

# Analysis of Area Suitability for the Railway Development from Sila at Station to the Destination Station at Phu Doo International Point of Entry for Supporting the Development of the Rail Transport System and Logistics of Uttaradit Province

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## Abstract

The objectives of this research were to study site suitability for developing the railway line from Sila At Station to the destination station at Phu Doo International Point of Entry for supporting the development of the rail transport system and logistics of Uttaradit Province and to increase the scope of rail transport connectivity from Indochina to Phu Doo International Point of Entry. This railway is an important route for goods transportation in the northern region of Thailand to Lao People's Democratic Republic (Lao PDR). The analysis of area suitability for developing the railway was conducted with 4 factors: land use, slope, distance from main road, and topography. These factors were analyzed and assessed on suitability of the railway by using analytic hierarchy process (AHP). The study results show that agricultural area is the largest proportion of the railway development at 22,098 rais (76.32%) of the whole suitable area. Regarding the 3 railway construction models overlaying with topographic map data and contour lines in the Google Earth program, the Railway 2 is the shortest route with the total distance of 141.01 kilometers passing Mueang District, Tha Pla District, Nam Pat District, Fak Tha District, and Ban Khok District of Uttaradit Province. According to the results from assessing the railway suitability with AHP, the total score of Railway 2 is the highest value. When considering each factor, the Railway 2 focuses on topography and land use in considering suitability for the railway development. However, the scores of Railway 3 are similar, noticeable from the significant equal scores on topography and land use.

**Keywords:** Area suitability, Development of railway, Rail transport system, Analytic hierarchy process.

## 1. Introduction

Phu Doo International Point of Entry is located in Ban Khok District, Uttaradit Province. At present it is under supervision of Uttaradit Provincial Administrative Organization and Muang Chet Ton Subdistrict Administrative Organization. Phu Doo International Point of Entry is the 3rd Thai-Lao border crossing point in connection with Chaiyaburi Province of Lao People's Democratic Republic (Lao PDR). The strength of Phu Doo International Point of Entry is in connectivity of travel and goods transportation from Thailand to Vientiane and Luang Prabang, Lao People's Democratic Republic (Lao PDR) [1].

In terms of goods transportation at Phu Doo International Point of Entry, most goods are transported from Indochina Intersection which is a transportation center under the strategies of economic cooperation in the Mekong Subregion in the East-West Economic Corridor Project in connection of Yangon-Tak – Phitsanulok - Khon Kaen – Suwankhet –

Da Nang, and the North-South Economic Corridor Project in connection of Kunming – Bangkok. Both projects have intersections in Thailand at Phitsanulok Province and Tak Province. It can be seen that goods transportation routes to Lao PDR come from these 2 main economic roads. At present the routes from Indochina intersection are the main transportation routes linking with Lao PDR through Phu Doo International Point of Entry. The route from Phu Doo International Point of Entry to Pak Lai City of Lao PDR facilitates quick and convenient transportation and consequently lower logistics cost [2]. In current economic situation, fuel cost is high. It is found that transportation cost of truck transport or road logistics system increase and transporters have to bear such burden and get less profits. If there is an additional rail transport system as an option, entrepreneurs can reduce fuel cost. The transportation from Indochina Intersection to Phu Doo International Point of Entry is currently not possible because the railway of the rail

transport system from Indochina Intersection namely Phitsanulok Railway Station only ends at Sila At Station, Uttaradit Province. If there are data for supporting decision to develop rail logistics from Sila At Station, Uttaradit Province to Phu Doo International Point of Entry, there will be another channel for cheaper transport, and a route for exporting seasonal fruit products of Uttaradit Province and nearby provinces as well.

