The Optimization of Transport Route from Chon Buri, Thailand to Kunming, China by Using AHP and TOPSIS

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Abstract

This research paper studies the optimal routes in intermodal transportation between Chonburi, Thailand to Kunming, China since Kunming has become one of the trade centers in China and located close to Thailand. Also both countries have a challenging development in transport network connectivity. Currently, the route between Thailand and China have been limited because the route still lack the missing link, some routes are under construction, and routes in the future of national transportation plan. However, this study will assume for the future transport route that the missing links have been connected, the under construction routes have been completed This actions will increase the number of alternatives. Then this paper will consider the ideal route for transporting the freight. The route selection process examines 5 current routes and also considers 5 future routes to determine optimal of intermodal transport route which only road and rail transportation are analyzed. Regarding the criteria on there are quantitative factors (Transportation time, Transportation distance, Transportation cost) and the qualitative factors (Level of difficulty for transportation, Transport congestion, Opportunity for revenue) of with total 6 main criteria and 7 in sub-criteria, the most efficient transport route should be at the lowest cost, shortest distance and least transport time. Also Transportation belong this route should consider a good infrastructure, smooth transport flow and less congestion also it have a good change to making a business and revenue. On the other hand, the criteria have been weighed and selected by establishment with a mathematic model based on Analytical Hierarchy Process (AHP). The final phase using TOPSIS to optimize the route based on the weight. The results showed that route number 2, from Chonburi to Mae Sai, Chiang Rai in Thailand then to Xishuangbanna direct to Kunming, have a total distance in 1610 km with the travel time of 32 hours and the total cost is 13497.38 Baht. Therefore, is the ideal route for transportation with the highest TOPSIS score 0.876.

Keywords: Route selection, TOPSIS, Multicriteria decision, AHP

Introduction

International trade between Thailand and China has been established since 1975 which have 7 keys development in trade, investment, science/ technology, digital, tourism, finance, and regional economic cooperation to bring stronger trade relationships the countries. Thailand and China have made agreements on Trade and economic such as China- ASEAN Free Trade Area, The Thailand - China Joint Trade Committee (JC), The Greater Mekong Sub- region Cooperation, and Silk Road Economic Belt. Nowadays trade between Thailand and China values more than 2.6 Billion US. The most export products from Thailand to China are rubber, machinery, plastics, and electrical. In contrast, the most import products from China to Thailand are electrical, machinery, iron, and steel. (Trading Economics, 2020). Growth of the international trade is a reason to contribute on the transportation routes.

This research established transportation between Thailand to China. The original point is Chonburi province in Thailand. This area is economics zone surrounded by free zone and industrial area which received investment and support from the government. The significance of this province is appealing to export industry because of maritime advantages, located near the Laem Chabang port, which is the largest port in Thailand. Also, it is close

to Bangkok, the capital city that support roads and Suvarnabhumi airport are developed. This city connects with rail transport between Lame Chabang port and inland container depot. Also, Kunming is the destination which located in the South of China. It is one of the important cities becoming the center connectivity with the countries in South East Asia which considered the main market and transportation consolidation point in the South of China. Currently, Thailand and China have a collaborate in international trade, investment to enhance the economics relationship. Transportation is a key function in the way of import and export for transfer the product. Expansion the alternative of transportation route has to be considered and planned. It led the import and exporter to select the best transport route.

Due to the movement of trade between Thailand and China including the neighbor countries such as Laos, Myanmar, Cambodia, Vietnam, the business activities are increasing every year. However, transport, which is one part in international trade, is still facing with the problems such as missing link between rail and road transport around 4,069 kilometers in Cambodia to Thailand, Thailand to Myanmar and Vietnam to Cambodia. The cause-effect problem came from financial constraints for implementation (Team ERIA Study, 2010). Secondly. Routing according to trade and policy plans have been under construction. Lastly, the future route in the national transportation plan have not been constructed. These reasons limit with an alternative in the transportation route. At the time of this study, no previous research has investigated to optimal decision routes in the future of international transport route by looking forward in the next 10-20 years, which assumes all of missing links would have been connected including the route under construction and assume in the future transport route follow by national transportation development plan would have been finished. This assumption contributes to increase of an alternative in transportation route for selecting the best transport route. the ASEAN Secretariat, 2011)

These studies intended to consider the existence of the transports route in the current situation and in the future between Thailand and China for route selection. The research objectives of this paper are to 1) fulfill and find new ways of transport between Thailand and China which solving transport problem in link missing, completing under construction route and ing the route from national transportation plan. 2) analyze the route characteristics in specific routes regarding effectiveness of transport between Thailand and China 3) select the ideal route solution from Chonburi,Thailand to Kunming, China by analyzing based on in lowest cost ,shortest distance and less transport time. Also the route have a good infrastructure, smooth transport flow and less congestion and it can make good change to making a business and revenue by using The AHP for evaluating the weight of criteria then using TOPSIS for optimal the ideal intermodal transport route. This study will be beneficial to the government, investors, and entrepreneurs for understanding the efficiency and competitiveness transportation of the current and future routes. Moreover, considering in the new route, it can support the relevant department to make an alternative of transportation which reducing on cost, time, enhance the transportation level for improving international trade economic development along Thailand and China.

As mentioned about the previous research, this study aims to fulfill the gap for future transport route selection which complete in missing link and route under construction process. At the same time, many research concentrated on the current route and current transport situation with less an alternatives. This paper claims that there should be more studies of the future route which can make more optional in transport route and alternative. For this reason, it would be advantageous for future research to complete this gap and make selection concept presented in section 2. Model and methodology for route selection explained in section 3, following by data

collecting from transport policy and development in the national transport plan between Thailand to China described in section 4 and section 5 which an analytical result. Lastly, the paper explains the conclusion and future development research in the last section.

Literature reviews

The related literature reviews are presented to review of transport route selection The outcome of literature to fulfill the gap and select the best alternative in intermodal transport routes.

