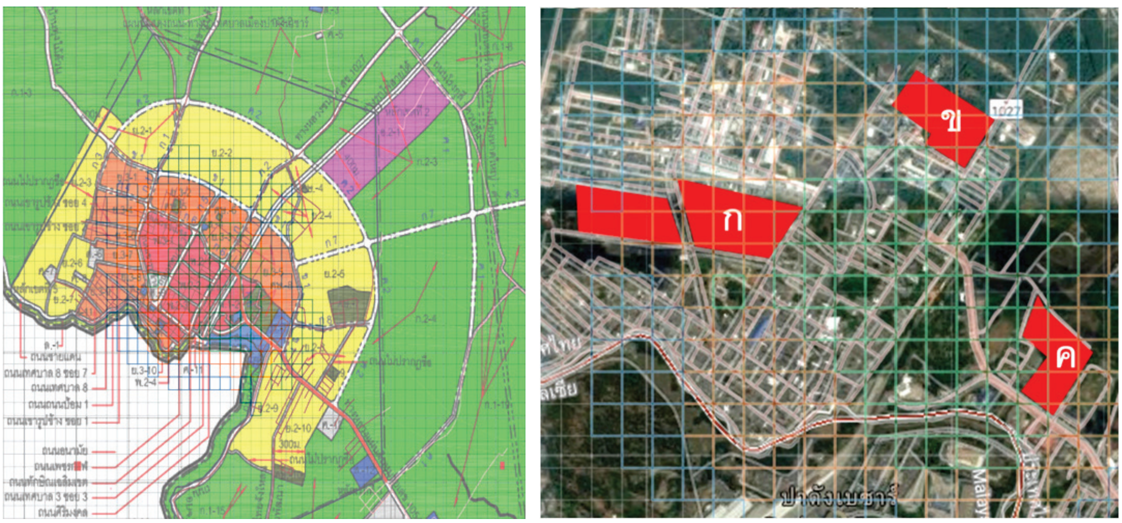


Figure 8:
Potential grids and 3 proposed lots for dwelling development in Padang Besar town
Source: National Housing Authority, 2017

4) Suitable Site to Build Housing Development in Betong Municipality

The overlay of the grid map and Betong Municipality's master plan indicates that most of the grids that have the potential for development, ranging from the best to mediocre, are shown on the commercial zones; most-, medium-, and low- crowded areas. However, some of the sites with good and mediocre potential for development are also found in government agencies zones and agricultural zones, which are highly suitable for the future housing development. Three sites are selected for build housing development and illustrated in Figure 10.

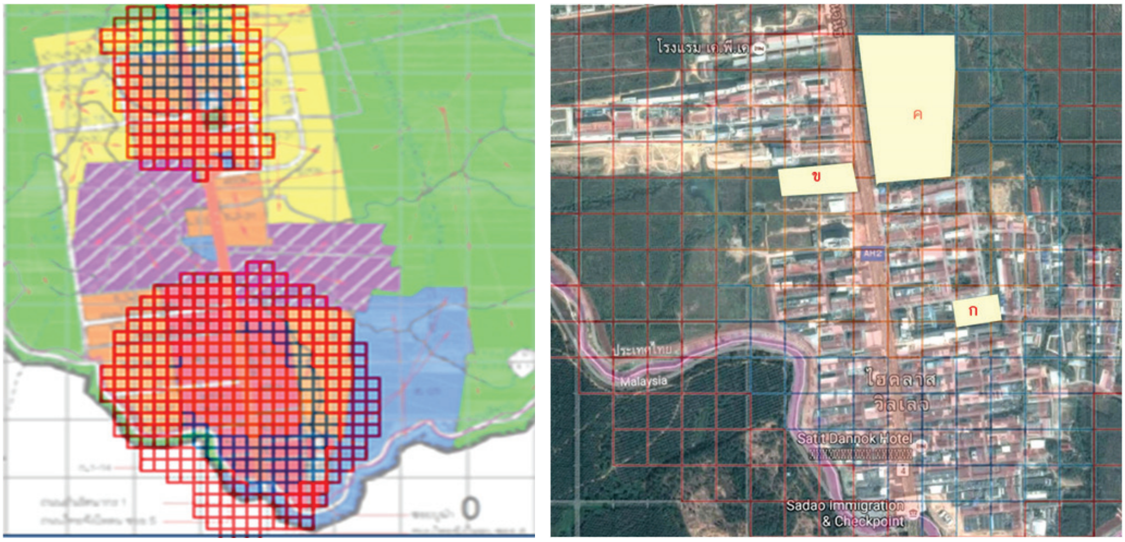


Figure 9:
Potential grids and 3 proposed lots for dwelling development in Samnakkham town
Source: National Housing Authority, 2017