Sila At Station located in Uttaradit Province is an important railway station and it is a center of container transport through the northern route trains. Goods in containers are unloaded from trains at Sila At Station and then they are loaded onto trucks to be further transported to Phu Doo International Point of Entry through road logistics to Lao PDR. It is obvious that goods transportation takes longer time for loading and unloading goods at Sila At Station, it also takes longer work period, and this gets more risk of accidents from goods loading and unloading goods that are goods in the watch list. Therefore, it is good to have a study to get data as information for decision making of State Railway of Thailand to develop the rail transport system in the future [2], and to increase the scope of rail transport connectivity from Indochina to Phu Doo International Point of Entry. This route will be the main transportation route in the northern region of Thailand to Lao PDR.

## **2. Related Work**

Rail logistics system refers to transportation of passenger or goods by vehicles running along rails. Rail transport system is a part of logistics chain, and train transport is transportation by rail to move and transport among stations only without travelling on other types of transportation [3]. However, rail transport can connect with road logistics system for various forms of transportation. Rail transport is one of the most effective transport methods in terms of saving, safety, fast, convenience, reliable and punctuality. This is consistent to the concept of Khamnai Aphiprachayasakun (2007) [4] which states that strategies for logistics management and supply chain management are to reduce cost and increase profits. Meanwhile, the concept of Piyanan Namwong (2008) [5] considers on transport suitability by focusing on transportation with large quantity of goods, low service rate, and definite transportation time. The weakness of train transport is on limitation in infrastructure as many provinces in Thailand do not

have railways. This weakness makes rail transport inaccessible to all areas.

In contrast, if infrastructures and various public utility systems are developed especially in developing transportation infrastructures, they will enhance competitiveness and integration of Thai transportation system to be more effective in accordance with the Strategies for Developing Transportation System of Thailand in 20 Years B.E. 2560 – 2579 (2017 – 2036), a plan for national development under Ministry of Transportation. Accordingly, the main mission is to develop transportation infrastructures and services to increase effectiveness of rail transport to support goods and services as well as to increase convenience for service users [6].

Kulapha Sorat (2019) [7] studied on logistics system analysis for the development of border town within the immediate vicinity of Phu Doo International Point of Entry, phase I. According to her study, Phu Doo International Point of Entry, Uttaradit Province is located in suitable area to be developed as a center of border trades, logistics activities, and tourism. It is a short and convenient transportation route from Thailand to Luang Prabang, Lao PDR so organizations from several sectors join together to push for development of infrastructures and various public utilities at the area of Phu Doo International Point of Entry to become a center of production and industry in the Indochina Region. At present, development of infrastructures of rail transport cannot be implemented due to lack of information for decision-making and data of analysis about land use for developing the railway from Sila At Railway Station to Phu Doo International Point of Entry. Therefore, the analysis of area suitability is necessary for developing the railway from Sila At Railway Station to Phu Doo International Point of Entry with the objectives to support development of rail transport system and logistics of Uttaradit Province. The analyzing results are important for strategies to develop Thai transportation system under the national development plan responsible by Ministry of Transportation.

The objectives of this research were to analyze area suitability for developing the railway from Sila At Station to the destination station at Phu Doo International Point of Entry by using geographic information system (GIS) to analyze 4 factors influencing selection of railway location. These 4