Most of the research focus on selection routing regarding the minimum cost, minimum time, and maximum profits. (Banomyong ,2001). However, other criteria must be concerned with the shortest distance, risk, best customs clearance, and environment which all combined and analyzed to optimize the best solution (Ma Rongwei, 2017). Pham & Yeo (2018) examined to select the routing transport between China and Vietnam to carrier the high-value product as electronic components that must be concerned with security and reliability. (Yang, Low, & Tan, 2011) The author presents 36 alternative routings transport from China to the Indian Ocean with the goal programming with the objective function to minimizing in transportation cost, transit time and transit time variability including the transit nodes compatibility using the sensitivity analysis for analyzing the potential and possible route that affect in current and future development. (Seo, Chen, & Roh, 2017) examine the route decision to transport a laptop from China to Rotterdam by using the cost model. In each route, it has to transfer the product to the other mode of transport such as rail, sea, and truck. However, each process concern with the risk and cost of movement. Finally, they found out that the best route should have lower cost and make a movement of product safely. (Wang & Yeo, 2016) state that the key reducing cost and other factors coming from how to decide and manage transport network efficiently. The author presented that after applying survey and fuzzy mathematic model to consider route and combine mode transport as a sea- rail and sea- road between Korea to Central Asia also consider in as cost, time, reliability, security and transport capability. It found that cost is the most considerable factors. The suitable mode for selection is sea and rail transport combination. (Kopytov & Abramov, 2012) The author had explained the method used in decision transport mode. The author recommended using multiple criteria decision analysis (MCDA) and Multiple attribute decision making (MADM) to select the alternatives of route and mode of multimodal transport. the most considerate factors are cost, time, reliability, and ecology. In contrast, this research states that the ELECTRE model and AHP do not suit to solve the problem because inaccurate results are possible when given the weight criteria. The ELECTRE and AHP need to evaluate in a different expert. (Moon, Kim, & Lee, 2015) This author using the triangular fuzzy number and TOPSIS to select the route between Korea and EU which consider on qualitative and quantitative criteria in the distance, time, cost, transport service, safety and awareness the results found that using Trans Korea railway mixed with Trans Siberia Railway (TRS) is the best route for competitiveness in the future transport. (Chanpuypetch & Kritchanchai, 2009) They stated that using FAHP to decide the route in the gateway for Thailand to export the rubber to China with the criteria consider in transportation, economics, port, customs clearance, and environment plus with 12 sub-criteria. However, the result of optimal cannot be identified and the author gives an idea that the results on selection will change in different conditions. (Kengpol, Tuammee, & Tuominen, 2014) The author applies ZOGP and AHP to find out the best route which the objective to minimize transportation costs, time, risk, and concern in CO2 emission the results found that sea transport from Bangkok

to Da Nang port can fulfill this objective. In addition, the number of alternative routes will influence of logistics and supply chain channel with can consider more route. It will affect the future competition in transportation (Fan, Wilson, & Tolliver, 2010).

For weight calculation (Kengpol, Meethom, & Tuammee, 2012) suggested using the questionnaire in pairwise comparison and AHP to identify and calculate the weight of decision-maker before using ZOGP analysis for the optimal route. This research also studies to select in the alternative by combining AHP and ZOGP to select a multimodal route between Greater Mekong sub-region countries (GMS) with the criteria concern in cost, time, and risk upon the transport route. Also, TOPSIS is one of the decision methods to select the ideal solution also applied with supplier selection, route selection, the supply chain in green logistics, and reverse logistics.

Following on the review of main and relative papers, they provide direction to decide in various original and destination points all around the world or crossing the region. Also, it can apply to select the mode of transportation and product of carrier. The direction on this research can suggest the methodology and method such as cost model, goal programming, AHP (Analytic Hierarchy Process), TOPSIS, Fuzzy Delphi and all multiple decision methods to support all decisions in route transportation to accomplish the objective function. (Sansanee, 2007).Lastly, the summary of the literature review related to transport route selection and decision are described as table 1 below

Table 1 Summary of literature reviews by author

Author	Criteria	Transport Route	Method	Objective
(Moon et al., 2015)	distance, time, cost, transport service, safety, and awareness	Korea and EU	Fuzzy number and TOPSIS	Select the best route
(Yang, Low, & Tan, 2011)	transportation cost, transit time, transit ,time variability, Transit node	36 alternative routes from China to Indian Ocean	Sensitivity analysis	Analyze the potential for future development
(Pham & Yeo, 2018)	Transportation costs, transportation mode capacity, and transportation time risk of freight damage and loss	Shenzhen (China) to Hai Phong (Vietnam) which carrier in electronic components	Delphi method and the Consistent Fuzzy Preference Relations (CFPR) and Sensitive analysis	Evaluate the competing transport routes for door-to-door transportation
(Seo et al., 2017)	Transport cost, transfer cost, transit time, transport distance, document charge, port congestion surcharge, customs charge,	Chongqing China to Rotterdam the Netherlands in 7 routes	Cost- Model	Make Decision for the best route with lower cost and safe produce during transport.

Table 1 (Cont.)

Author	Criteria	Transport Route	Method	Objective
(Wang & Yeo, 2016)	Cost, time, reliability, security, and transport capability	Korea to Central Asia	Fuzzy mathematic model in Fuzzy Delphi method	Decide the transport network
(Kopytov & Abramov, 2012)	Cost, time, reliability, and ecological impact	Shanghai to Moscow	Multiple criteria decision analysis (MCDA) and Multiple attribute decision making (MADM) and AHP	Suggest the method to evaluate the alternative in cargo transportation
(Chanpuypetch & Kritchanchai, 2009)	Transportation factors, economic factor, port/customs considerations, and environment considerations 12 sub criteria	Thailand to East China	Fuzzy analytic hierarchy process (FAHP)	Explore the new alternative gateway and selection the gateway
(Kim, Lee, Seo, & Kim, 2019)	Development plan, political instability, and possible linkages	Trans-Siberian Railway (TSR) in the Russian Far East	SWOT-FAHP plus questionnaire	Identify the factors that impact on operation in multimodal transport
(Kengpol et al., 2012)	**Quantitative** The budget and time. **Qualitative** criteria are risk of freight damaged, risk of infrastructure and equipment and risk of other factors	Greater Mekong sub-region countries (GMS).	AHP/questionnaire + Zero-One Goal Programming (ZOGP)	Develop a decision support system (DSS) model to optimize route in GMS
(Kengpol, et al., 2014)	Cost, time, risk, CO2 emission	Bangkok in Thailand to a destination at Da Nang port in Vietnam.	AHP/questionnaire + Zero-One Goal Programming (ZOGP)	Minimize transportation costs, transportation time, risk and CO2 emission.

In conclusion, the previous studies mostly focused on transport mode distribution, mode of transport, and route selection by transporting some products from origin to destination all around the world such as from Asian to Europe, Asia to North America or South America, Asia to Central Asia, Far East to Europe which the proposal to reduce cost, lead time, risk, service. Some of the research focused on the environment in CO2, green route. Furthermore, the researchers have studied in specific areas and between Thailand and China; for example, it optimizes of the route for the cheapest way with 7 international transport routes, or Selection of export route in the GMS region and the gateway to export the rubber from Thailand. Most of the research use quantitative method such as model selection, genetic algorithm, dynamic programming, and AHP. Some of the research use questionnaires and interviews to solve the problem and find out the answer. In this study, the author would like

to focus and find the best option at the time of study. All of the research still lacks of studying in the future situation and route options which is the gap for further study.