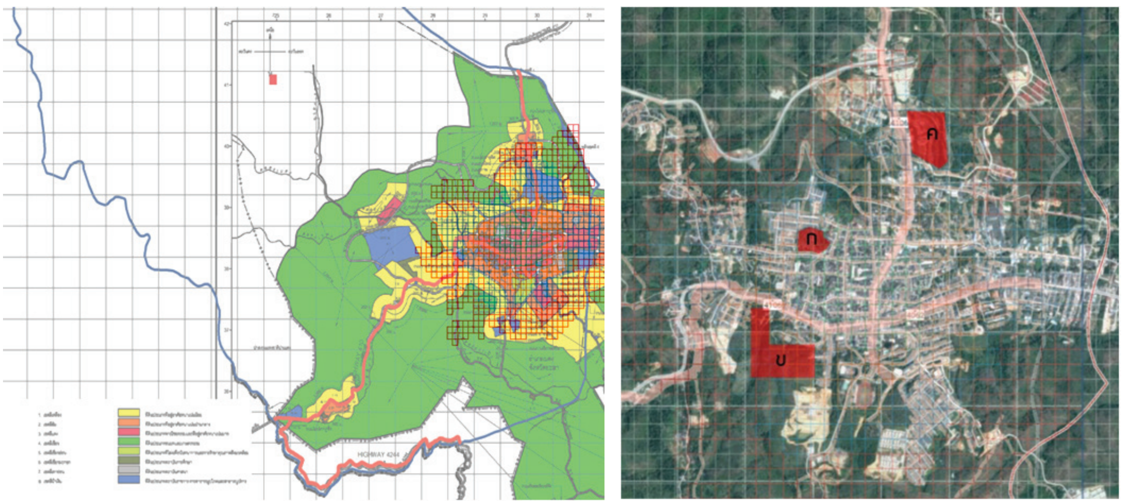


Figure 10:
Potential grids and 3 proposed lots for dwelling development in Betong town
Source: National Housing Authority, 2017

CONCLUSION AND IMPLICATION

The modified sieve analysis was adopted as the instrument for selecting the site for the housing development projects under this study. The study was supported by National Housing Authority and aimed to select the sites for housing development in four cities located in the Thailand and Malaysia Border Trade Areas, including three cities from Songkhla province (Sadao, Samnak Kham, and Padang Besar) and one city from Yala Province (Betong). Results from the Modified Sieve Analysis enable city planners to identify sites that are suitable for each type of land uses. This study, however, primarily focuses on the search and selection of sites for building housing development projects.

The modified sieve analysis yields better results than the traditional sieve analysis. It technique provides more specific statistical data and can be used to analyze numerous spatial variables and yield reliable findings. The visit to the actual sites with low total penalty scores indicates that the sites in all four cities have high potential. Likewise, the cross-checking with the local government agencies, through small-group meetings, points that all the stakeholders agree that the selected sites are suitable for housing development.

However, the use of the modified sieve analysis alone might not be able to bring to the conclusion which sites of cities are the most suitable ones for future urban development. The search and selection of an appropriate site requires other different instruments to ensure the accurate selections e.g. field surveys, questionnaire, analysis of land prices, meetings with stakeholders, and analysis of the existing policies on urban development. All the mentioned procedures should be taken until the most optimal sites for housing development projects are selected. Findings obtained all these procedures will serve as the fundamental guidelines for the urban planning in terms of housing development projects either under the support of National Housing Authority or of local government agencies. The ultimate goal is to ensure that the projects are successful and compatible with all respects of the cities.

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