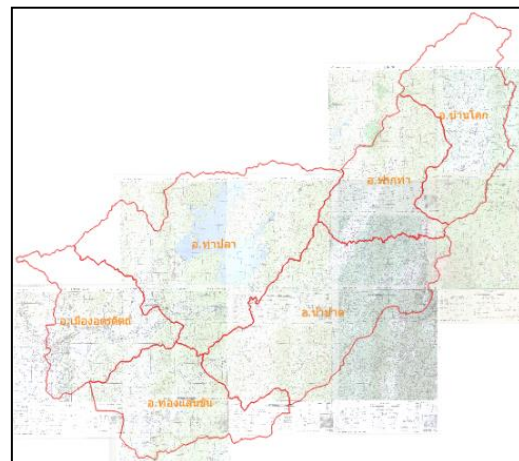
factors were land use, slope, distance from the main road, and topography. The GIS is widely applied in transportation as transportation data are associated with geographical areas. The GIS is capable in collecting, processing, and presenting spatial data for supporting transportation works [8], and it is also widely used in research works. In the study of Poonyanuch Ruthirako and Chanisada Choosuk (2019) [9], the GIS was applied to find area suitability for developing recreational green space in Hatyai City Municipality and Khohong Town Municipality, Hatyai District, Songkhla Province. The factors used for the analysis were density of population, access from the main road, vacant area, buffer from existing recreation green space, and land surface temperature. In addition, Thidapath Anuchan (2016)[10] analyzed 6 factors namely inundation zone, land use, road network, slope, distance from water sources and stream line, and soil drainage in order to determine suitable areas for evacuation and evacuation site from inundation zone, a case study in Hat Yai District, Songkhla Province. Moreover, Lalitaporn Wongho (2017) [11] showed main road factor affecting road accident in areas with much density of population or main road in the community zone. Meanwhile, Jidapa Chunjumpa (2020) [12] gave importance on transportation factors, distance from main road, and travel from business center area because the area with potential to construct dry port needed connectivity of road and rail transports for supporting various forms of logistics transports. According to the above research, it can be seen that if the GIS is applied to analyze suitable areas for developing the railway, it will be useful for planning infrastructures of rail transport according to the national development plan under supervision of Ministry of Transportation in the future.

### 3. Methodology

Regarding the scope of the study area, the area was surveyed and area suitability was classified according to relevant factors. The areas were determined for developing the railway including the areas in Mueang Uttaradit District, Tha Pla District, Nam Pat District, Fak Tha District, and Ban Khok District, Uttaradit Province. In this study, spatial data were used for the analysis by using data from organizations. The topologic map data at the scale 1:50,000 were received from Royal Thai Survey Department Set L7018 [13] used for inspecting positions and

considering topography for analyzing soil series, and the land use data in 2020 was obtained from Land Development Department [14] for considering suitable areas for developing the railway. All data were grouped according to criteria and made up into the GIS database used for analyses by using the GIS software according to the area potential and suitability. The procedures for analyzing and assessing the areas for developing the railways are as follows.

- 3.1 Determine the areas to be studied (Figure 1) and create a GIS database by using the GIS data of the physical areas namely topography, high-resolution satellite images, roads, land use, geographical map at the scale 1:50,000, contour lines, slope, road data, administrative districts, positions of important places, horizontal section view, and topographic elevation.



**Figure 1. Topographic Map of Uttaradit Province in the scale 1:50000**

- 3.2 Determine factors for the data analysis

Determine layers of the main factor and sub-factor data used for area analysis in terms of land use, slope, distance from main roads, and topography.

Determine the data score values according to sub-factor classification by inquiring experts. Determine score values according to each sub-factor. For example, topographic elevation at 0-100 m. was given 3 points whereas topographic elevation over 300 m. was given 0 point etc.

The main factors, the sub-factors and rating criteria used in the data analysis are shown in Table 1.

Table 1. Factor data and rating

Main Factors / Sub-factors	Sub-factor Rating
1. Land Use	
- Agricultural Area (A)	3
- Urban & Community Area (U)	2
- Forest Area (F)	1
- Water Source Area (W)	0
2. Slope	
- Slope 0-5 %	3
- Slope 6-10 %	2
- Slope 11-20 %	1
- Slope > 20 %	0
3. Distance from main roads	
- Distance 0-100 m.	3
- Distance 101-200 m.	2
- Distance 201-300 m.	1
- Distance > 300 m.	0
4. Topography	
- Elevation 0-100 m.	3
- Elevation 101-200 m.	2
- Elevation 201-300 m.	1
- Elevation > 300 m.	0

**3.3** Analyze data by importing GIS data with the GIS software about area potential and suitability as shown in Figures 2 - 5.