This research focuses on various routes of transportations in response to trade and policy between Thailand and China. During the time of study, the route optional is limited because of the construction and remaining of missing link of routes. This affects the decision of less alternative in selection. However, the transport route option will be assumed after fixing the missing link and all of the routes under construction are completed. It will increase the number of route alternative for selection. The propose of this research to study and design the future transportation route. Then using the decision model to analyze the best alternative route by considering transport cost, transport time, transport distance, level of difficulty for transportation, transport congestion, and opportunity for revenue in both of current and future route. Therefore, the research contributes to an increase in the number of alternatives in the transportation route. Also, these studies using the decision method to select the ideal transport route between Thailand and China.

Methodology

As the previous studies related to routing decision mostly focused on a current route situation, It did also not consider in the future route by analyzing in missing link, future transport policy, and route under construction to design and adding more alternatives in route selection. To fulfill the gap of study, this paper considers both current and future routes to optimize in the ideal transportation route. The overview of the study process shows in Fig. 1, the step 1: define areas of study from review the transport information from Chonburi Thailand to Kunming China. Step 2. Reviewing and collecting the international transportation route which identify all the transportation routes the current and future situation. This route composes of rail and road transportation. Step 3: Integrating quantitative and qualitative decision making from review the previous research in intermodal transportation relating with decision making quantitative concern in distance, cost, and time. Also, the qualitative in the criteria of decision concern to level of difficulty for transportation, transport congestion, and opportunity for revenue. Step 4: Calculate weight of criteria by using AHP and pairwise comparison. last step use TOPSIS to optimize the ideal solution in transportation route.

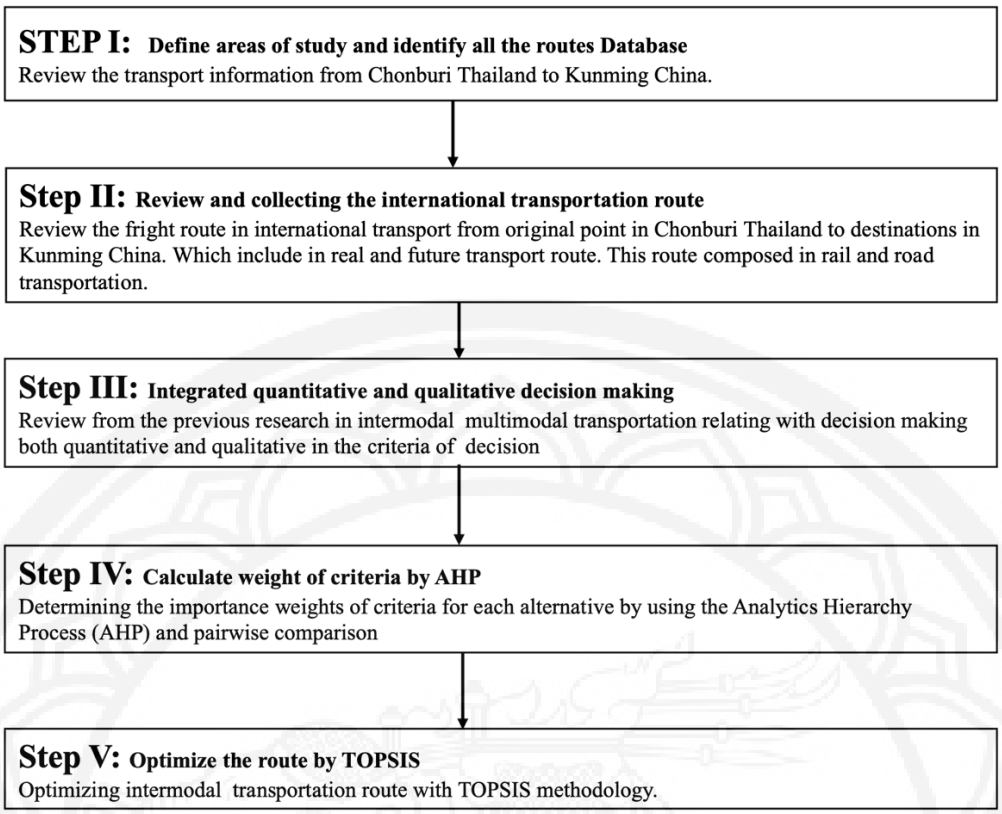

Figure 1 The process overview to optimize routes selection

Collecting Data and Identifying criteria and weight factor calculation

The feasible transportation route from Chonburi in Thailand to Kunming in China adopts the data of transport policy, transport development plan, missing link transportation, conference, and literature review from previous research. The description for the entire route described in section 4 in collecting data. Moreover, the factors related to transport route selection were divided into 2 sections; quantitative factors and qualitative factors. The criteria gained from studied in the previous research and interview with the expert in logistics. The criteria can support to evaluate and optimal the decision. The details of the criteria and sub-criteria show in table 2. The criteria in quantitative factors such as transport distance, transport time, and transport cost are numerical data. These criteria have been used for supporting the operation transport as less time, low cost and short distance. Also, the qualitative factors concern level of difficulty for transportation (facility of infrastructure, surface condition), transport congestion (number of cars, slow and speeds, traffic congestion), and opportunity for revenue (opportunity for revenue belong to the transport route and opportunity for opening the business). The qualitative criteria able to analyze route characteristic in traffic and opportunity on the route for support transport route decision. Transport experts for examine the importance of the criteria and examine by using pairwise comparison and AHP.

Table2 Detail of Criteria and Sub criteria

Criteria/	Sub – Criteria	Definition
Transport distance		Total distance from origin to destination
Transport time		Total time belong the transport form origin to destination
Transport cost		Total cost required for transportation
Level of difficulty for transportation	Facility of infrastructure	Facility of infrastructure in route transportation
	Surface Condition	Surface Condition in the transportation
Transport congestion	Number of cars	Number of cars on the road
	Slow and speeds	Slow and speeds belong the transportation route
	Traffic congestion	Traffic congestion in transport route
Opportunity for revenue	Opportunity for revenue	Opportunity for revenue in transportation route
	Opportunity for business	Opportunity for business belong route

Be consider studies on the criteria of route selection. The hierarchically classified as shown in Fig 2. The framework for transport route decision between Thailand and China illustrate that It need to consider 10 alternative routes under the 6 main criteria and 7 sub-criteria before select the best alternative.