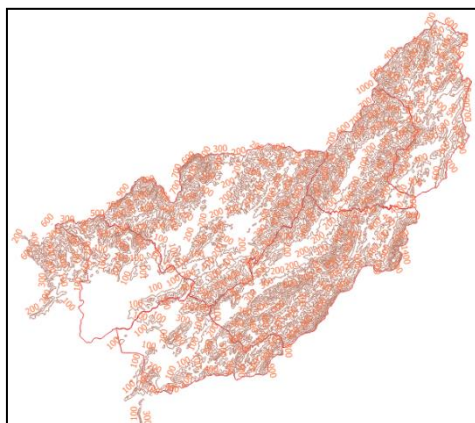


Figure 2. Contour Map

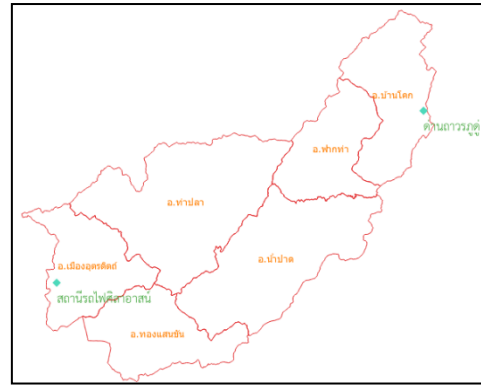


Figure 3. Positions of Sila At Railway Station and Phu Doo International Point of Entry

Data layers of 3 railway models were created by overlaying with topographic and contour data, as shown in Figure 4.

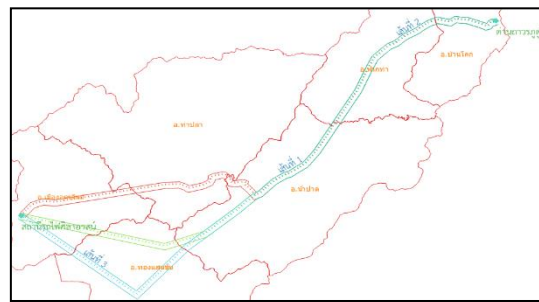


Figure 4. Data layers of 3 railway models

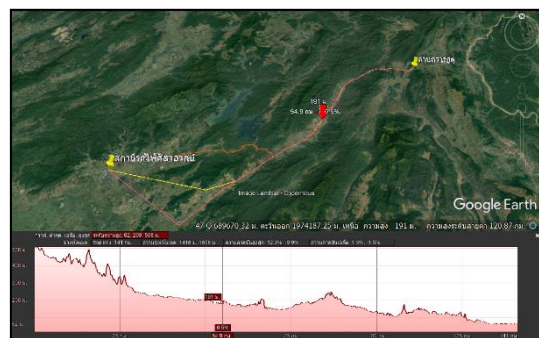


Figure 5. Horizontal section view overlaying high-resolution satellite image data and topographic elevation by using the Google Earth program

**3.4** Assess suitability of the 3 railway models as follows.

Determine factor weighting for prioritizing of different factors affecting railway development by inquiring experts.

Determine railway suitability in factors used in the analysis by considering each railway one by one to find each factor's suitability score value. The suitability criteria are shown in Table 2.

**Table 2. Factors, factor weighting, and suitability scores**

Factors	Factor Weighting	Suitability Scores			
		3	2	1	0
1. Land Use	0.295				
2. Slope	0.207				
3. Distance from Main Road	0.113				
4. Topography	0.385				

Determination of Suitability Scores

3 points refers to the highest suitability of the factor.

2 points refers to high suitability of the factor.

1 point refers to low suitability of the factor.

0 point refers to unsuitability of the factor.