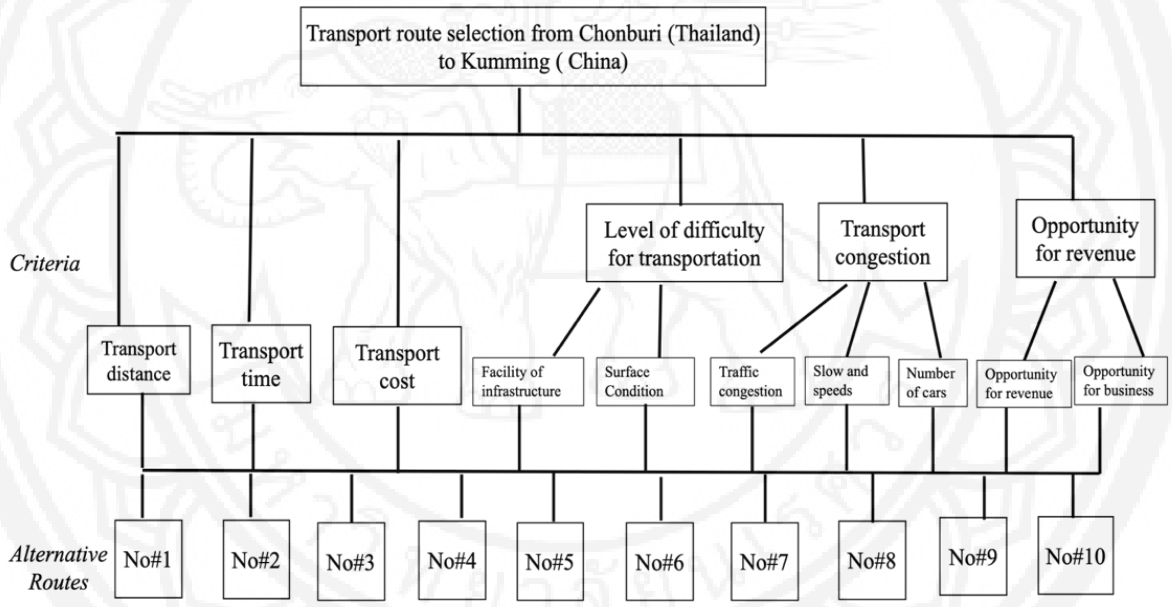

Figure 2 The framework for transport route decision between Thailand and China

Analytic Hierarchy Process (AHP)

AHP is one of the methods to manage and evaluate from the multiple decision-makers. The AHP is used to organize complicated problems and resolve these criteria into different levels from various directions. In the AHP, get many criteria into consideration for evaluation of any situation such as route selection, evaluation of supplier, evaluation of mechanism. In this study, AHP is used to determine the weight of criteria by using the fundamental scale (see Table 3) and pairwise comparison for analyzing the score given by the specialist opinion (Yan, Tsai, & Wang, 2006). Besides, one of the advantages of AHP can formulate the problem in the matrix between quantitative and qualitative criteria as well. (Hamed, 2017) Regarding the step to calculate the AHP, firstly, it starts with establishing the goal and criteria for the decision-maker in the questionnaire. The second

step, conduct the pairwise comparison and design the questionnaire which specific in pairwise, and the scale ranges from 1 to 9. The scale can imply the element of the importance of the fundamental scale of pairwise comparison. The last step, evaluate the weight of pairwise comparison then calculate to merging amount of answer, this should be repeated several times when facing with incompatible matrix showing on the equation below.

$$Aw=\lambda_{max}w, \lambda_{max} \geq n$$

$$\lambda_{max} = \frac{\sum a_j w_j - n}{w_1}$$

A=$\{a_{ij}\}$ with $a_{ij}=1/a_{ij}$

A : Pair wise comparison

w: normalized weight vector

λmax : maximum eigen value of matrix A

a_{ij}: numerical comparison between the values i and j

Table 3 The fundamental scale of pairwise comparison

Numerical Rating	Definition
9	Extremely important
8	Very to extremely important
7	Very strongly important
6	Strongly to very strongly important
5	Strongly important
4	Moderately to strongly important
3	Moderately important
2	Moderately important
1	Equally important

The next step, for more accuracy, consistency should be checked for ratio by using the method CR = CI/RI which the CI can calculate follow on this equation 1. Lastly, RI generates from random the value and n depend on the number of elements showing on below.

$$CI = \frac{\lambda max - n}{n - 1}$$

n	3	4	5	6	7	8
RI	0.058	0.90	1.12	1.24	1.32	1.41

However, using AHP on multiple criteria decisions to weight the importance of each criteria which the constrain in consistency index for the paired comparison matrix is less than 0.1 (CI < 0.1). It implied that the pairwise matrix are acceptable and consistency (Kengpol, Meethom, & Tu, 2012; Hamed, 2017; Yan et 2006)

TOPSIS

Technique for Order Preference by Similarity to the Ideal Solution is one of the most popular method for multiple criteria decision analysis to evaluate and select an alternative. Basically, TOPSIS select an alternative which nearest the ideal solution and far from non-ideal solution. In this study, TOPSIS can determine the objective in each criteria. The objective for maximizing is opportunity for revenue whereas the objective to minimize is cost, distance, time, congestion and difficult in transportation. TOPSIS calculation for route selection following on the step (Singh & Singh,2018).

Step 1 : Using the normalized decision matrix $[rij]_{m\times n}$, where $rij(i = 1,...,m$ and ; $j = 1,...,n)$ to indicate the score of j and j in criterion

$$rij = \frac{\mathrm{xij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

Step 2 : Construct the weighted of factor to Normalized Decision Matrix to get the weight of normalized performance rating

$[v_{ij}]_{m\times n}$, where v_{ij} $(i = 1,...,m;\ j = 1,...,n)$

$$v_{ij} = r_{ij} \times w_{ij}$$

wj is the weight of criterion m j and $\sum_{j=1}^{n} w_j = 1$

Step 3 : Identify the positive and negative ideal solution as following the equation.

$$A^+ = \{v_1^+, v_2^+, \dots\dots\dots, v_n^+\} = \{(\max v_{ij} : i \in I),(\min v_{ij} : i \in J)\}_{jj}$$

$$A^- = \{v_1^-, v_2^-, \dots\dots\dots, v_n^-\} = \{(\min v_{ij} : i \in I),(\max v_{ij} : i \in J)\}$$

Step 4 : Calculate the separation measures in the positive and negative ideal solution

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}\ ,\quad i=1,...,m\ ,j=1,...,n$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}\ ,\quad i=1,...,m\ ,j=1,...,n$$

Step 5 : the preference the ideal solution value of each route alternative Ai is defend

$$c_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

Step 6 : The alternations have a high value result. It can determine that alternative in the first ranked.

AHP and TOPSIS method are employed in this research because of the function and charterers of the method support the requirement for solving the transport solution. Both methods can support each other; AHP can solve the complex decision-making problem by analyzing the weight of criteria and the pairwise comparison matrix provides a completely consistent evaluation. TOPSIS precise scores that each alternative receives from all the criteria then use to combine and complete the objective by selecting the ideal transportation routes. (Karim & Karmaker, 2016)

Collecting data

This research focuses on routing in current transportation and future route transportation from Chonburi Thailand to Kunming in South of China which considers and collects the data on transport agreement, literature review, transport policy & development plan, the competitive transport system of each nation. For deep information enquire and interview a specialist in transportation (Moon, Kim, & Lee, 2015).

The current route between Thailand and China under the transportation development plan are Greatest Mekong sub- region, Singapore Kunming rail link, Asian Highway network, The Master Plan on ASEAN Connectivity (MPAC), The ASEAN Framework Agreement on Multimodal Transport (AFAMT), of Southern Transport Corridor (STC) all of those master plan related with transport facilitation, transport infrastructure, international transport procedures to reduce logistics cost and cargo movement between the countries. State the problem between Thailand and China. Thailand faces the problem of the limited infrastructure and network, insufficient facilities, highway, and railway network which still under development. In contrast, China has more development in transport in the way of land and sea to connect transport in internal and external between the nation as well. The transportation route and transport development plan related to Thailand to China were described below.

Transport network

Road transport

Thailand shares the boarder with Myanmar, Cambodia, Laos, and Malaysia but not with China. Therefore transport goods to China has to be via Lao, Myanmar, and Vietnam which can generate the development plan as below.

Greatest Mekong sub-region

Greatest Mekong sub-region brings 6 counties; Cambodia, China (specifically Yunnan), Laos, Myanmar, Thailand, and Vietnam. The proposal of this transport route is to improve the connectivity of transport, infrastructure, and facilitation of cross-border to enhance the economic corridors- current route transport via Greatest Mekong sub-region from Thailand to Kunming.

1. Route No. 3A (R3A) connects between northern Thailand and the South of China which starting from Chiang Khong District in Thailand to Houayxay of Laos, Bo Ten, Mohan, and Kunming (Yunnan Province) in China's Yunnan Province. The R3A is one of the busiest routes for business and transport after the Fourth Thai-Laos Friendship Bridge (Chiang Khong- Ban Houayxay) have been officially commenced.

2. Route No. 3B (R3B) this route is similar to the R3A starting point is in Thailand and the destination is in Kunming, China but the route pass through Tachilek in Myanmar and Mae Sai District in Thailand. However, this route does not have much usage because of high risk and lack of security including additional extra in logistics cost. The quality of road is less convenient (Luangvisethgul & Sirira, 2017).

The main advantage for Thailand on route R3, R9 was the reduction of logistics cost and time and spent more days to allocate the goods to China; specifically, route R3 spent only 2 days to transport goods from the North of Thailand to China instead of transport by sea which spent more than 7 days. The Greatest Mekong sub-region is still having the route from Thailand to China in way of East-West Economic Corridor: EWEC in route R5 running from Thailand to Hanoi and going Guangxi in China. Also, R8 starting from Thailand to Bueng Kan to Pak Song in Lao passing Hanoi in Vietnam and end in Guangxi in China. R9 this route starting from Bangkok passes through Mukdahan and Savanna Khet to Dansavan – Laobao in Laos passing Langsan – Youyiguan Vietnam next to Nanning in Guangxi in China (Gong & Cullinane, 2018). Lastly with R12 start with Nakhon Phanom in Thailand to Kham Muon in Lao running through Hanoi of Vietnam and ending in Guangxi. In conclusion, R5 R8 and R12 are one of the transport developing plans from origination in Thailand and destination in Guangxi China. (Tantrakonnsab & Tantrakoonsab, 2018)

There are many routes that have been under construction to improve road transport between the countries. Firstly, Fifth Mekong Friendship Bridge to connect Bueng Kan, Thailand, Laos, Vietnam, and China. Secondly, the future route transport planning to use in 2022 on Sixth Mekong Friendship Bridge in Na Tai district in Ubon Ratchathani across the Mekong River to Muang Lakhonpheng in Salavan province of Laos. The advantage of Greatest Mekong sub-region is lower cost than air transport with the advantages of low risks and save time comparing maritime transports (Pham & Yeo, 2018; Tantrakonnsab & Tantrakoonsab, 2018; The nation, 2018)

Kunming-Bangkok Expressway

Kunming- Bangkok Expressway, this route running Kunming, Yunnan (China) to Bangkok, Thailand via Laos. To compare this road route is the same way Route No. 3A (R3A) by starting at Chiang Khong (Thailand) enter to Northern Laos in Mohan (China- Lao border) next to Kunming in China. The advantage of this expressway will increase the number of transport and it has been reduced to 8- 9 hours using this expressway (Zhenghua, 2020). However, some routes of this project have a construction plan in the future and some routes are under construction along from Kunming to Mandalay (Burma) and Kunming to Hanoi Vietnam. (Trans-Asia discovery, 2020)

On the other hand, Freight Transportation in Thailand mostly uses road transport over 80%. Because of the government support to develop the infrastructure of road transport to connect with Asian highway, it contributes the connectivity of transport from North to South and East- West which connects to Myanmar's Mawlamyine Port and Dawei port in the west, through Central and Northeastern Thailand and Laos, to Vietnam's port city of Danang. In Eastern region, there are 13 highways connecting neighbor countries with and four- lane highway. Hence, the highway can reduce transport distance around 800 km. In the future, Thailand should focus on intercity roads for connecting with neighboring countries and sub- regional groups. Also, Thailand has an agreement with neighboring countries to cooperate for fright transport of goods by Thailand, Malaysia to Singapore. Likewise, Thailand and Laos have an agreement to open cross border, trade and market without quota limitation (Pomlaktong, Jongwilaiwan, Theerawattanakul, & Pholpanich, 2014).

Rail transport

Rail transport has an advantage in cheapest transport for the cargo in high volume. However, rail transport still lack in infrastructure as railway network is not available in every province; also lack of missing link. The 91 percent of railway have been "single-track" which is one of transport delay in Thailand. However, double-

track railway and new line should have been supported and developed for increasing some rail connectivity and coverage.

However, the rail transport project between Thailand and China is ″Thai-Chinese Railway″ "Trans-Asian Railway network" and "Singapore-Kunming Railway" government have a plan for develop high speed rail connecting ASEAN and China with the goal of improve transportation and collaboration in free trade between China and Asia. In addition, rail transport can increase trade and economics of each countries (Menz, 2012).

1. Trans-Asian Railway network connect rail network transport from China to Bangkok and Kuala Lumpur which the destination is in Singapore. Cambodia, Vietnam, and Myanmar connect and linking by train is in the future plan. (Menz, 2012)

2. Thai-Chinese Railway linking in 3 countries, China, Laos and Thailand, Nong Khai - Nakhon Ratchasima - Kaeng Khoi - Map Ta Phut Pier, and Kaeng Khoi - Bangkok. The route of the project will connect with the Silk Road from Kunming, China, through Luang Prabang, Laos, and finally converge in the Nong Khai province of Thailand.