Multiply factor weight by suitability scores (Weighting X Suitability), referring to the scoring method of Malczewski J. [15] to consider suitability of the 3 railway models.

$$A_i = \sum_j W_i X_{ij} \quad (1)$$

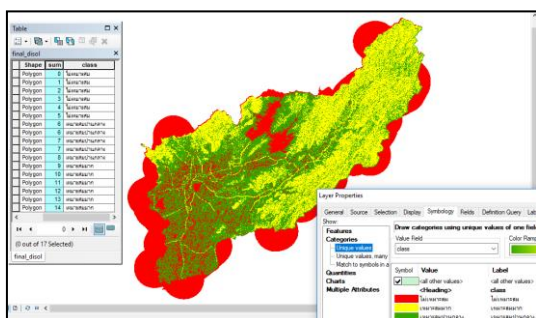
$A_i$  = score of each alternatives  $i$

$W_i$  = weighting normalized by  $\sum W_i = 1$

$X_{ij}$  = score of attribute  $j$

#### 4. Results and Discussion

The analyzing results to find suitable areas by summing up the given score values of 4 data layers into union, as shown in Figure 6 below.



**Figure 6. Land Use**

#### 4.1 Land use for railway development

The total area of Uttaradit Province is 4,899,120 rais divided into 4 types of land use: agricultural area, urban and community area, forest area and water source area. Each type of land use is summarized as follows.

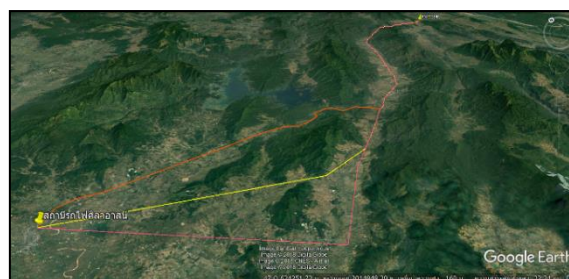
- 1) Agricultural area was the largest proportion in the development of this railway at 22,098 rais, accounting for 76.32% of the most suitable area.
- 2) Urban and community area covered the area of 1,869 rais, accounting for 6.46% of the most suitable area.
- 3) Forest area was the least suitable area for the railway development at 1,411 rais, accounting for 4.87%.
- 4) Water source area was the 2<sup>nd</sup> largest area at 3,575 rais, accounting for 12.35%.

**Table 3. Land use for the railway development**

Main Factors / Sub-Factors	Areas (rais)	Percentage
1. Land Use		
- Agricultural Area	22,098	76.32
- Urban and Community Area	1,869	6.46
- Forest Area	1,411	4.87
- Water Source Area	3,575	12.35

#### 4.2 Analysis of railway models

The 3 railway construction models were considered by analyzing data and creating 3 railway data layers overlaying with topographic map data and contours in the Google Earth program, as summarized in Figure 7.



**Figure 7. The 3 railway models**

The Railway 1 is referred to the route from the main road starting from Highway No. 1045, Highway 1046, and Highway 1047 with the total distance of 142.62 km. The advantage is that the railway can be

developed in parallel to the main roads which are currently used. The disadvantage is that the railway has to be constructed through Sirikit Dam (Figure 8) which is the largest earthen dam in Thailand. Therefore, the Railway 1 is difficult to be developed.



Figure 8. The Railway 1

The Railway 2 is referred to topography and factor suitability. It is the route not in parallel to all main roads but it is referred to topography and suitability of such areas. The Railway 2 has the total distance of 141.01 km. so it is the shortest route passing the areas of 5 districts: Mueang District, Thong San Khan District, Nam Pat District, Fak Tha District, and Ban Khok District (Figure 9). The advantage is that it is the route passing agricultural areas which had the highest suitability scores in laying the railway. The disadvantage is that the bridge across the Nan Rivers is necessarily constructed at the distance of about 400 – 500 m.

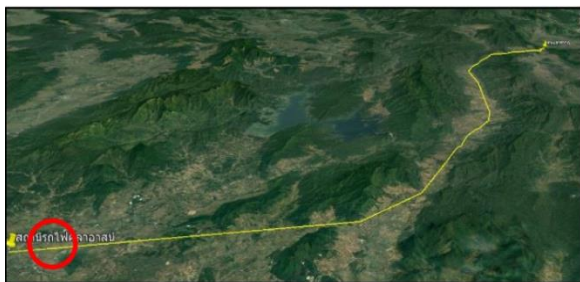


Figure 9. The Railway 2

The Railway 3 is referred to topography and factor suitability in slope as the main factor in order to avoid constructing the railway over the Nan River. The Railway 3 has the total distance of 153.50 km. so it is the longest route due to construction focusing on slope not over 5% and agricultural area (Figure 10). The advantage is on ease of railway construction as the area is an agricultural plain without drilling tunnel, drilling through mountains, and constructing a bridge across the Nan River. The disadvantage is on the long distance which causes higher construction cost.



Figure 10. The Railway 3

#### 4.3 Assessment of the railway suitability

The questionnaire data from experts were analyzed through the analytic hierarchy process (AHP) to find the railway suitability of 4 main factors: land use, slope, distance from main roads, and topography, as summarized in Table 3.

Table 4. Suitability analysis of the 3 railway models

Factors	Weighting	Railway 1	Railway 2	Railway 3
1. Land Use	0.295	0.506	0.885	0.885
2. Slope	0.207	0.503	0.591	0.523
3. Distance from Main Roads	0.113	0.323	0.307	0.323
4. Topography	0.385	0.990	1.100	1.100
<b>Total</b>	<b>1</b>	<b>2.321</b>	<b>2.883</b>	<b>2.840</b>

According to the analyzing results in Table 3, the total score of Railway 2 is the highest. When considering in each factor, it can be seen that the Railway 2 gives importance on topography and land use in considering suitability of the railway development. However, the scores of the Railway 3 are similar, noticeable from the significant equal scores on topography and land use.

Regarding the railway suitability scores and the analysis of the previous railway models, it is found that topography and land use of the Railway 2 and the Railway 3 are similar in terms of the railway development with construction in the areas with topographic elevation not over 100 m. and most areas are agricultural plains according to the data of land use. The Railway 2 is shorter than the Railway 3. All 3 railways are shown in Figure 11.

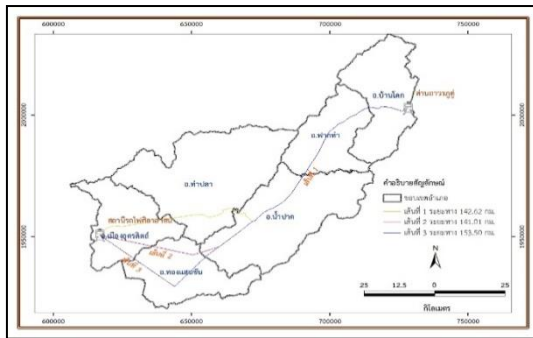


Figure 11. The 3 railways models

## 5. Conclusion

The study was implemented to find area suitability for developing a railway from Sila At Station to the destination at Phu Doo International Point of Entry, Uttaradit Province by using the geographic information system (GIS) to analyze 4 main factors: 1) land use, 2) slope, 3) distance from main roads, and 4) topography. The collected data were used to create a database for analyzing area potential and suitability by considering the sub-factors' scores with the GIS software. The 3 railway models from the departure station to the destination stations were created, and the scores of each factor were used, and the simple factor weighting were summed to obtain the total score of all factors for analyzing and assessing the railway suitability and potential for the railway development in the future. The analyzing results showed that the area which can be developed into the railway was the agricultural area with the largest proportion at the area of 22,098 rais accounting for 76.32% of the most suitable area, followed by the water source area at 3,575 rais accounting for 12.35%, the urban and community area at 1,869 rais accounting for 6.46%, and the forest area, the least suitable area at 1,411 rais accounting for 4.87%. When considering the 3 railway construction models overlaying with the topographic map data and the contours in the Google Earth program, the Railway 1 is a route to pass Sirikit Dam which is the largest earthen dam in Thailand. Therefore, the Railway 1 is difficult to be developed. The Railway 2 is the shortest route with the total distance of 142.62 km. but its disadvantage is on necessity to build a bridge across the Nan River at the distance about 400 – 500 m. The Railway 3 has the total distance of 153.50 km. and it is the longest route. Its advantage is on ease of the railway development since the area is agricultural plain, not necessary to drill tunnels or mountains and not necessary to build the bridge across the Nan River. However, its