3. Southern corridor rail connects Europe to Southeast Asia, merging Turkey, Iran, Pakistan, India, Bangladesh, Myanmar, and Thailand, with link to China's Yunnan Province and, via Malaysia, to Singapore.

4. Singapore-Kunming Railway Link is the route from Kunming (Yunnan province) China to Singapore. Start with Central Route (Kunming-Vientiane-Bangkok-Kuala Lumpur-Singapore) Eastern route (Kunming - Hanoi- Ho Chi Min city - Phnom Penh - Bangkok - Kuala Lumpur- Singapore) Western route (Kunming - Mandalay-Rangoon - Bangkok-Kuala Lumpur- Singapore) (Geopolitical Monitor, 2019). Therefore, focus the route from Thailand to Kunming China is Central Route (Bangkok - Vientiane- Kunming) Eastern route (Bangkok- Phnom Penh- Ho Chi Min city -Kunming) Western route (Bangkok-Rangoon- Mandalay-Kunming). In addition, (Termpittayapaisith, 2011) the author gave details in the potential route from Thailand to Kunming China that firstly, route pass though Myanmar in (Bangkok - Three Pagodas - Myanmar - China). Also though Lao in (Bangkok - Chiang Rai - Chiang Khong/Houy Sai - Lao PDR - China) next pass to Vietnam and Lao in in (Bangkok - Nong Khai - Lao PDR - Vietnam - China),(Bangkok - Ubon Ratchathani - Lao PDR - Vietnam - China),(Bangkok - Bua Yai -Mukdaharn - Lao PDR - Vietnam - China) and Lastly this route pass Cambodia and Vietnam (Bangkok - Aranyaprathet - Cambodia - Vietnam - China)

However, the rail route between Thailand to China showed that development still faces the problem in missing links; 1) Thailand and Cambodia between Aranyaprathet-Klongluk (Thailand) and Poipet-Sisophon (Cambodia), 2) Cambodia and Vietnam between Phnom Penh to Loc Ninh to Ho Chi Minh City, 3) Vietnam and Lao the missing route between Mu Gia-Tan Ap-Vung Ang (Viet Nam)- Vientiane-Thakek-Mu Gia (Lao PDR) (Cheen, 2014) the missing link inside of Thailand between Bangkok and Nong Khai was a plan for high-speed rail since 2018, 5) the route between Thailand and Myanmar Thanbyuzayat - Three pagoda - Nam Tok (De & Chirathivat, 2018). Lastly, one of the missing links from Mandalay Myanmar to Kunming China. One of the interesting on this missing link in Myanmar to complete it will expand the railway links from India to ASEAN countries. Trade and economics more stronger.

Analysis on current and future transportation routes from Chonburi Thailand to Kunming China.

This section concludes the concept on a transportation route. This case illustrates of reality from Chonburi, Thailand to Kunming, China in the current route (Route number 1 - Route number5) and feasible route in the future (Route number 6 - Route number 10) which consolidation route from the missing link, route under

construction, and transport policy. These routes are composed of 2 transport modes, road, and railway. This paper analyzes and selects the best transportation route in the current and feasibility route between Chonburi Thailand to Kunming China. Then the overview of route shown on table 4.

Table 4 Overview of route transportation between Chonburi Thailand to Kunming China

Route no	Name of route
No#1	Chonburi # Chiang Rai, Mai Sai# Keng Tung# Mong La # Menghai # Kunming
No#2	Chonburi # Chiang Rai, Mai Sai # Xishuangbanna # Kunming
No#3	Chonburi#Chiang Rai,Chiang Khong#Luang Namtha/Boten# # Xishuangbanna #Kunming
No#4	Chonburi # Nakhon Phanom # Vinh#Hanoi#LaoCai# Kumming
No#5	Chonburi# Huaikon # Pang Hoc# LaoCai# Kumming
No#6	Chonburi # Chiang Khong #Lashio (MY) # Kunming
No#7	Chonburi # Fifth Mekong Friendship Bridge to connecting Bueng Kan and Bolikhamxay # Hanoi # Kunming.
No#8	Chonburi = Bangkok = Nong Kai= Vientiane =Mohan= Kunming
No#9	Chonburi = Aranyaprathet/Klongluk = Poipet-Sisophon =Ho Chi Minh City = Hanoi = Kunming
No#10	Chonburi = Bangkok = Nam Tok = Three pagoda= Thanbyuzayat = Yangon = Mandalay = Lashio = Kunming

Note 1: # road transportation =rail transportation

Note 2 : Route# 1-Route#5 is current situation Route# 6-Route#10 the future transportation route

Source : (Thiengburanathum, Banomyong, & Sopadang, 2006; Songmuang & Ocha, 2017; De & Chirathivat, 2018); Atom,2020; Krebs & Boonsub,2019; Trans-Asia discovery,2020)

The illustrates; international transport route between Chonburi Thailand to Kunming China showed in figure 3 and the detail in each route described below.

Route 1: Chonburi to Kunming in China starting from Chonburi to Chiang Rai and Mai Sai of Thailand by road transportation then continue to Keng Tung and Mong La in Myanmar near the border of Thailand pass through to Mong La, Menghai and direct to Kunming

Route 2: Staring from Chonburi to Chiang Rai and Mai Sai in Thailand passing Xishuangbanna in the south of Yunnan province in China after that direct to Kunming by road transport for the entire the route.

Route 3: Chonburi to Chiang Rai and Chiang Khong in Thailand and cross the border to Luang Namtha Boten in Lao before going to Xishuangbanna and direct to Kunming. This route also use road transportation entirely.

Route 4: Chonburi to Nakhon Phanom in the northeast of Thailand direct to Vinh and Hanoi in Vietnam and pass Lao Cai in the north of Vietnam and cross the border before direct o Kumming. This route has a long-distance because of pass-through Vietnam with road transportation.

Route 5: Chonburi to Huaikon located in Nan, North of Thailand then going to Pang Hoc in Lao and pass Lao Cai in Vietnam before direct to Kumming China with road transportation. This route pass with many countries that it increases the opportunity in economic and business along the route

Route 6: This route is a future route planning from Chonburi Thailand to Chiang Khong which is a district in the northeastern part of Chiang Rai province, northern Thailand then crosses the border to Lashio in Myanmar before direct transport Kunming China with road transportation.

Route 7: Depart form Chonburi Thailand to Bueng Kan the northeast of Thailand cross the Fifth Mekong Friendship Bridge (This bridge is still under construction and it plans to finish in 2023) (Trans-Asia discovery, 2020). Then cross countries to Bolikhamxay in Lao and pass to Hanoi before direct o Kunming in China.

Route 8: Chonburi to Bangkok by rail transport and then to Nong Khai in Northeast of Thailand and using rail transport to Vientiane in Mohan in the south of Yunnan before using rail transport to Kunming. This route is under the high-speed train plan from the Kunming to Singapore rail link.

Route 9: This route starts from the East of Thailand passing through Cambodia and Vietnam before directing to Kunming. Chonburi, Thailand to Aranyaprathet/ Klongluk, Poipet- Sisophon in Combodia by rail transport, then using rail and road connecting to Ho Chi Minh City and Hanoi in Vietnam before Kunming in China by using rail transportation. The missing link are between Aranyaprathet-Klongluk (Thailand) and Poipet-Sisophon (Cambodia) and missing between Cambodia and Vietnam, Phnom Penh to Loc Ninh to Ho Chi Minh City.

Route 10: This route has a direction to the west of Thailand starting from Chonburi to Bangkok and Nam Tok Railway Station in Kanchanaburi in the west of Thailand using rail transport and going to Three pagoda and then Thanbyuzayat, Yangon, Mandalay and Lashio from the border from south to north of Myanmar before using the rail transport to Kunming in China. This route has a missing link of rail transport between Nam Tok to Three Pagodas and Thanbyuzayat and Lashio to Kunming.

Analysis Results

The information on qualitative and quantitative method results examined comparison both of current and future routes, it found that the current route in route number 2 from Chonburi to Mae Sai, Chiang Rai in Thailand passing Xishuangbanna and leading to Kunming is the shortest distance with the lowest cost in transportation. On the other hand, future route on route number 8 which is under transportation plan and some part is under construction by rail from Chonburi via Bangkok to Nong Khai (Thailand) with the direct to Kunming passing Vientiane of Laos, has the shortest transportation time approximately 26 hours. Furthermore, considering transport congestion, the number of cars, flow of traffic congestion, the result shows that route number 5 from Chonburi passing Huaikon and Pang Hoc to Lao Cai and end at Kumming have no convenience for transport comparing the other routes. These results are from the perspective of specialists in contrast of route number 8 which is more convincing to transport than the other routes. Route number 5 gives more opportunity for Economic in way of opening the new business along the route. Lastly. Route number 4, from Chonburi to Nakhon Phanom in Thailand, then to Vinh and Hanoi and the border point at Lao Cai in Vietnam before going to Kumming shows the most difficulty in transportation by facing of the facility of infrastructure and surface condition with the value of 4.50 from the expert perspective as shown in table 5. However, the result on the table number 5 collected from the data on the website such as a google map on the distance and approximately in time. The cost calculates form the transportation cost structure in one the transport company located in Chonburi Thailand. Lastly, Transport congestion, opportunity for economic, level of difficulty for transportation earns the data on the questionnaire with 10 specialists in transport sections and the results show on table 5.

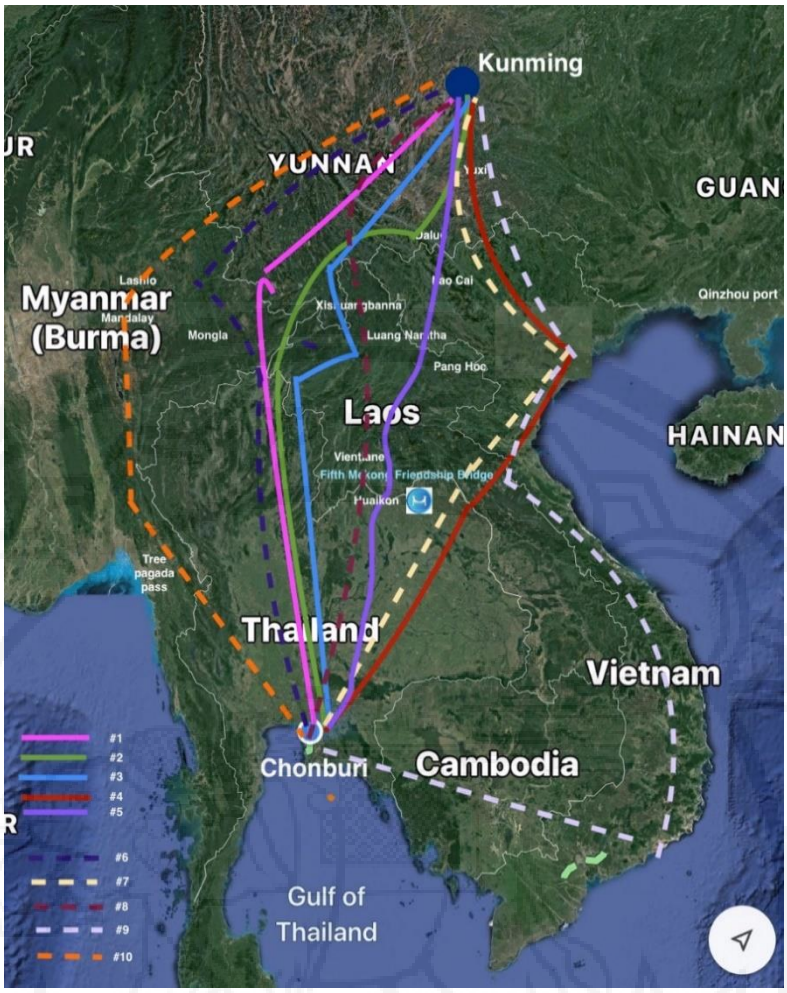

Figure 3 illustration of international transport route between Chonburi, Thailand and Kunming, China

Table 5 Transport route information data

Route no	Distance	Hour	Cost	Transport congestion	Opportunity for Economic	Level of difficulty for transportation
No#1	1870	38	14667.38	3.7	3.30	2.95
No#2	1610	32	13497.38	3.9	3.33	2.95
No#3	1855	39	14599.88	3.2	3.67	4.30
No#4	2071	43	21713.88	3.3	3.27	4.50
No#5	1854	39	18303.38	3.9	3.83	3.45
No#6	2031	43	19453.88	3.8	3.17	3.65
No#7	2206	45	22691.38	3.1	3.43	2.45
No#8	2733	26	24016.88	2.3	3.33	3.95
No#9	3276	40	29546.38	2.9	3.47	3.45
No#10	2070	34	21007.38	2.8	3.33	3.95

Weights of criteria is one of the most important criteria to select the best transportation route. The perspective are from the 10 specialists in logistic filed determining the score in questionnaire on the criteria. Then using the AHP pairwise comparison matrix to determine the criteria which the consistency index is less than 0.1 (CI <