disadvantage is on long distance which causes higher construction cost. According to the assessment of the railway suitability with the analytical hierarchy process (AHP), the summed score of the Railway 2 is the highest. When considering in each aspect, the Railway 2 focuses on topography and land use in considering suitability of the railway development. The scores of the Railway 3 are similar, noticeable from the significant equal scores on topology and land use.

Regarding the GIS application in analyzing area suitability for the railway development, it is found that the area suitable for the railway development is the agricultural area which topography is not too high but easy for railway construction and development. The application of GIS for making decision on several factors like this is consistent to the study of Herzberg et al. (2019) [16] which analyzed factors for assessing possibility of land use for agriculture in the hilly areas of Central Vietnam by using instrument of public participation, hierarchy analysis, geographic information system, and factor weighting. The study results showed that the hilly areas were potential in doing 5 agricultural types: rice, tapioca, acacia, banana and rubber. Plantation of acacia and tapioca was the most suitable for agriculture in the hilly areas in the central Vietnam. In addition, Mustafa Topuz & Mehmet Deniz (2023) [17] applied the GIS for analyzing land use suitability in a case study of Demirci District, Turkey by setting factor weighting such as topographic elevation and slope. The study found that the land use at that time was suitable for agricultural land use, and the study results also indicated that most area of Demirci District should be grassland used for agriculture and forest, especially at the hilly areas in the south of Simav Demirci to enhance local economy and surrounding ecosystem. Moreover, Orhan (2021) [18] studied area suitability for citrus cultivation in Mersin, Turkey by applying the GIS for making multicriteria decisions. The study results showed that climate change was the main condition of citrus cultivation, and the suitable areas for citrus cultivation was at the size of 84 hectares, so the study suggests that studies on area suitability need to create sustainable agricultural strategies in the East Mediterranean. Similarly, Jidapa Chunjumpa (2020) [12] applied the analytical hierarchy process to analyze area potential for dry port in Udon Thani Province. The study found that the construction of the land port in Udon Thani Province mostly focused on transportation, the most suitable area was in the area

of 2,720.34 square kilometer accounting for 23.92% of the whole area. Manat Srivanit and Pattamon Selanon (2017) [19] performed GIS-based land suitability analysis to support Transit-Oriented Development (TOD) Master Plan in a case study of the Campus Station of Thammasat University and its surrounding communities. They assessed from GIS data and set weighting criteria for analyzing effect on community with the focus on public transport in order to obtain guidelines for developing a city plan of the surrounding area of Thammasat University. The study results showed that the suitable and potential area was in the area of 100.78 sq. km., and the area around Phahonyothin Road had high density of residences and commercial buildings so such area was suitable for being developed according to the TOD Master Plan. We can see that analysis to find areas with potential suitable for different development is very important. Therefore, the GIS application in a decision-making process is another effective option [20].

The study results on finding area suitability for developing the railway station from Sila At Station to the destination station at Phu Doo International Point of Entry for supporting development of rail transport and logistics of Uttaradit Province can be used as a framework for selecting areas with consideration on land ownership. Therefore, the railway development from Sila At Station to Phu Doo International Point of Entry should be implemented under the development plan of infrastructures and public transportation, especially in developing rail transport infrastructures in accordance with Strategies for Developing Transportation System of Thailand in 20 Years B.E. 2560 – 2579 (2017 – 2036) which is a national development plan under supervision of Ministry of Transportation for increasing effectiveness of rail transport and services as well as for connecting various forms of transportation system at the border trade area to be more effective in the future.

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