0.1) meaning that acceptable consistency. For calculating of route selections with results of AHP to calculate in weight by specialists, in transportation of weight in criteria and sub criteria found that the most important factor to consider respectively as following; transport cost (0.27), Transport time (0.20) and Transport distance (0.17). Then Transport congestion coming to the fourth (0.14) with sub criteria in number of cars (0.02), slow and speeds(0.05), traffic congestion (0.07) are also important. After that the experts give the opportunity for Economics (0.13) in fifth rank with opportunity for revenue (0.06) and opportunity for business (0.07). For the expert opinion seeing that level of difficulty for transportation is the least with facility of infrastructure (0.06) and surface condition (0.03) the detail shown in the table 6. Table 6: The results weight of Criteria

Table 6 The results weight of Criteria

Criteria	Weight	Sub- Criteria	Weight
Transport distance		0.17	
Transport cost		0.27	
Transport time		0.20	
Level of difficulty for transportation	0.09	Facility of infrastructure	0.06
		Surface Condition	0.03
Transport congestion	0.14	Number of cars	0.02
		Slow and speeds	0.05
		Traffic congestion	0.07
Opportunity for Economic	0.13	Opportunity for revenue	0.06
		Opportunity for business	0.07

For the final phase of this research, the TOPSIS was used to optimize the best transport routes. The substantial weight gained via AHP with the specialist in transportation giving the transport cost is the most important criteria followed with transport time, transport distance, transport congestion, the opportunity for economic and level of difficulty for transportation is the last one. The paper considers on current route and future route from Chonburi Thailand to Kunming China for 10 routes.

Table 7 The results of ideal route by using TOPSIS

Route no	Route	TOPSIS score	Rank
1	Chonburi # Chiang Rai, Mai Sai# Keng Tung# Mong La # Menghai # Kunming	0.821	2
2	Chonburi # Chiang Rai, Mai Sai # Xishuangbanna # Kunming	0.876	1
3	Chonburi#Chiang Rai,Chiang Khong#Luang Namtha/Boten# # Xishuangbanna #Kunming	0.754	4
4	Chonburi # Nakhon Phanom # Vinh#Hanoi#LaoCai# Kumming	0.709	8
5	Chonburi# Huaikon # Pang Hoc# LaoCai# Kumming	0.791	3
6	Chonburi # Chiang Khong #Lashio (MY) # Kunming	0.742	6
7	Chonburi # Fifth Mekong Friendship Bridge to connecting Bueng Kan and Bolikhamxay # Hanoi # Kunming.	0.654	9
8	Chonburi = Bangkok = Nong Kai= Vientiane =Mohan= Kunming	0.752	5
9	Chonburi = Aranyaprathet/Klongluk = Poipet-Sisophon =+Ho Chi Minh City = Hanoi = Kunming	0.577	10

Table 7 (Cont.)

Route no	Route	TOPSIS score	Rank
10	Chonburi = Bangkok = Nam Tok = Three pagoda= Thanbyuzayat = Yangon = Mandalay = Lashio = Kunming	0.737	7

The results found that the optimal route is the transport from Chonburi by road to Mae Sai Chiang Rai, then direct to Xishuangbanna and end at the destination at Kunming (Route 2) which is the ideal one with transportation cost approximately 13,500 Baht with transport time for 32 hr and transport distance of 1610 Km. Then the result of the score of transport congestion and an opportunity for economics is equal to 3.9 and 3.3 respectively. The level of difficulty for transportation is 2.95. The results show on the table 7 state the rank by using Fuzzy TOPSIS that the with route 1 >route 5> route 3 > route 8 > route 6 > route 10 > route 4 > route 7 > route 9. For discussion on the results found that the top 4 in best alternative are range in the current situation as shown on route 2, route 1 and route 5. Also, the best range of future route is route 8 coming in sequence fifth following with route 6 > route 10 > route 7 > route 8 which implies the current route alternative can fulfill the objective than the future route. However, this research still has inconsistent information from future routes by the time the transport route would have been completed. It can re-calculate and re-consideration again the result might have changed following on the real situation.

Moreover, the future analysis showed that the best ideal is route number 2 is the shortest distance, lowest time, and cost. This route can fulfill the ideal solution in the operation transport route. In contrast. this route was no answer the best solution in qualitative factors as the results show a high score in transport congestion and a medium score in the level of difficulty for transportation. However, the final score by TOPSIS showed that this route is the best route. Regarding the research can increase the route alternative inland transport only 5 way but increase to 10 options in future transport. This is more surprising in the future route that was not in the top 3. It is implied that the current situation can support the decider to decide transportation route in the current situation. Lastly, the future transport might not a top range in ideal solution but it will suggest a direction for more development in all of the future route.

Conclusion

This study set out to evaluate the route for selecting the ideal solution in the transportation route from Chonburi, Thailand Kunming China. This study also shows the possible route in the current situation and future situation which the future transportation route coming from the missing link of, route under construction and route in the national transportation plan. The finding of the research found that there are 5 current routes and 5 future routes to transport from Chonburi Thailand to Kunming China to connect with the neighbored countries and transport through to Myanmar, Cambodia, Vietnam, and Laos including road and rail transportation. For instance, this study has raised the route characteristics to belong to transport. The criteria of this study can generate in quantitative factor (Transportation time, Transportation distance, Transportation cost) and the qualitative factors (Level of difficulty for transportation which considers the sub-criteria on the facility of infrastructure and surface condition, Transport congestion considers in the number of cars, slow and speeds, and

traffic congestion. including consider on Opportunity for Economic in opportunity for revenue and opportunity for business. In total, there are 6 main criteria and 7 in sub-criteria which have been evaluated by weight from the perspective of specialists in logistics and transportation. After that it launches with a mathematic model based on pairwise comparison and Analytical Hierarchy Process (AHP), the weight of criteria showed that transportation cost (0.27) has the highest weight to consider followed by transport time (0.20), transport distance (0.17), transport congestion (0.14), the opportunity for economic (0.13), and lastly level of difficulty for transportation (0.09). The final phase using TOPSIS to optimize the route based on their competitiveness, the resulted showed that route number 2 starting from Chonburi by road to Chiang Rai, Mai Sai in Thailand then pass to Xishuangbanna direct to Kunming, have a total distance of 1610 Km using transportation time of 32 hours and the total cost of 13,497.8 Baht. Therefore, it is the ideal route for transportation evaluate by TOPSIS showing score equal to 0.876. Also, for the future route, route number 8 with TOPSIS score equal to 0.752 is the best option which staring from Chonburi to Bangkok direct to Nong Kai by train and future project plan between Thailand and China will connect the route to Vientiane pass to Mohan and direct to Kunming is the good option for future transportation including the growing on the trade and transport. For further research, the scope of the study can be extended by considering more accurate alternative routes and consider international transportation policy between each country; considering different origins-destinations for operate with another mathematic model. Also adding more criteria to consider more objectives by developing a new algorithm to solve the intermodal transportation larger-scale problem such as connectivity of transport to increase an alternative of decision making.

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